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Heavy Truck Pre-Crash Scenarios For Safety Applications Based on Vehicle-to-Vehicle Communications

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13. ABSTRACT
This report describes pre-crash scenarios involving at least one heavy truck (gross vehicle weight rating greater than 10,000 pounds), which might be addressed with crash-imminent warning systems based on short range vehicle-to-vehicle (V2V) communications. The analysis focuses on 17 target pre-crash scenarios that are statistically described using the 2004-2008 General Estimates System (GES) crash databases and the Large-Truck Crash Causation Study (LTCCS) database. GES data is queried to quantify the societal cost and describe the driving environment, driver characteristics, and crash contributing factors of target pre-crash scenarios. LTCCS data is analyzed to portray crash causal factors. Approximately 233,000 annual police-reported crashes involving at least one heavy truck were associated with the 17 target pre-crash scenarios. These police-reported crashes contributed to about 21 billion dollars in comprehensive economic costs based on 2007 economics and 153,000 functional years lost annually. Heavy-truck drivers of interest accounted for about 57 percent of all drivers involved in these crashes.

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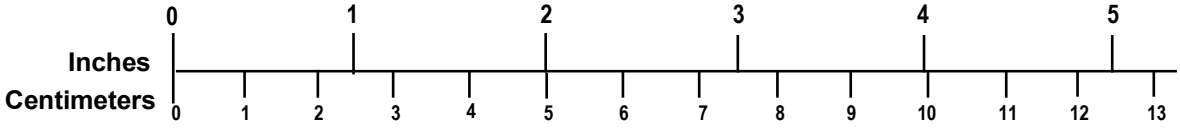

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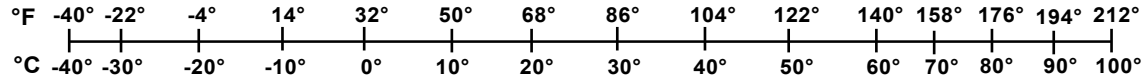

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List of Acronyms

AIS	Abbreviated Injury Scale
CDS	Crashworthiness Data System
FARS	Fatality Analysis Reporting System
FYL	functional years lost
GES	General Estimates System
GVWR	gross vehicle weight rating
LTAP/OD	left turn across path/opposite direction
LTCCS	Large Truck Crash Causation Study
LVA	lead vehicle accelerating
LVD	lead vehicle decelerating
LVM	lead vehicle moving
LVS	lead vehicle stopped
MAIS	Maximum Abbreviated Injury Scale
NASS	National Automotive Sampling System
SCP	straight crossing paths
TCD	traffic control device
TTC	time-to-collision
V2I	vehicle-to-infrastructure
V2V	vehicle-to-vehicle
VSC-A	Vehicle Safety Communications-Applications

Executive Summary

A new crash typology is developed consisting of 37 pre-crash scenarios that depict vehicle movements and dynamic as well as the critical event occurring immediately prior to crashes. The statistics for this 37-pre-crash-scenario typology are populated using 2004-2008 General Estimates System data along with additional data from the Large Truck Crash Causation Study database. Moreover, comprehensive economic costs based on 2007 economics are used to quantify their societal cost. This new analysis focuses on pre-crash scenarios involving at least one heavy truck (gross vehicle weight rating greater than 10,000 pounds), which might be addressed with crash-imminent warning systems based on short range vehicle-to-vehicle (V2V) communications. As a result, 17 of the 37 pre-crash scenarios are statistically described in terms of their societal cost, driving environment, driver characteristics, and contributing and causal factors. These statistical descriptions are used to categorize target pre-crash scenario groups that will drive future research into priority heavy truck crash kinematics and V2V-based countermeasures to reduce the frequency and harm of crashes.

Five rear-end, pre-crash scenarios accounted for the most harm at about 24 percent of the societal cost of all 17 applicable V2V pre-crash scenarios, followed by two opposite-direction pre-crash scenarios that together made up 22 percent of the total societal cost. The third most harmful pre-crash scenarios were junction crossings at 17 percent of the total comprehensive economic costs.

Based on 2004-2008 GES statistics about the driving environment, most crashes occurred on a straight road, dry surface, with clear weather during daylight. A large portion of crashes associated with changing lanes/drifting in the same direction, rear-end lead vehicle moving, and rear-end lead vehicle decelerating pre-crash scenarios happened on roads whose posted speed limit was greater than or equal to 55 mph. In contrast, a large portion of running stop sign, opposite direction/maneuver, and turning at non-signalized junctions pre-crash scenarios were reported at speed limits less than or equal to 35 mph.

The 2004-2008 GES statistics show that the age breakdown of heavy-truck drivers was 12 percent by younger drivers (24 or younger), 85 percent by middle-age drivers (25 to 64 years old), and 3 percent by older drivers (65 or older). In terms of gender, male and female drivers respectively comprised about 94 and 6 percent of all heavy-truck drivers, respectively. Moreover, about 31 percent of drivers of interest were cited with violations, 27 percent were distracted, 10 percent were speeding, 5 percent had obscured vision, and 1 percent were involved with alcohol or drugs. In response to the critical event of the crash, steering was attempted by 16 percent of all drivers of interest, most often in opposite-direction and rear-end lead-vehicle-accelerating pre-crash scenarios. Braking only was reported for 9 percent of drivers, primarily in running-red-light, rear-end/lead-vehicle-moving, and left-turn-across-path/opposite-direction pre-crash scenarios.

Based on LTCCS data, 35 percent of heavy-truck drivers had inadequate surveillance, 33 percent were following lead vehicles too closely, 27 percent were traveling too fast, 15 percent were inattentive, 15 percent had false assumptions, 11 percent were fatigued, 11 percent attempted inadequate evasive action, and 11 percent misjudged the gap or velocity between vehicles.

The results of this report feed into the crash scenario framework that will be used to identify intervention opportunities and define crash countermeasure profiles based on V2V communications for heavy trucks. The statistical and kinematical depiction of target pre-crash scenarios will enable the development of countermeasure functional requirements and minimum performance specifications as well as the estimation of potential safety benefits.

I. Introduction

This report presents a detailed description of heavy truck pre-crash scenarios to identify intervention opportunities for crash avoidance systems based on vehicle-to-vehicle (V2V) communications. This analysis is conducted in support of the Intelligent Transportation Systems' Vehicle-to-Vehicle Safety Application program [1]. V2V safety applications will be designed to increase situational awareness and reduce or eliminate crashes through V2V and vehicle-to-infrastructure (V2I) data transmission that supports driver advisories, driver warnings, and vehicle and/or infrastructure controls. It is envisioned that each vehicle on the roadway (inclusive of automobiles, trucks, transit vehicles, and motorcycles) will be able to communicate with other vehicles, and that this rich set of data and communications will support a new generation of active safety applications and systems. This report documents the results of a crash analysis that focused on police-reported crashes involving at least one heavy truck (i.e., gross vehicle weight rating greater than 10,000 pounds). Such results provide a basis for the selection and development of V2V active safety applications that address the most critical crash scenarios for heavy trucks. A companion report, titled "Heavy Truck Crash Avoidance Needs and Countermeasure Profiles for Safety Applications Based on Vehicle-to-Vehicle Communications,," describes heavy vehicle V2V crash avoidance needs in terms of performance and functional requirements for five high-priority pre-crash scenario groupings.

Understanding pre-crash scenarios contributes to the evolution of advanced-technology safety systems that have been introduced to motor vehicles over the last decade such as brake assist, stability control, adaptive cruise control, and driver warning systems. Pre-crash scenarios depict vehicle movements and dynamics as well as the critical event that occurs immediately prior to a crash. Enhanced knowledge is needed to identify new intervention opportunities, set research priorities and direction in technology development, and evaluate the effectiveness of potential crash countermeasures. Statistical description of pre-crash scenarios provides that knowledge to better define the functions, develop performance guidelines, set up test procedures, and estimate the benefits for active safety technologies such as crash avoidance and crash severity reduction systems based on V2V communications.

I.1. Study Objectives

This study seeks to address two main objectives:

1. Assess the severity of target pre-crash scenarios in terms of annual crash frequency, comprehensive economic costs, and functional years lost.
2. Characterize the crash circumstances, contributing factors, and causes.

The emphasis of the analysis is on crashes involving at least two vehicles in the pre-crash events so as to support V2V-based crash countermeasure concepts that assist drivers in avoiding imminent crashes. Such impending crashes usually arise within a relatively short period of time (i.e., under 10 seconds) from the drivers' encounter with hazardous driving conditions. National crash databases are used including the National Automotive Sampling System General Estimates System crash database [2] and the Large Truck Crash Causation Study [3].

I.2. Prior Analyses of Pre-Crash Scenarios

A number of crash typologies have been developed to provide a common foundation for public and private organizations to develop and estimate potential safety benefits of effective crash countermeasure systems. Two crash typologies were widely used for crash avoidance research in support of the Intelligent Vehicle Initiative within the Intelligent Transportation Systems program: "44-crashes" [4, 5] and "pre-crash scenarios" [6].

The "44-crashes" typology was developed by General Motors and adopted by automakers for the design, development, and benefits assessment of potential crash countermeasure technologies. Specific crash scenarios representing all collisions in the United States were identified and causes associated with each crash scenario were investigated using the 1991 GES crash database and samples of 1990-1991 police-reported crashes from Michigan and North Carolina. Shortcomings of this method for typology generation include the limited study of State crash data and the amount of effort required to replicate the results using recent crash data.

The "pre-crash scenarios" typology was devised by the United States Department of Transportation based primarily on pre-crash variables in NASS crash databases including the GES and Crashworthiness Data System. This typology was used to identify intervention opportunities, develop performance guidelines and objective test procedures, and estimate the safety benefits for crash countermeasure systems. Single-vehicle and two-vehicle crashes of common crash types were analyzed to produce the list of representative pre-crash scenarios. Multivehicle (more than two vehicles) crashes were not included in the analysis. Some low-frequency crash types were also excluded such as vehicle failure, non-collision incidents, and evasive action scenarios. As a result, the "pre-crash scenarios" typology did not account for all police-reported crashes.

A third typology of pre-crash scenarios has been developed for crash avoidance research as shown in Table 1, which combines crash information from both typologies mentioned above [7]. This new typology consists of 37 pre-crash scenarios that depict vehicle movements and dynamics as well as the critical event occurring immediately prior to crashes. The goal of this typology was to establish a common vehicle safety research foundation for public and private organizations, which will allow researchers to prioritize traffic safety issues for further investigation and to develop concomitant crash avoidance systems. A follow-on study was conducted on the 37 pre-crash scenarios typology as applied to all police-reported heavy truck crashes using the 1996-2005 GES crash databases [8]. That study examined the frequency and societal impact of heavy truck crashes, but did not statistically describe crash characteristics, contributing factors, and causes.

Figure 1 summarizes and links the three crash typologies mentioned above. As seen in Figure 1, a subset of the 37 pre-crash scenarios was deemed applicable to V2V-based crash countermeasure applications. Table 2 lists the 22 target V2V pre-crash scenarios. The first 17 scenarios are described in Section V of this report. The last five scenarios in Table 2, control loss (vehicle action and no-vehicle action), backing, parking, and other, are not covered in this report since the scenarios might be more efficiently addressed by vehicle-based systems or because additional V2V data about a vehicle losing control serve as input to advisory systems rather than crash-imminent warning systems.

Table 1. 37 Pre-Crash Scenario Typology

1	Vehicle Failure	21	Vehicle Not Making a Maneuver – Opposite Direction
2	Control Loss with Prior Vehicle Action	22	Following Vehicle Making a Maneuver
3	Control Loss without Prior Vehicle Action	23	Lead Vehicle Accelerating
4	Running Red Light	24	Lead Vehicle Moving at Lower Constant Speed
5	Running Stop Sign	25	Lead Vehicle Decelerating
6	Road Edge Departure with Prior Vehicle Maneuver	26	Lead Vehicle Stopped
7	Road Edge Departure without Prior Vehicle Maneuver	27	Left Turn Across Path from Opposite Directions at Signalized Junctions
8	Road Edge Departure While Backing Up	28	Vehicle Turning Right at Signalized Junctions
9	Animal Crash with Prior Vehicle Maneuver	29	Left Turn Across Path from Opposite Directions at Non-Signalized Junctions
10	Animal Crash without Prior Vehicle Maneuver	30	Straight Crossing Paths at Non-Signalized Junctions
11	Pedestrian Crash with Prior Vehicle Maneuver	31	Vehicle Turning at Non-Signalized Junctions
12	Pedestrian Crash without Prior Vehicle Maneuver	32	Evasive Action with Prior Vehicle Maneuver
13	Pedalcyclist Crash with Prior Vehicle Maneuver	33	Evasive Action without Prior Vehicle Maneuver
14	Pedalcyclist Crash without Prior Vehicle Maneuver	34	Non-Collision Incident
15	Backing Up into Another Vehicle	35	Object Crash with Prior Vehicle Maneuver
16	Vehicle Turning – Same Direction	36	Object Crash without Prior Vehicle Maneuver
17	Vehicle Parking – Same Direction	37	Other
18	Vehicle Changing Lanes – Same Direction		
19	Vehicle Drifting – Same Direction		
20	Vehicle Making a Maneuver – Opposite Direction		

- Vehicle Action refers to a vehicle decelerating, accelerating, starting, passing, parking, turning, backing up, changing lanes, merging, or making a successful corrective action in response to a previous critical event.
- Vehicle Maneuver denotes passing, parking, turning, changing lanes, merging, or successful corrective action to a previous critical event.

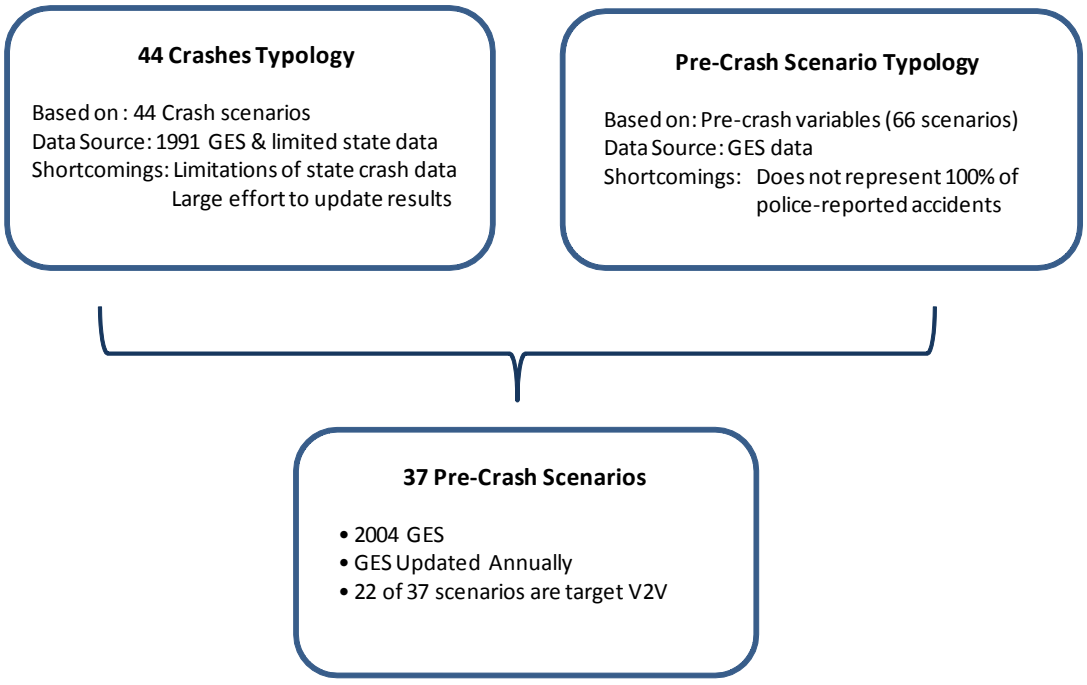


Figure 1. Pre-Crash Scenario Typologies

Table 2. Target V2V Pre-Crash Scenarios

22 Vehicle-to-Vehicle Pre-Crash Scenarios	Used in Analysis
Running Red Light	✓
Running Stop Sign	✓
Turning/Same Direction	✓
Changing Lanes/Same Direction	✓
Drifting/Same Direction	✓
Opposite Direction/Maneuver	✓
Opposite Direction/No Maneuver	✓
Rear-End/Striking Maneuver	✓
Rear-End/Lead Vehicle Accelerating (LVA)	✓
Rear-End/Lead Vehicle Moving at Slower Constant Speed (LVM)	✓
Rear-End/Lead Vehicle Decelerating (LVD)	✓
Rear-End/Lead Vehicle Stopped (LVS)	✓
Left Turn Across Path (LTAP)/Opposite Direction (OD) at Signal	✓
Turn Right at Signal	✓
LTAP/OD at Non Signal	✓
Straight Crossing Path (SCP) at Non-Signal	✓
Turn at Non-Signal	✓
Control Loss/No Vehicle Action	✗
Control Loss/Vehicle Action	✗
Parking/Same Direction	✗
Backing Into Vehicle	✗
Other	✗

I.3. Annual Frequency of Target Pre-Crash Scenarios

Based on statistics from the 2005-2008 GES crash databases, V2V systems potentially address about 267,000 police-reported heavy truck crashes annually, with the 95 percent confidence interval between 228,000 and 306,000 [9]. V2V systems predominantly apply to crashes that involve vehicle-to-vehicle pre-crash scenarios. This criterion recognizes that, in general, V2V systems require two or more equipped vehicles in communication to be effective. The exception to that rule is the broadcast of control loss message in the single-vehicle control loss pre-crash scenarios. This analysis adopted the control loss warning function under investigation by the Crash Avoidance Metrics Partnership in the Vehicle Safety Communications–Applications (VSC-A) project [10]. If considered as the primary countermeasure, V2V systems have the potential to deal with 70 percent of all crashes involving at least one heavy truck. Excluding drivers impaired by alcohol or drowsiness, these systems address 71 percent of all heavy truck crashes involving unimpaired drivers. About 14 percent of the crashes were not assigned to any crash countermeasure due to the lack of information. The remaining 15 percent of the heavy truck crashes can be addressed by either V2I or vehicle-based systems or both. Table 3 lists the different criteria used to map applicable crash data to V2V systems as the primary countermeasure and the remaining crashes to V2I and vehicle-based systems.

Table 3. Mapping of Pre-Crash Scenarios to V2V as Primary Systems

Pre-Crash Scenario	V2V	V2I	AV
No driver present	None	None	None
Vehicle failure	None	None	All Crashes
Control loss/vehicle action	All Crashes	None Remaining	None Remaining
Control loss/no vehicle action	All Crashes	None Remaining	None Remaining
Running red light	2+ Vehicle Crashes	All Remaining Crashes	None Remaining
Running stop sign	2+ Vehicle Crashes	All Remaining Crashes	All Remaining Crashes
Road edge departure/maneuver	None	Speeding Crashes	Conditional Speeding Crashes
Road edge departure/no maneuver	None	Speeding Crashes	All Crashes
Road edge departure/backing	None	None	All Crashes
Animal/maneuver	None	None	All Crashes
Animal/no maneuver	None	None	All Crashes
Pedestrian/maneuver	None	Crosswalk Crashes	All Crashes
Pedestrian/no maneuver	None	Crosswalk Crashes	All Crashes
Cyclist/maneuver	None	None	All Crashes
Cyclist/no maneuver	None	None	All Crashes
Backing into vehicle	All Crashes	None	None
Turning/same direction	All Crashes	None	None Remaining
Parking/same direction	All Crashes	None	None Remaining
Changing lanes/same direction	All Crashes	None	None Remaining
Drifting/same lane	All Crashes	None	None Remaining
Opposite direction/maneuver	All Crashes	None	None Remaining
Opposite direction/no maneuver	All Crashes	None	None Remaining
Rear-end/striking maneuver	All Crashes	None	None Remaining
Rear-end/lead vehicle accelerating	All Crashes	None	None Remaining
Rear-end/lead vehicle constant speed	All Crashes	None	None Remaining
Rear-end/lead vehicle decelerating	All Crashes	None	None Remaining
Rear-end/lead vehicle stopped	All Crashes	None	None Remaining
LTAP/OD @ signal	All Crashes	None Remaining	None
Turn right @ signal	All Crashes	None Remaining	None
LTAP/OD @ non signal	All Crashes	None Remaining	None
SCP @ non signal	All Crashes	None Remaining	None
Turn @ non signal	All Crashes	None Remaining	None
Evasive maneuver/maneuver	Uncertain	Uncertain	Uncertain
Evasive maneuver/no maneuver	Uncertain	Uncertain	Uncertain
Rollover	None	Speeding Crashes	Conditional Speeding Crashes
Noncollision - No impact	None	None	None
Object contacted/maneuver	None	Speeding Crashes	Conditional Speeding Crashes
Object contacted/no maneuver	None	Speeding Crashes	All Crashes
Hit and run	Uncertain	Uncertain	Uncertain
Other - Rear-end	All Crashes	None	None Remaining
Other - Sideswipe	All Crashes	None	None Remaining
Other - Turn Across Path	All Crashes	None Remaining	None

LTAP/OD: Left Turn Across Path/Opposite Directions, SCP: Straight Crossing Paths

II. Data Sources

Two data sources were used to identify and statistically describe target pre-crash scenarios involving heavy trucks for V2V-based safety applications, the 2004-2008 GES crash databases and the LTCCS database.

II.1. General Estimates System

The GES crash database estimates the national crash population each year based on a weighted sample of about 55,000 police-reported crash cases that include all vehicle types and injury levels. This report presents results based on an average annual estimate from yearly crashes over a 5-year period including 2004-2008 datasets. These crash estimates do not account for non-reported crashes. Thus, the national estimates produced from the GES data may differ from the true population values because they are based on a probability sample of police-reported crashes rather than a census of all crashes. The GES was selected for this study due to the following characteristics:

- Nationally representative,
- Updated annually,
- Variables about the crash type and pre-crash attributes that enable the identification of dynamically-distinct scenarios, and
- Descriptive variables of the environmental and driving conditions at the time of the crash, driver and vehicle contributing factors, and injury levels of persons involved.

II.1.a. Identification of Pre-Crash Scenarios

Appendix A presents the coding scheme to identify common pre-crash scenarios leading to all single-vehicle and multiple vehicle crashes based on GES variables and codes. A total of 46 pre-crash scenarios are listed starting with scenarios associated with crash contributing factors such as vehicle control loss and driver violation of a red light or stop sign (numbers 2 to 6). The 46 scenarios were narrowed down to the core 37 pre-crash scenarios by combining the 7 "Other" scenarios and eliminating the Rollover and Hit-and-Run scenarios. The remaining 37 scenarios result in different crash types. For example, loss of vehicle control due to excessive speed could lead to a vehicle running off the road, rear-ending another vehicle, or encroaching into another lane and side-swiping an adjacent vehicle. From a crash avoidance perspective, the problem of vehicle control loss is identical in all three cases. A potential crash countermeasure function would detect the excessive speed or the imminent loss of control regardless of what crash type these conditions might lead to. Therefore, scenarios based on crash contributing factors in Appendix A supersede remaining scenarios that represent dynamically-distinct driving situations based on vehicle movements and dynamic states. The 37 pre-crash-scenario typology was created by deducting the scenarios in the same order listed in Appendix A using the process of elimination. The sum of the resulting frequency distribution adds to 100 percent, eliminating double counting of crashes in each of the scenarios.

The Accident Type, Movement Prior to Critical Event, and Critical Event variables from the GES Vehicle File were primarily used to identify dynamically-distinct pre-crash scenarios. The first event in a crash from the GES Event File helped to distinguish pre-crash scenarios in multi-

vehicle crashes. In addition to these variables, the coding schemes use the following GES variables.

- Traffic Control Device: Type of traffic control device, if any.
- Violations Charged: Any violations for which the drivers were cited.
- First Harmful Event: first property damaging or injury-producing event in the crash.
- Crash Event Sequence Number: Number assigned to each harmful event in a crash, in chronological order.
- Vehicle Number-This Vehicle: Number assigned to an in-transport motor vehicle involved in the event.
- Vehicle Number-Other Vehicle or Object Contacted: Vehicle number of the other vehicle or object hit, or the type of non-collision involved in the event.
- Vehicle Role: Vehicle role (e.g., striking, struck) in single- or multiple-vehicle crashes.
- Rollover Type: Indicates if a rollover occurred and whether it was tripped or untripped. Rollover is defined as any vehicle rotation of 90 degrees or more about any true longitudinal or lateral axis. Rollover can occur at any time during the crash.
- Hit and Run: Indicates that a motor vehicle in transport or its driver departed the scene; vehicles not in transport are excluded. It does not matter whether the hit-and-run vehicle was striking or struck.
- Number of Vehicles Involved: Number of vehicles involved in the crash.

The following GES variable and codes were queried to identify the heavy truck:

- Body Type (Hot-Deck Imputed) = 60, 64, 66, 78, and 79.

II.1.b. Description of GES Descriptive Variables

Table 4 lists the GES descriptive variables used in this analysis. The descriptions of each variable are grouped according to driving environment, driver characteristics, and driver and vehicle contributing factors. The following describes the variables of the driving environment.

- ROADWAY ALIGNMENT (imputed): horizontal alignment of roadway.
  - Straight
  - Curve
- ROADWAY SURFACE CONDITION (imputed): condition of road surface at the time of the crash.
  - Dry
  - Wet/slippery – wet; snow or slush; ice; sand, dirt, and oil; and other.
- ATMOSPHERIC CONDITIONS (imputed): general atmospheric conditions at the time of crash.
  - Clear – no adverse conditions
  - Adverse – rain; sleet; snow; fog; rain and fog; sleet and fog; and other (smog, smoke, blowing sand/dust/snow, crosswind, and hail).

Table 4. GES Descriptive Variables

Category	GES Variable
Driving Environment	Road Alignment
	Surface Condition
	Atmospheric Condition
	Relation to Junction
	Traffic Control Device
	Lighting Condition
	Posted Speed Limit (MPH)
Driver Characteristics	Age (Years)
	Gender
Driver Contributing Factors	Police-Reported Alcohol Involvemet
	Police-Reported Drug Involvement
	Person's Physical Impairment
	Violations Cited
	Speed Related
	Driver's Vision Obscured by
	Driver Distracted by
Vehicle Factors	Vehicle Contributing Factors
Avoidance Maneuver	Corrective Action Attempted

- RELATION TO JUNCTION (imputed): Indicates if the first harmful event is located within a junction or interchange area. If the first harmful event occurs off the roadway, the location classified is the point of departure. (Non-interchange area and interchange area are combined).
    - Non-junction
    - Intersection/intersection-related
    - Driveway, alley access, etc.
    - Entrance/exit ramp
    - Rail grade crossing
    - On a bridge
    - Crossover-related
    - Other
- TRAFFIC CONTROL DEVICE (imputed): Indicates whether or not a traffic control device was present for the crash and the type of traffic control device.
    - No traffic controls

    Not at railroad grade crossing trafficway traffic signals
    - 3 color traffic signal
    - Other traffic signal type - flashing traffic control signal or flashing beacon; other traffic signal; and unknown traffic signal

    Regulatory, school zone signs
    - Stop sign
    - Other sign type - yield sign; school zone-related sign; other sign; unknown sign

Warning signs
    - Other sign type (cont.) - advisory speed sign; warning sign for road conditions (hill, steep grade, etc.); warning sign for road construction; warning sign for environment/traffic (fog ahead, wind, crash ahead, etc.); and unknown type warning

Miscellaneous, not at railroad crossing
    - Officer, crossing guard, flagman, etc.

At railroad grade crossing
    - RR crossing device - active devices (e.g., gates, flashing lights, traffic signal) and passive devices (e.g., stop sign, cross bucks)

Other
    - Other - traffic control present - no details and other traffic control (whether or not at RR grade crossing)

- LIGHTING CONDITIONS (imputed): general light conditions at the time of the crash, including light from external roadway illumination fixtures
    - Daylight
    - Dark
    - Dark but lighted
    - Dawn/dusk
- SPEED LIMIT (imputed): Posted Speed Limit indicates the highest posted speed limit of all roads involved in a crash. Vehicle Speed Limit refers to the posted speed limit of the road that the heavy truck was on

The following two variables describe driver characteristics.

- AGE (imputed): Indicates the person's age at the time of the crash, with respect to the person's last birthday
    - Younger: 24 years old or younger
    - Middle-age: 25 to 64 years old
    - Older: 65 or older
- GENDER (imputed): Indicates the police reported gender for this person
    - Male
    - Female

Crash contributing factors attributed to the driver or vehicle are obtained from these variables.

- POLICE-REPORTED ALCOHOL INVOLVEMENT (imputed): Indicates that the person (drivers of 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 police report indicates that opened or unopened alcohol bottles were found in the vehicle, then this information does not by itself constitute involvement.
    - No alcohol
    - Alcohol
- POLICE-REPORTED DRUG INVOLVEMENT**:** 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 or were not a cause of the crash. If the police report indicates

that drugs were found in the vehicle, then this information does not by itself constitute involvement.
    - No drugs
    - Drugs
    - Unknown - not on police report; not coded; and unknown (police reported)
- PERSON'S PHYSICAL IMPAIRMENT*:* Identifies physical impairments for all drivers and non-motorists which may have contributed to the cause of the crash.
    - None
    - Ill, blackout
    - Sleepy - drowsy, sleepy, fell asleep, fatigued
    - Other - requires cane or crutches, paraplegic or restricted to wheelchair, impaired due to previous injury, deaf, blind, physical impairment - no details, and other physical impairments
    - Unknown - hit & run (and no information); not on police report; not coded; and unknown if physically impaired
- VIOLATIONS CHARGED (imputed): Indicates which violations are charged to drivers.
    - No – no violations
    - Yes - alcohol or drugs; speeding; alcohol or drugs and speeding; reckless driving; driving with a suspended or revoked license; failure to yield right-of-way; running a traffic signal or stop sign; violation charged-no details; and other violation
- SPEED RELATED**:** Indicates whether speed is a contributing factor to the cause of the crash.
    - No
    - Yes
    - Unknown
- DRIVER'S VISION OBSCURED by*:* Identifies visual circumstances that may have contributed to the cause of the crash.
    - No obstruction
    - Obstruction - rain, snow, smoke, sand, dust; reflected glare, bright sunlight, headlights; curve or hill; building, billboard, or other design features (includes signs embankment); trees, crops, vegetation; moving vehicle (including load); parked vehicle; splash or spray of passing vehicle; inadequate defrost or defog system; inadequate lighting system; obstruction interior to vehicle; external mirrors; head restraints; broken or improperly cleaned windshield; fog; vision obscured-no details; and other obstruction
    - Unknown - hit & run vehicle (and no information); not on police report; not coded; and unknown whether vision was obstructed
- DRIVER DISTRACTED BY: Identifies all distractions which may have influenced driver performance and contributed to the cause of the crash. The distraction can be either inside the vehicle (internal) or outside the vehicle (external).
    - No distraction
    - Distraction - looked but did not see; by other occupants; by moving object in vehicle; while talking or listening to phone; while dialing phone; while adjusting climate control; while adjusting radio, cassette or CD; while using other devices integral to vehicle; while using or reaching for other devices; distracted by outside person or object; eating or drinking; smoking-related; other cellular phone-

related; distraction or inattention, details unknown; inattentive or lost in thought; other distraction
    - Sleepy - sleepy or fell asleep
    - Unknown - hit & run (and no information); not on police report; not coded; and unknown if distracted
- VEHICLE CONTRIBUTING FACTORS: Indicates vehicle factors that may have contributed to the cause of the crash.
    - No contributing factors
    - Vehicle contributing factors – tires, brake system, steering system-tie rod, kingpin, ball joint, etc.; suspension-springs, shock absorbers, McPherson struts, control arms, etc.; power train-universal joint, drive shaft, transmission, etc.; exhaust system; headlights; signal lights; other lights; wipers; wheels; mirrors; driver seating and control; body, doors; trailer hitch vehicle contributing factors-no details; and other vehicle contributing factors
    - Unknown - hit-and-run vehicle and unknown if vehicle has contributing factors

The following variable describes the driver's attempted avoidance maneuver.

- CORRECTIVE ACTION ATTEMPTED: Indicates the maneuver attempted by the driver of interest just prior to the crash.
    - No Avoidance Maneuver
    - Braking - braking with lockup, braking without lockup, breaking with unknown lockup, releasing brakes
    - Steering - steering to right, steering to left
    - Braking and Steering - braking and steering right, braking and steering left
    - Accelerating - accelerating straight, accelerating to right, accelerating to left
    - Other action attempted

It should be noted that imputed variables in the GES were used to account for unknown information, when present. The GES employs two different statistical procedures to identify values for unknown data: univariate imputation and hot-deck imputation. If imputed values were not available, the unknowns were imputed using the univariate method [11].

II.2. Large-Truck Crash Causation Study

The objective of the LTCCS was to collect on-scene information about the events and associated factors leading up to commercial crashes that involve at least one large truck (GVWR > 10,000 pounds) and resulted in at least one fatality or at least one incapacitating or non-incapacitating but evident injury [3]. This information facilitates the statistical and clinical analyses that would help identify effective crash countermeasures from the 963 records in the LTCCS. The LTCCS database contains over 1,000 data elements including narratives, diagrams, and schematics for each documented crash. For some of the crashes that resulted in fatalities or severe injuries, crash data were unavailable directly from the drivers involved and may have been gathered from interviews with surrogate drivers or heavy truck experts.

II.2.a. General LTCCS Statistics

LTCCS collected data on a total of 1,070 crashes from 2001 to 2003. Of these, 963 crashes comprised a nationally representative sample. The remaining 107 crashes were meant for clinical studies. Based on the weights attached to the sample of 963 crashes, this sample represented an estimated 82,216 crashes at the national level.

The LTCCS data provide detailed information about the driver and the events leading up to the crash. About 33 percent of the driver-related critical reasons were recognition errors that include inattention, internal and external distractions, inadequate surveillance, etc. About 29 percent of the driver-related critical reasons were decision errors that included too fast for conditions, too fast for curve, false assumption of others' actions, illegal maneuver, and misjudgment of gap or others' speed. In only 2 percent of the crashes, the critical reason was a performance error such as over-compensation, poor directional control, etc.

II.2.b. Description of LTCCS Variables

Table 5 lists the LTCCS variables that were queried in this study.

Table 5. Key LTCCS Variables

Category	LTCCS Variable
Critical Reason	Critical Reason for the Pre-Crash Event
Driver Condition	Driver Fatigued
Driver Recognition Error	Inattention
	Conversing
	Inadequate Surveillance
	Other Driver Recognition Error
Driver Decision Error	Misjudgment of Gap or Velocity
	False Assumption
	Following Too Closely
	Traveling Too Fast
	Other Driver Decision Error
Driver Action Error	Inadequate Evasive Action

The Critical Reason for the Pre-crash Event establishes the critical reason for the occurrence of the critical event. The critical reason is the immediate reason for this event and is often the last failure in the causal chain (i.e. closest in time to the critical pre-crash event). Although the critical reason is an important part of the description of crash events, it is not the cause of the crash nor does it imply the assignment of fault:

- No critical reason;
- Sleep, that is, actually asleep;
- Heart attack or other physical impairment of the ability to act;
- Driver error - inattention (i.e., daydreaming); internal distraction; external distraction; inadequate surveillance (e.g., failed to look, looked but did not see); unknown recognition error; too fast for conditions to be able to respond to unexpected actions

of other road users; misjudgment of gap or other's speed; following too closely to respond to unexpected actions; false assumption of other road user's actions; illegal maneuver; inadequate evasive action, e.g. braking only, not braking and steering; aggressive driving behavior; other decision error (specify); unknown decision error; panic/freezing; too fast for curve/turn; overcompensation; poor directional control e.g., failing to control vehicle with skill ordinarily expected; type of driver error unknown.

- Vehicle issues - tires/wheels failed; brakes failed; steering failed; cargo shifted; suspension failed; trailer attachment failed; other vehicle failure (specify); signs/signals missing; degraded braking capability; transmission/engine failure.
- Weather /road /sign-signal issues – road design - roadway geometry (e.g., ramp curvature); road design - other; slick roads (low friction road surface due to ice, loose debris, any other cause); wind gust; fog; glare; unknown reason for critical event.

The Fatigue variable assesses driver fatigue at the time of the crash. The assessment is based on an evaluation of the driver's current and preceding sleep schedules, current and preceding work schedules, and a variety of other fatigue-related factors including recreational and non-work activities.

- Driver not fatigued
- Driver fatigued

The variables of Driver Recognition Error are:

- DRIVER INATTENTION: documents if the driver was inattentive due to focusing on concerns and the nature of those concerns:
  - No inattention factors;
  - Inattention factors - personal problem; family problem; financial problem; preceding argument; future event (e.g., vacation, wedding, etc.); and other;
  - Unknown.
- DRIVER CONVERSING: establishes if the driver was participating in conversation during the pre-crash phase:
  - Not conversing;
  - Conversing - conversing with passenger; talking on phone; talking on CB radio; and other;
  - Unknown.
- INADEQUATE SURVEILLANCE: Identifies inadequate surveillance actions on the part of the driver:
  - No inadequate surveillance factors;
  - Inadequate surveillance factors - failed to look far enough ahead; failed to look either side ahead; failed to look to side; failed to look to rear (mirrors); failed to look-other; looked, but did not see; and other.
  - Unknown.

Driver Decision Errors are described by the following variables:

- MISJUDGMENT OF DISTANCE OR SPEED OF OTHER VEHICLE: documents the involvement of a decision error in which the subject driver either misjudges the gap distance to the other vehicle or misjudges the velocity of the other vehicle.
    - No misjudgment factors;
    - Misjudgment factors - misjudgment of gap distance; misjudgment of velocity of other vehicle; misjudgment of both factor.
    - Unknown.
- FALSE ASSUMPTION OF OTHER ROAD USER'S ACTION: Identifies false assumptions on the part of this driver with respect to other driver's actions or intended actions:
    - No false assumption factors;
    - False assumption factors - assumed that other driver would merge without stopping; assumed that other driver would turn without stopping; assumed that other driver would continue to proceed; assumed that other driver would yield right-of-way; and other false assumption factors;
    - Unknown.
- FOLLOWING TOO CLOSELY: Documents reasons given by the driver for traveling with less than the recommended gap interval to traffic forward of the driver's position.
    - No following too closely factors;
    - Following too closely factors - rush hour, heavy traffic; keeping up with traffic; did not realize too close; always drive at this gap distance; and other;
    - Unknown.
- SPEEDING: Documents reasons given by the driver for traveling at his/her pre-crash travel speed. This variable is only relevant in the circumstance where the driver had been assessed as traveling too fast for conditions:
    - No traveling too fast factors;
    - Traveling too fast factors – keeping up with traffic; did not realize caution required; and other;
    - Unknown.

Driver Action Errors are described by the following variable:

- INADEQUATE EVASIVE ACTION: Establishes inadequate evasive actions on the part of this driver. This variable does not deal with legal requirements and the final assessment may be subjective:
    - No inadequate evasive action factors;
    - Inadequate evasive action factors - insufficient steering inputs; insufficient braking inputs; combination of insufficient steering and braking inputs; and other inadequate evasive action;
    - Unknown

III. Heavy Truck Pre-Crash Scenario Statistics

Target V2V pre-crash scenarios are statistically described in terms of their societal cost, driving environment, driver characteristics, crash contributing factors, and causes based on the 2004-2008 GES and 2001-2003 LTCCS crash databases.

III.1. Societal Cost

Societal cost of target pre-crash scenarios is estimated from the 2004-2008 GES data by two harm measures: comprehensive economic cost and functional years lost. The functional years lost harm measure was selected for this analysis over other measures such as "equivalent lives" in order to harmonize with automakers who have been using this measure in their crash avoidance research. These harm measures are derived from the maximum injury severity of all injured people involved in a specific crash scenario according to the Abbreviated Injury Scale . The AIS is a classification system for assessing impact injury severity developed by the Association for the Advancement of Automotive Medicine. It provides the basis for stratifying the economic costs and functional years lost of crashes by injury severity. The Maximum Abbreviated Injury Scale is a function of AIS on a single injured person, which measures overall maximum injury severity.

III.1.a. Injury Severity Scale Conversion

The GES does not provide detailed information regarding injury severity based on the AIS coding scheme. Instead, the GES records injury severity by crash victim on the KABCO scale from police crash reports. Police reports in almost every state use KABCO to classify crash victims as K – killed, A – incapacitating injury, B – non-incapacitating injury, C – possible injury, O – no apparent injury, or ISU – Injury Severity Unknown. The KABCO coding scheme allows non-medically trained persons to make on-scene injury assessments without a hands-on examination. However, KABCO ratings are imprecise and inconsistently coded between states and over time. To estimate injuries based on the MAIS coding structure, a translator derived from 1982–1986 NASS and 2000-2007 CDS data was applied to the GES police-reported injury profile as shown in Table 6 [12].

It should be noted that the National Highway Traffic Safety Administration recommends that fatal crashes and fatalities be extracted from the Fatality Analysis Reporting System, not GES, since it contains records on all fatal traffic crashes and thus provides a more accurate representation of fatal crashes and fatalities than the sample contained in the GES. This report, however, counts fatalities from the GES because FARS does not contain the Accident Type and Critical Event variables needed to identify pre-crash scenarios. Starting with 2010 fatal crash data, the FARS database will include the same pre-crash variables already available in NASS crash databases.

Table 6. MAIS-KABCO Conversion Matrix

MAIS	Police-Reported Injury Severity System						
	O	C	B	A	K	U	
	No Injury	Possible Injury	Non-Incapacitating	Incapacitating	Fatality	Injured, Severity Unknown	Unknown
0	0.92458	0.23203	0.06995	0.03341	0	0.22274	0.42883
1	0.07329	0.69145	0.78039	0.55819	0	0.61725	0.41108
2	0.00201	0.06413	0.11026	0.20748	0	0.10289	0.08667
3	0.00009	0.01061	0.0308	0.1407	0	0.04072	0.04748
4	0	0.00148	0.0063	0.03859	0	0.00418	0.00609
5	0.00003	0.00012	0.0009	0.01702	0	0.01174	0.00277
Killed	0	0.00018	0.0014	0.00461	1	0.00048	0.01708
Total	1	1	1	1	1	1	1

Source: 1982-1986 Old NASS and 2000-2007 CDS

III.1.b. Comprehensive Costs and Functional Years Lost

Comprehensive economic cost account for goods and services that must be purchased or productivity that is lost as a result of motor vehicle crashes [13]. Intangible consequences of these events to individuals and families, such as pain and suffering or loss of life, are not included. Comprehensive cost encompasses medical, emergency medical service, market productivity, household productivity, insurance administration, workplace productivity, legal and court, and travel delay costs. In addition, comprehensive costs include the value of quality-adjusted life-years. Figure 2 illustrates the values of comprehensive cost associated with each MAIS level based on 2007 economics.

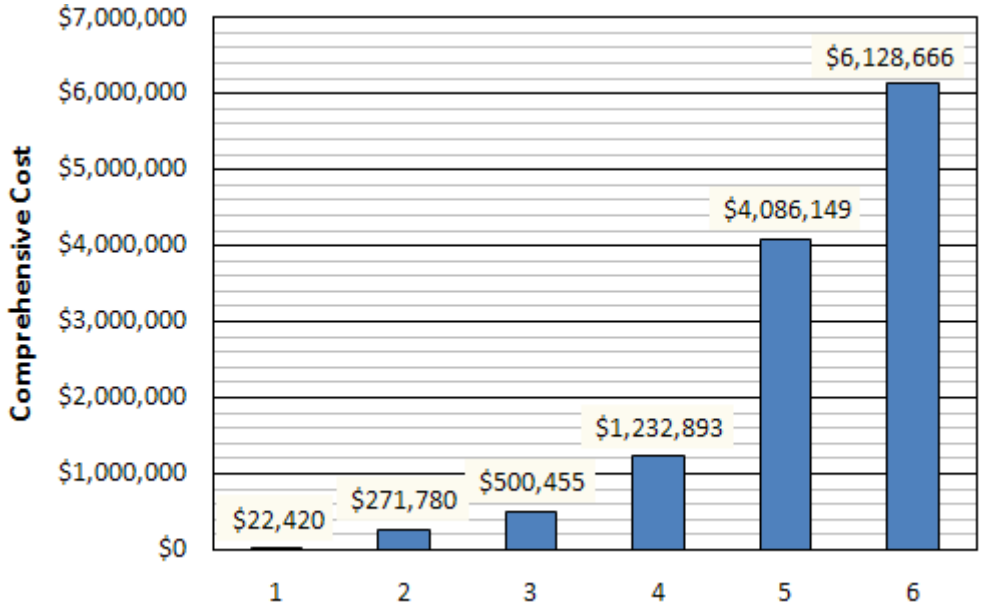


Figure 2. Values of Comprehensive Cost by MAIS Level

Functional years lost is a non-monetary measure that sums the years of life lost to fatal injury and the years of functional capacity lost to nonfatal injury [14]. This measure does not mirror the monetary economic cost. It assigns a different value to the relative severity of injuries suffered from motor vehicle crashes. Figure 3 shows the values of functional years lost associated with each MAIS level. Comprehensive economic cost and functional years lost are presented independently to allow comparisons against other research that uses either dollar values or years as a measure.

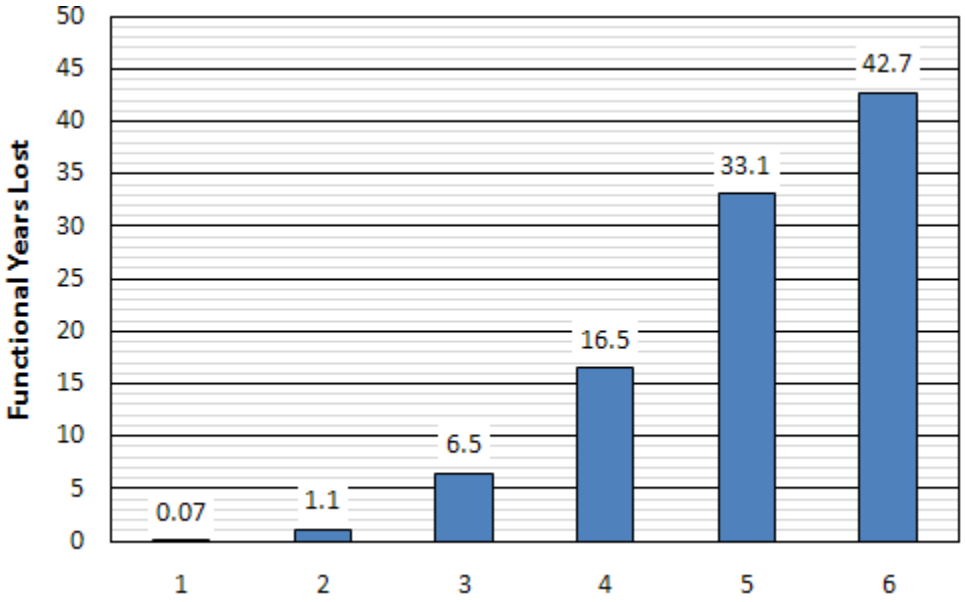


Figure 3. Values of Functional Years Lost by MAIS Level

III.1.c. Heavy Truck Crash Severity Statistics

Table 7 provides the average annual values of frequency of occurrence, comprehensive costs, and functional years lost for 22 target pre-crash scenarios involving at least one heavy truck based on 2004-2008 GES crash statistics of injured persons. It is noteworthy that these cost estimates reflect the injury levels of persons involved in police-reported crashes only. This analysis excludes the cost of crashes that were not reported to the police. The top four pre-crash scenarios that individually accounted for close to or over ten percent of the total cost are listed below in a descending order by the comprehensive cost:

1. Opposite direction without any vehicle attempting a maneuver in the pre-event movement
2. Straight crossing paths at non-signalized junctions
3. Control loss without any vehicle action in the pre-event movement
4. Lead vehicle stopped

Collectively, the top four most harmful pre-crash scenarios comprised 55 percent of the total comprehensive costs and functional years lost. Figure 4 illustrates the ranking of the 22 pre-crash scenarios based on comprehensive costs. The top 10 pre-crash scenarios, each accounting for over 3 percent of the total cost, resulted in 85 percent of the total comprehensive costs and functional years lost.

The two control loss pre-crash scenarios accounted for 12 percent of the total comprehensive costs and 13 percent of functions years lost. These scenarios are currently addressed by stability control systems. In addition, the VSC-A project investigated a crash countermeasure that provides an advisory message to the vehicles surrounding the vehicle experiencing the control loss. Since the crash risk to the surrounding vehicles may or may not be imminent, this report does not consider these control loss pre-crash scenarios for V2V-based crash-imminent warning applications and, therefore, does not statistically describe their driving environment and crash contributing factors and causes.

Table 7. Frequency, Societal Cost, and Rank of Target Heavy Truck Pre-Crash Scenarios

Pre-Crash Scenario	Crash Frequency	Comprehensive Cost			FYL		
		Total	Percentage	Rank	Total	Percentage	Rank
Opposite direction/no maneuver	13,000	$ 4,964,000,000	20.1 %	1	35,000	19.9 %	1
SCP @ non signal	22,000	$ 3,838,000,000	15.5 %	2	27,000	15.4 %	2
Control loss/no vehicle action	16,000	$ 2,515,000,000	10.2 %	3	18,000	10.2 %	3
Rear-end/LVS	32,000	$ 2,405,000,000	9.7 %	4	17,000	9.6 %	4
Rear-end/LVM	14,000	$ 2,068,000,000	8.4 %	5	15,000	8.4 %	5
Changing lanes/same direction	51,000	$ 1,907,000,000	7.7 %	6	14,000	7.8 %	6
Rear-end/LVD	18,000	$ 924,000,000	3.7 %	7	7,000	3.7 %	7
Running red light	9,000	$ 821,000,000	3.3 %	8	6,000	3.4 %	8
LTAP/OD @ non signal	5,000	$ 795,000,000	3.2 %	9	6,000	3.2 %	10
LTAP/OD @ signal	5,000	$ 778,000,000	3.1 %	10	6,000	3.2 %	9
Turning/same direction	28,000	$ 698,000,000	2.8 %	11	5,000	2.8 %	11
Drifting/same direction	20,000	$ 638,000,000	2.6 %	12	5,000	2.6 %	12
Control loss/vehicle action	5,000	$ 573,000,000	2.3 %	13	4,000	2.4 %	13
Opposite direction/maneuver	1,000	$ 490,000,000	2.0 %	14	4,000	2.0 %	14
Turn right @ signal	3,000	$ 377,000,000	1.5 %	15	3,000	1.5 %	15
Backing into vehicle	18,000	$ 244,000,000	1.0 %	16	2,000	0.9 %	17
Rear-end/striking maneuver	5,000	$ 244,000,000	1.0 %	17	2,000	1.0 %	16
Rear-end/LVA	1,000	$ 169,000,000	0.7 %	18	1,000	0.7 %	18
Running stop sign	1,000	$ 118,000,000	0.5 %	19	1,000	0.5 %	19
Parking/same direction	3,000	$ 101,000,000	0.4 %	20	1,000	0.4 %	20
Turn @ non signal	4,000	$ 77,000,000	0.3 %	21	1,000	0.3 %	21
Other	3,000	$ 5,000,000	0.0 %	22	-	0.0 %	22
All	279,000	$ 24,750,000,000	100.0 %		178,000	100.0 %	

FYL: Functional Years Lost, SCP: Straight Crossing Paths, LVS: Lead Vehicle Stopped, LVD: Lead Vehicle Decelerating, LTAP/OD: Left Turn Across Path/Opposite Directions, LVM: Lead Vehicle Moving, LVA: Lead Vehicle Accelerating

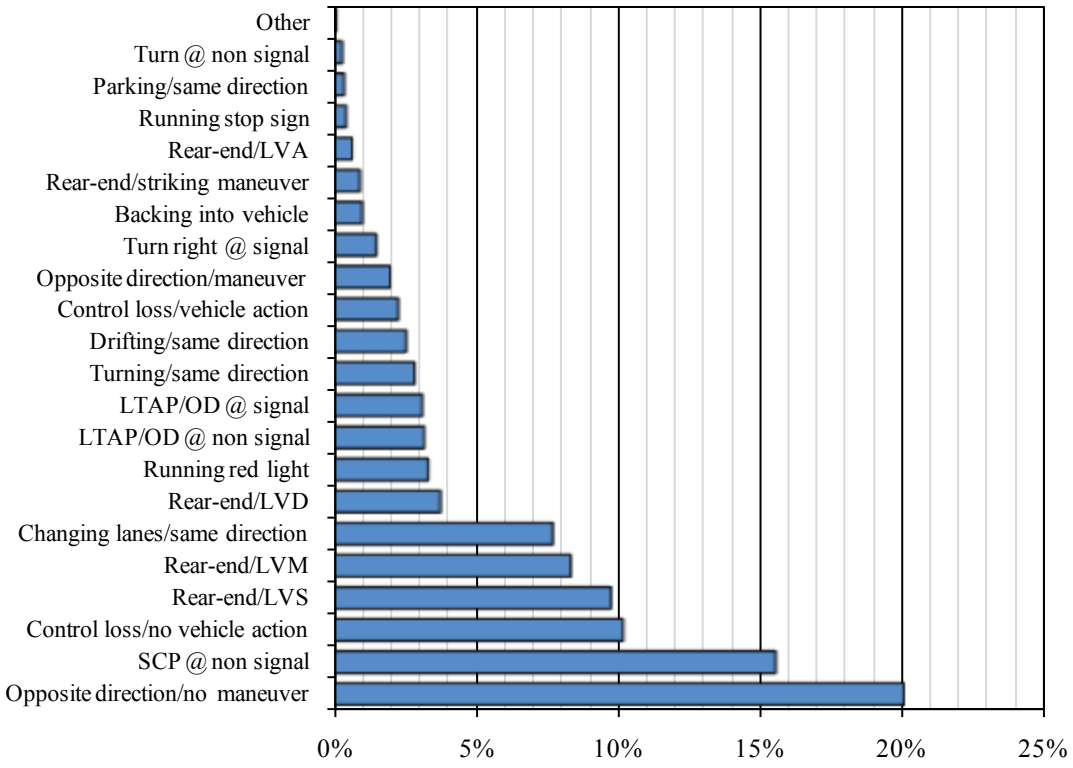


Figure 4. Relative Comprehensive Costs of Target Heavy Truck Pre-Crash Scenarios by Rank

III.2. Driving Environment

The driving environment of target pre-crash scenarios was described by four categories comprised of different variables in the GES Accident Data Set.

- Roadway alignment × roadway surface condition × atmospheric condition
- Relation to junction × traffic control device
- Lighting condition
- Posted speed limit

Table 8 provides the relative frequency of crashes occurring under main conditions of the driving environment for each of the target V2V pre-crash scenarios. The list of pre-crash scenarios in Table 8 excludes the control loss pre-crash scenarios for reasons provided earlier in this section of the report. Also excluded are the "parking/same direction," "backing into vehicle," and "other" pre-crash scenarios due to their very low contribution to the comprehensive costs and functional years lost (1%).

The following are key observations from Table 8:

- Most crashes occurred on a straight road and dry surface in clear weather. The opposite direction/no maneuver pre-crash scenario happened more on a curved road and dry surface under clear weather than any other target pre-crash scenario.
- Many rear-end pre-crash scenarios were reported at intersections controlled by 3-color signals, especially lead vehicle stopped and lead vehicle accelerating scenarios. A large

portion of the LTAP/OD at non-controlled junction pre-crash scenario happened at driveways or alleyways.

- Most crashes occurred in daylight. The rear-end/lead vehicle moving pre-crash scenario happened more in dark conditions than any other scenario. Moreover, a large portion of the drifting/same direction and turning right at signalized junction pre-crash scenarios occurred during non-daylight conditions.
- A large portion of crashes associated with changing lanes/same direction, drifting/same direction, rear-end/lead vehicle moving, and lead vehicle decelerating pre-crash scenarios occurred at speed limits greater than or equal to 55 mph. In contrast, a very large portion of crashes tied to running stop sign, opposite direction/maneuver, and turn at non-signalized junction pre-crash scenarios were reported at speed limits less than or equal to 35 mph.

Table 8. Statistical Description of Driving Environment in Target Heavy Vehicle V2V Pre-Crash Scenarios

Pre-Crash Scenario	Road Alignment x Surface Condition x Atmospheric Condition			Relation to Junction x Traffic Control Device						Lighting Condition			Posted Speed Limit (MPH)		
	Straight, Dry, Clear	Straight, Slippery, Adverse	Curved, Dry, Clear	Non-Junction, No Traffic Controls	Non-Junction, Other Sign Type	Intersection, No Traffic Controls	Intersection, RGY Traffic Signal	Intersection, Stop Sign	Driveway, Alley Access, etc., No Traffic Controls	Day Light	Dark	Dark but Lighted	< 35	35 to 55	> 55
Running Red Light	73 %	13 %	2 %	0 %	0 %	0 %	93 %	0 %	0 %	80 %	1 %	14 %	13 %	86 %	2 %
Running Stop Sign	75 %	11 %	8 %	0 %	0 %	0 %	0 %	98 %	0 %	87 %	5 %	7 %	38 %	54 %	8 %
Turning/Same Direction	80 %	8 %	5 %	1 %	0 %	23 %	37 %	7 %	16 %	86 %	3 %	8 %	28 %	68 %	4 %
Changing Lanes/Same Direction	78 %	8 %	7 %	66 %	4 %	3 %	7 %	0 %	0 %	80 %	7 %	10 %	11 %	53 %	36 %
Drifting/Same Direction	68 %	13 %	10 %	68 %	3 %	5 %	12 %	0 %	2 %	77 %	8 %	12 %	18 %	49 %	33 %
Opposite Direction/Maneuver	62 %	5 %	15 %	70 %	10 %	7 %	4 %	6 %	0 %	80 %	10 %	7 %	32 %	61 %	7 %
Opposite Direction/No Maneuver	38 %	6 %	39 %	80 %	6 %	3 %	1 %	0 %	1 %	80 %	12 %	3 %	14 %	81 %	5 %
Rear-End/Striking Maneuver	70 %	12 %	10 %	44 %	5 %	8 %	16 %	4 %	2 %	82 %	7 %	10 %	18 %	61 %	20 %
Rear-End/LVA	80 %	5 %	4 %	30 %	3 %	0 %	46 %	9 %	0 %	89 %	5 %	5 %	5 %	81 %	14 %
Rear-End/LVM	78 %	11 %	4 %	71 %	3 %	6 %	10 %	1 %	1 %	67 %	17 %	14 %	10 %	46 %	44 %
Rear-End/LVD	73 %	13 %	6 %	49 %	3 %	11 %	15 %	1 %	5 %	88 %	3 %	7 %	10 %	62 %	28 %
Rear-End/LVS	75 %	11 %	5 %	31 %	2 %	7 %	39 %	3 %	2 %	87 %	3 %	8 %	14 %	73 %	12 %
LTAP/OD at Signal	76 %	17 %	1 %	0 %	0 %	0 %	95 %	0 %	0 %	78 %	3 %	14 %	14 %	84 %	2 %
LTAP/OD at Non Signal	75 %	8 %	7 %	0 %	0 %	38 %	0 %	15 %	32 %	82 %	3 %	10 %	28 %	71 %	1 %
Turn Right at Signal	84 %	9 %	4 %	0 %	0 %	0 %	93 %	0 %	0 %	80 %	0 %	18 %	16 %	82 %	2 %
SCP at Non Signal	78 %	8 %	4 %	1 %	0 %	11 %	0 %	48 %	25 %	84 %	5 %	9 %	27 %	68 %	4 %
Turn at Non Signal	78 %	8 %	8 %	3 %	0 %	27 %	0 %	23 %	22 %	82 %	3 %	12 %	38 %	59 %	3 %

III.3. Heavy-Truck Driver Characteristics

Driver characteristics were obtained for drivers of interest who were cited with traffic control device violation, attempted a maneuver, or were in the following vehicles in rear-end pre-crash scenarios. Crash contributing factors and causes were also obtained from the heavy truck vehicle/driver of interest. Table 9 provides the codes to identify the heavy truck vehicle/driver of interest from the GES and LTCCS.

Table 9. Vehicle/Driver of Interest Identification Codes

Pre-Crash Scenario	Vehicle Criteria
Running red light	AND MVIOLATN = 7
Running stop sign	AND MVIOLATN = 7
Turning/same direction	AND (MANEUV_I = 10 - 12 OR ACC_TYPE = 70, 72)
Changing lanes/same direction	AND (MANEUV_I = 6, 15, 16 OR ACC_TYPE = 46, 47)
Drifting/same lane	AND P_CRASH2 = 10-14
Opposite direction/maneuver	
Opposite direction/no maneuver	AND (P_CRASH2 = 10-14 OR ACC_TYPE = 01, 06, 50, 64)
Rear-end/striking maneuver	AND VROLE_I = 1
Rear-end/LVA	AND VROLE_I = 1
Rear-end/LVM	AND (VROLE_I = 1 OR ACC_TYPE = 24)
Rear-end/LVD	AND (VROLE_I = 1 OR ACC_TYPE = 28)
Rear-End/LVS	AND (VROLE_I = 1 OR ACC_TYPE = 20)
LTAP/OD @ signal	AND (MANEUV_I = 11 OR P_CRASH2 = 15 OR ACC_TYPE = 68)
LTAP/OD @ signal	AND not (MANEUV_I = 11 OR P_CRASH2 = 15 OR ACC_TYPE = 68)
Turn right @ signal	AND (MANEUV_I = 10 OR P_CRASH2 = 16 OR ACC_TYPE = 78, 80)
Turn right @ signal	AND not (MANEUV_I = 10 OR P_CRASH2 = 16 OR ACC_TYPE = 78, 80)
LTAP/OD @ non signal	AND (MANEUV_I = 11 OR P_CRASH2 = 15 OR ACC_TYPE = 68)
LTAP/OD @ non signal	AND not (MANEUV_I = 11 OR P_CRASH2 = 15 OR ACC_TYPE = 68)
SCP @ non signal	
Turn @ non signal	AND (MANEUV_I = 10 - 12 OR P_CRASH2 = 15-16)
Turn @ non signal	AND not (MANEUV_I = 10 - 12 OR P_CRASH2 = 15-16)

Table 10 shows the results of applying this filter to crash data across the scenarios. Of all 255,000 drivers who were involved in target heavy truck pre-crash scenarios, about 146,000 heavy-truck drivers or 57 percent were drivers of interest. Heavy-truck drivers who initiated the turning maneuver in the turning/same direction pre-crash scenario comprised about 69 percent of all drivers involved. Moreover, heavy trucks were the striking vehicle in 65 and 62 percent of all vehicles involved respectively in rear-end/lead vehicle decelerating and rear-end/lead vehicle stopped pre-crash scenarios. It is noteworthy that heavy-truck drivers who ran the red light or stop sign accounted for 38 percent of all drivers involved in running red light/stop sign pre-crash scenarios.

Table 10. Heavy-Truck Drivers of Interest

Pre-Crash Scenario	All Drivers	Heavy-Truck Drivers	
		Number	% of All Drivers
Running red light	3,217	1,238	38%
Running stop sign	1,441	555	38%
Turning/same direction	34,752	23,984	69%
Changing lanes/same direction	52,965	28,610	54%
Drifting/same lane	12,964	7,240	56%
Opposite direction/maneuver	979	474	48%
Opposite direction/no maneuver	13,112	7,528	57%
Rear-end/striking maneuver	4,750	2,603	55%
Rear-end/LVA	1,211	526	43%
Rear-end/LVM	13,215	7,394	56%
Rear-end/LVD	17,091	11,076	65%
Rear-end/LVS	31,221	19,226	62%
LTAP/OD @ signal (left turning)	5,837	3,579	61%
LTAP/OD @ signal (non left turning)	4,750	1,546	33%
LTAP/OD @ non signal (left turning)	5,483	3,207	58%
Turn right @ signal (right turning)	3,162	1,748	55%
Turn right @ signal (non right turning)	2,057	1,126	55%
LTAP/OD @ non signal (non left turning)	4,911	1,944	40%
SCP @ non signal	35,790	18,536	52%
Turn @ non signal	6,224	3,757	60%
All	255,131	145,897	57%

Table 11 shows the relative frequency statistics of driver characteristics for age and gender in each of the target heavy truck V2V pre-crash scenarios based on average values of 2004-2008 GES data. From age statistics:

- Overall most heavy-truck drivers were middle-aged. The actual breakdown by age was 12 percent by younger drivers, 85 percent by middle-age drivers, and 3 percent by older drivers.
- Higher rates of involvement by younger drivers appeared in drifting/same direction, rear-end/lead vehicle accelerating, and rear-end/lead vehicle moving pre-crash scenarios as compared to other scenarios.
- Higher rates of involvement by older drivers showed up in opposite direction/maneuver, rear-end/striking maneuver, and LTAP/OD at non signal (non-left-turning) pre-crash scenarios as compared to other scenarios.

The following observations are gleaned from gender statistics:

- Overall, the breakdown of drivers of interest by gender was about 94 percent by male truck drivers and 6 percent by female drivers.
- A large portion of the crashes attributed to female drivers were in the opposite direction/maneuver pre-crash scenario. Moreover, higher rates of involvement by female drivers were observed in changing lanes and drifting in the same direction scenarios.

Table 11. Driver Characteristics in Target Heavy Truck V2V Pre-Crash Scenarios

Pre-Crash Scenario	Age (Years)			Gender	
	≤ 24	25 - 64	≥ 65	Male	Female
Running Red Light	9 %	91 %	0 %	99 %	1 %
Running Stop Sign	11 %	88 %	0 %	95 %	5 %
Turning/Same Direction	7 %	90 %	3 %	97 %	3 %
Changing Lanes/Same Direction	14 %	84 %	2 %	91 %	9 %
Drifting/Same Direction	25 %	72 %	2 %	92 %	8 %
Opposite Direction/Maneuver	12 %	76 %	12 %	74 %	26 %
Opposite Direction/No Maneuver	12 %	87 %	1 %	94 %	6 %
Rear-End/Striking Maneuver	15 %	77 %	8 %	97 %	3 %
Rear-End/LVA	20 %	80 %	0 %	100 %	0 %
Rear-End/LVM	16 %	80 %	3 %	93 %	7 %
Rear-End/LVD	11 %	85 %	4 %	97 %	3 %
Rear-End/LVS	13 %	85 %	2 %	94 %	6 %
LTAP/OD at Signal - Left Turning	12 %	87 %	1 %	97 %	3 %
LTAP/OD at Signal - Non Left Turning	10 %	89 %	1 %	98 %	2 %
LTAP/OD at Non Signal - Left Turning	10 %	85 %	5 %	97 %	3 %
LTAP/OD at Non Signal - Non Left Turning	10 %	83 %	7 %	100 %	0 %
Turn Right at Signal - Right Turning	6 %	92 %	1 %	94 %	6 %
Turn Right at Signal - Non Right Turning	9 %	90 %	1 %	100 %	0 %
SCP at Non Signal	7 %	87 %	5 %	95 %	5 %
Turn at Non Signal	7 %	88 %	5 %	95 %	5 %

III.4. Contributing and Causal Factors of Heavy Truck Crashes

Crash contributing and causal factors were obtained for drivers/vehicles of interest as defined in Table 9. Table 12 shows 2004-2008 GES statistics about these factors in each of the target V2V pre-crash scenarios including alcohol and drug involvement, physical impairment, violation, vision obscuration, inattention, and vehicle factors. The following observations are made from the average GES data for overall target V2V pre-crash scenarios:

- Alcohol was involved in just over 1 percent of all drivers of interest.
- Drugs were implicated in less than 1 percent of all drivers of interest.
- Violations were cited to about 31 percent of all drivers of interest.
- Speeding was attributed to ten percent of all vehicles of interest. About 84 percent of all speeding vehicles of interest were associated with rear-end pre-crash scenarios.
- Obscured vision was reported by 5 percent of all drivers of interest. Higher rates of obscured vision appeared in rear-end/lead vehicle accelerating, oppposite direction/maneuver or no maneuver pre-crash scenarios as compared to other scenarios.
- Inattention was noted by 27 percent of all drivers of interest. Higher inattention rates emerged in rear-end striking maneuver, rear-end/lead vehicle moving, and rear-end/lead vehicle stopped pre-crash scenarios as compared to other scenarios.
- Vehicle contributing factors accounted for only 2 percent of all vehicles of interest.

Table 12. Heavy Truck Crash Contributing and Causal Factors Based on 2004-2008 GES Statistics

Pre-Crash Scenario	Alcohol Involved	Drug Involved	Physical Impairment	Violation Cited	Speeding	Vision Obscured	Distracted	Vehicle Factors
Running Red Light	0.0 %	0.0 %	0.4 %	100.0 %	3.9 %	2.5 %	22.1 %	49.7 %
Running Stop Sign	0.0 %	0.0 %	0.0 %	100.0 %	1.2 %	1.4 %	32.2 %	49.2 %
Turning/Same Direction	0.5 %	0.0 %	0.0 %	21.0 %	0.5 %	3.3 %	17.5 %	0.5 %
Changing Lanes/Same Direction	2.1 %	0.0 %	0.1 %	37.9 %	2.0 %	6.0 %	36.3 %	1.1 %
Drifting/Same Direction	1.4 %	0.1 %	2.2 %	19.2 %	1.8 %	1.2 %	19.9 %	0.6 %
Opposite Direction/Maneuver	0.0 %	0.0 %	0.0 %	3.6 %	1.4 %	12.2 %	0.0 %	0.0 %
Opposite Direction/No Maneuver	1.8 %	0.0 %	1.9 %	19.9 %	5.8 %	9.7 %	13.9 %	2.2 %
Rear-End/Striking Maneuver	1.8 %	0.2 %	0.2 %	35.6 %	12.3 %	8.5 %	46.9 %	4.0 %
Rear-End/LVA	0.0 %	0.0 %	0.0 %	38.9 %	28.0 %	25.6 %	19.2 %	0.0 %
Rear-End/LVM	1.0 %	0.0 %	2.9 %	47.4 %	37.5 %	5.1 %	41.9 %	2.6 %
Rear-End/LVD	1.2 %	0.0 %	0.6 %	39.4 %	36.2 %	1.7 %	32.4 %	1.9 %
Rear-End/LVS	2.0 %	0.0 %	1.1 %	45.7 %	30.0 %	4.1 %	44.4 %	3.3 %
LTAP/OD at Signal - Left Turning	0.0 %	0.0 %	0.0 %	36.7 %	0.0 %	1.9 %	20.6 %	0.1 %
LTAP/OD at Signal - Non Left Turning	0.0 %	0.0 %	0.0 %	5.1 %	7.8 %	5.8 %	0.5 %	0.6 %
LTAP/OD at Non Signal - Left Turning	0.3 %	0.0 %	0.2 %	41.9 %	0.0 %	8.0 %	30.1 %	0.0 %
LTAP/OD at Non Signal - Non Left Turning	0.0 %	0.0 %	0.6 %	9.5 %	1.2 %	0.6 %	4.3 %	0.1 %
Turn Right at Signal - Right Turning	2.9 %	0.0 %	0.0 %	22.2 %	10.1 %	2.6 %	26.3 %	0.1 %
Turn Right at Signal - Non Right Turning	0.1 %	0.0 %	0.0 %	1.8 %	0.1 %	0.1 %	0.3 %	0.0 %
SCP at Non Signal	0.1 %	0.0 %	0.1 %	19.8 %	1.3 %	4.4 %	10.2 %	0.3 %
Turn at Non Signal	0.0 %	0.0 %	0.0 %	13.2 %	3.2 %	4.4 %	22.8 %	0.0 %

Tables 13 and 14 present results from the analysis of LTCCS data, which describe the statistics of the critical reason behind the pre-crash critical event and crash contributing and causal factors in each of the target V2V pre-crash scenarios. The critical reason refers to the immediate reason for the critical pre-crash event and is often the last failure in the causal chain. The contributing and causal factors covered in this analysis include conversing, fatigue, false assumptions, following too closely, inadequate evasive action, inadequate surveillance, inattention, misjudgement of the gap distance or velocity of the other vehicle, and traveling too fast. Due to the low number of LTCCS cases available for some target pre-crash scenarios, a smaller set of target V2V scenarios was analyzed as seen in Tables 13 and 14.

Notable observations from Table 13 about critical reason statistics for the driver/vehicle of interest are:

- Drivers' physical factors accounted for just 4 percent of drivers, most of which were attributed to the rear-end/lead vehicle stopped pre-crash scenario.
- Driver error was the most cited critical reason in every target pre-crash scenario, which was reported in over 90 percent of the cases in seven pre-crash scenarios.
- Vehicle issues were implicated in slightly less than 5 percent of of heavy trucks of interest across only four scenarios with the bulk of these incidents occuring in the rear-end/lead vehicle stopped scenario.
- Weather, road, or traffic control device issues were mentioned in 3 percent of crashes.

Table 13. Critical Reason Statistics Based on LTCCS Data

Heavy Truck Pre-Crash Scenarios	No Critical Reason	Driver Physical Factors	Driver Error	Vehicle Factors	Weather / Road/ TCD/
Running red light	13.0%	0.0%	76.3%	10.7%	0.0%
Running stop sign	0.0%	0.0%	95.4%	0.0%	4.6%
Turning/same direction	28.2%	0.0%	71.8%	0.0%	0.0%
Changing lanes/same direction	9.3%	0.0%	90.7%	0.0%	0.0%
Drifting/same lane	0.9%	0.5%	98.6%	0.0%	0.0%
Opposite direction/maneuver	0.0%	0.0%	100.0%	0.0%	0.0%
Opposite direction/no maneuver	0.0%	1.5%	79.5%	9.5%	9.5%
Rear-end/LVA	9.6%	0.0%	90.4%	0.0%	0.0%
Rear-end/LVM	6.1%	8.8%	85.1%	0.0%	0.0%
Rear-end/LVD	7.6%	1.0%	70.4%	4.4%	16.7%
Rear-end/LVS	0.0%	13.7%	63.8%	21.5%	1.0%
LTAP/OD @ signal - Turning	31.7%	0.0%	68.3%	0.0%	0.0%
LTAP/OD @ signal - Non Turning	100.0%	0.0%	0.0%	0.0%	0.0%
Turn right @ signal - Turning	0.0%	0.0%	100.0%	0.0%	0.0%
LTAP/OD @ non signal - Turning	36.0%	0.0%	64.0%	0.0%	0.0%
LTAP/OD @ non signal - Non Turning	100.0%	0.0%	0.0%	0.0%	0.0%
SCP @ non signal	72.3%	0.0%	27.7%	0.0%	0.0%
Turn @ non signal	0.0%	0.0%	100.0%	0.0%	0.0%

TCD: Traffic Control Device

Table 14 lists statistics about crash causal factors based on LTCCS data. Key results are:

- Fatigue was a factor in 11 percent of all drivers of interest. Higher fatigue rates were noted in opposite direction (63%), running stop sign (47%), and rear-end/lead vehicle moving (13%) pre-crash scenarios as compared to other scenarios.
- Inattention was cited in 15 percent of all drivers of interest. Higher inattention rates were observed in LTAP/OD at signalized junctions - turning vehicle (85%), LTAP/OD at non-signalized junctions - turning vehicle (42%), and turning in the same direction (38%) pre-crash scenarios as compared to other scenarios.
- Inadequate surveillance was implicated in 35 percent of all drivers of interest. Rates over 90 percent were in drifting in the same direction, turning right at signalized junctions - turning vehicle, and turning at non-signalized junctions pre-crash scenarios.
- Following too closely was relevant in rear-end pre-crash scenarios. It was reported at 33 percent of all drivers of interest. Rear-end/lead vehicle accelerating, lead vehicle moving, and lead vehicle decelerating scenarios dominated, each with over 65 percent.
- False assumption of other road user's action was mentioned by 15 percent of all drivers of interest. The rate of this driver decision error amounted to 45 percent of changing lanes in the same direction, 34 percent of LTAP/OD at non-signalized junctions - turning, and 26 percent of SCP at non-signalized junctions scenarios.
- Traveling too fast was recorded for 27 percent of all vehicles of interest. Opposite direction/maneuver, rear-end/lead vehicle stopped, and rear-end/lead vehicle moving pre-crash sceanarios exhibited the greatest frequency of traveling too fast at 87, 51, and 41 percent, respectively.

Table 14. Crash Contributing and Causal Factors Based on LTCCS Data

Heavy Truck Pre-Crash Scenarios	Conversing	Driver fatigued	False Assumption	Following Too Closely	Inadequate Evasive Action	Inadequate Surveillance	Inattention	Misjudgement of Gap or Velocity	Traveling Too Fast
Running red light	17.1 %	12.1 %	6.0 %	0.0 %	2.8 %	40.6 %	30.6 %	0.0 %	10.6 %
Running stop sign	0.6 %	47.2 %	0.0 %	0.0 %	0.0 %	55.1 %	0.0 %	0.0 %	0.0 %
Turning/same direction	21.8 %	0.0 %	2.0 %	0.0 %	0.0 %	24.8 %	37.5 %	2.0 %	0.0 %
Changing lanes/same direction	7.6 %	8.2 %	45.4 %	24.7 %	8.1 %	38.5 %	0.0 %	22.9 %	5.4 %
Drifting/same lane	3.6 %	0.0 %	0.9 %	58.8 %	2.9 %	95.1 %	17.7 %	0.0 %	27.1 %
Opposite direction/maneuver	0.0 %	0.0 %	0.0 %	0.0 %	58.5 %	5.2 %	0.0 %	0.0 %	87.4 %
Opposite direction/no maneuver	13.2 %	62.8 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	27.0 %
Rear-end/LVA	0.0 %	15.6 %	15.5 %	66.6 %	15.6 %	59.3 %	31.1 %	0.0 %	0.0 %
Rear-end/LVM	0.0 %	19.2 %	12.5 %	76.0 %	20.9 %	36.2 %	13.3 %	23.6 %	40.9 %
Rear-end/LVD	0.0 %	15.2 %	15.7 %	87.0 %	4.0 %	36.7 %	27.5 %	12.1 %	38.4 %
Rear-end/LVS	0.7 %	5.0 %	16.6 %	28.4 %	22.5 %	18.2 %	14.7 %	22.2 %	51.3 %
LTAP/OD @ signal - Turning	0.0 %	0.0 %	14.6 %	0.0 %	0.0 %	71.5 %	85.8 %	18.6 %	0.0 %
LTAP/OD @ signal - Non Turning	0.0 %	0.0 %	5.0 %	0.0 %	1.8 %	0.0 %	0.0 %	0.0 %	3.0 %
Turn right @ signal - Turning	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	100.0 %	0.0 %	0.0 %	0.0 %
LTAP/OD @ non signal - Turning	0.0 %	6.4 %	33.9 %	0.0 %	0.0 %	6.4 %	42.3 %	57.7 %	0.0 %
LTAP/OD @ non signal - Non Turning	0.0 %	0.0 %	0.0 %	0.0 %	16.1 %	0.0 %	0.0 %	0.0 %	0.0 %
SCP @ non signal	0.0 %	0.8 %	25.6 %	0.0 %	15.2 %	19.5 %	3.3 %	5.2 %	17.7 %
Turn @ non signal	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	100.0 %	0.0 %	0.0 %	0.0 %

III.5. Corrective Action Attempted by Heavy-Truck Driver

The statistics of corrective action attempted were obtained from heavy-truck drivers/vehicles of interest as defined in Table 9. Table 15 presents the 2004-2008 GES statistics about corrective action in each of the target V2V pre-crash scenarios including braking, steering, and combinations of both actions. The following observations are made from the average GES data for overall target V2V pre-crash scenarios:

- No avoidance maneuver was recorded for 51 percent of all drivers of interest. This was most prevalent in turning in the same direction, LTAP/OD (left turning vehicle), and turning right at signal (turning vehicle) pre-crash scenarios. Applying brakes was reported for just 9 percent of all drivers of interest. Higher rates of braking were reported for running red light, rear-end/lead vehicle moving, and LTAP/OD (non left turning vehicle) scenarios when compared against all pre-crash scenarios.
- Braking with lockup was experienced by 9 percent of all drivers of interest.
- As can be expected, 97 percent of drivers of interest involved in opposite drection/maneuver crashes were reported steering to avoid a crash. Across all scenarios, steering was reported by 26 percent of drivers of interest especially in oppposite direction/no maneuver, rear-end/LVA, and running stop sign.
- Combined braking and steering was coded for just 5 percent of all drivers of interest.
- Just 1 percent of drivers reported an attempted avoidance manuever other than braking or steering.

Table 15. Heavy Truck Corrective Action Attempted Based on 2004-2008 GES Statistics

Pre-Crash Scenario	No Avoidance Maneuver	Braking (No Lockup)	Braking (Lockup)	Steering*	Braking and Steering	Other Action**
Running red light	27.6 %	29.9 %	16.9 %	22.5 %	2.5 %	0.6 %
Running stop sign	29.7 %	2.4 %	17.6 %	49.4 %	0.0 %	0.8 %
Turning/same direction	97.0 %	0.5 %	0.8 %	1.7 %	0.0 %	0.0 %
Changing lanes/same direction	77.8 %	0.4 %	3.8 %	14.9 %	3.0 %	0.0 %
Drifting/same direction	81.4 %	0.2 %	2.6 %	15.8 %	0.0 %	0.0 %
Opposite direction/maneuver	0.0 %	0.0 %	2.8 %	96.8 %	0.0 %	0.5 %
Opposite direction/no maneuver	16.8 %	3.3 %	10.1 %	63.6 %	6.1 %	0.2 %
Rear-end/striking maneuver	67.2 %	2.2 %	10.7 %	7.9 %	12.0 %	0.0 %
Rear-end/LVA	21.0 %	2.2 %	7.4 %	58.2 %	11.1 %	0.0 %
Rear-end/LVM	22.3 %	35.2 %	20.4 %	10.2 %	8.3 %	3.7 %
Rear-end/LVD	26.2 %	28.1 %	16.5 %	16.4 %	11.3 %	1.5 %
Rear-end/LVS	38.8 %	19.1 %	23.1 %	11.9 %	5.3 %	1.8 %
LTAP/OD @ signal (left turning)	80.2 %	10.7 %	3.8 %	0.7 %	0.0 %	4.7 %
LTAP/OD @ signal (non left turning)	17.8 %	30.4 %	15.5 %	17.5 %	3.6 %	15.3 %
Turn right @ signal (right turning)	82.9 %	0.0 %	0.0 %	15.6 %	0.0 %	1.5 %
Turn right @ signal (non right turning)	55.9 %	0.6 %	20.1 %	23.3 %	0.0 %	0.0 %
LTAP/OD @ non signal (left turning)	90.7 %	0.2 %	4.3 %	4.6 %	0.0 %	0.2 %
LTAP/OD @ non signal (non left turning)	10.5 %	0.1 %	64.2 %	16.2 %	5.5 %	3.5 %
SCP @ non signal	46.5 %	7.2 %	13.6 %	21.3 %	10.8 %	0.7 %
Turn @ non signal	65.2 %	0.0 %	0.3 %	23.6 %	6.1 %	4.8 %

*includes categories: "accelerating and steering left" and "accelerating and steering right"

**includes categories: "releasing brakes" and "accelerating"

III.6. Heavy Truck Pre-Crash Scenario Groups

Target heavy truck V2V pre-crash scenarios are arranged into six groups as shown in Table 16. This arrangement is devised based mostly on vehicle movements and orientations prior to the occurrence of the crash critical event. Six safety applications may be developed to implement these pre-crash scenario groups as individual or integrated crash countermeasure systems based on V2V communications. The rear-end pre-crash scenarios involve at least two vehicles following each other in the same direction, same lane. The lane change pre-crash scenarios comprise of two vehicles traveling in the same direction, in adjacent lanes, and at close proximity. The opposite direction pre-crash scenarios involve two vehicles approaching each other from opposite directions, either in the same lane or adjacent lanes prior to the critical event. This group typically occurs away from junctions. The LTAP/OD pre-crash scenarios consist of two vehicles approaching each other from opposite directions, initially in adjacent lanes, with one vehicle initiating a left turn maneuver across the path of the other. This group of scenarios happens at junctions. The junction crossing group incorporates all crossing path pre-crash scenarios in which the two vehicles approach each other from perpendicular directions at mostly non-signalized junctions. The last group, TCD violation, is different from the other five groups since it accounts for a driver error at signed or signalized junctions rather than vehicle movements. While this last group is made up of multiple vehicle crashes, it may be better addressed by V2I countermeasures.

Table 16 lists the six pre-crash scenario groups and provides their societal cost in terms of comprehensive economic cost and functional years lost. Values for individual scenarios are drawn from Table 7. Figure 5 illustrates the ranking of these target V2V pre-crash scenario groups based on comprehensive cost. Their total amounted to 86 percent of the overall comprehensive economic cost provided in Table 7. The remaining cost of 14 percent was due mostly to control loss pre-crash scenarios. As seen in Figure 5, rear-end pre-crash scenarios were the most dominant among the six groups and accounted for about 24 percent of the cost of crashes involving heavy trucks. Based on statistics of drivers of interest presented in Table 10, heavy-truck drivers who struck lead vehicles accounted for 60 percent of all drivers involved in rear-end pre-crash scenarios involving heavy trucks. Heavy trucks in the six target pre-crash scenario groups were responsible for less than half, 48 percent, of all heavy truck-involved crashes reported in the 2004-2008 GES crash databases.

Table 16. Groups and Societal Cost of Target V2V Pre-Crash Scenarios Involving Heavy Trucks

Pre-Crash Scenario		Comprehensive Cost		Functional Years Lost		Rank
		Total	Percentage	Total	Percentage	
Rear-End	Rear-end/LVS	$ 2,405,000,000	9.7 %	$ 17,000	9.6 %	4
	Rear-end/LVD	$ 924,000,000	3.7 %	$ 7,000	3.7 %	7
	Rear-end/LVM	$ 2,068,000,000	8.4 %	$ 15,000	8.4 %	5
	Rear-end/striking maneuver	$ 244,000,000	1.0 %	$ 2,000	1.0 %	16
	Rear-end/LVA	$ 169,000,000	0.7 %	$ 1,000	0.7 %	18
	Total	**$ 5,810,000,000**	**23.5 %**	**$ 42,000**	**23.4 %**	
Lane Change	Changing lanes/same direction	$ 1,907,000,000	7.7 %	$ 14,000	7.8 %	6
	Turning/same direction	$ 698,000,000	2.8 %	$ 5,000	2.8 %	11
	Drifting/same direction	$ 638,000,000	2.6 %	$ 5,000	2.6 %	12
	Total	**$ 3,243,000,000**	**13.1 %**	**$ 24,000**	**13.2 %**	
Opposite Direction	Opposite direction/no maneuver	$ 4,964,000,000	20.1 %	$ 35,000	19.9 %	1
	Opposite direction/maneuver	$ 490,000,000	2.0 %	$ 4,000	2.0 %	14
	Total	**$ 5,454,000,000**	**22.0 %**	**$ 39,000**	**21.9 %**	
LTAP/OD	LTAP/OD @ non signal	$ 795,000,000	3.2 %	$ 6,000	3.2 %	10
	LTAP/OD @ signal	$ 778,000,000	3.1 %	$ 6,000	3.2 %	9
	Total	**$ 1,573,000,000**	**6.4 %**	**$ 12,000**	**6.4 %**	
Junction Crossing	SCP @ non signal	$ 3,838,000,000	15.5 %	$ 27,000	15.4 %	2
	Turn @ non signal	$ 77,000,000	0.3 %	$ 1,000	0.3 %	21
	Turn right @ signal	$ 377,000,000	1.5 %	$ 3,000	1.5 %	15
	Total	**$ 4,292,000,000**	**17.3 %**	**$ 31,000**	**17.2 %**	
TCD Violation	Running red light	$ 821,000,000	3.3 %	$ 6,000	3.4 %	8
	Running stop sign	$ 118,000,000	0.5 %	$ 1,000	0.5 %	19
	Total	**$ 939,000,000**	**3.8 %**	**$ 7,000**	**3.9 %**	

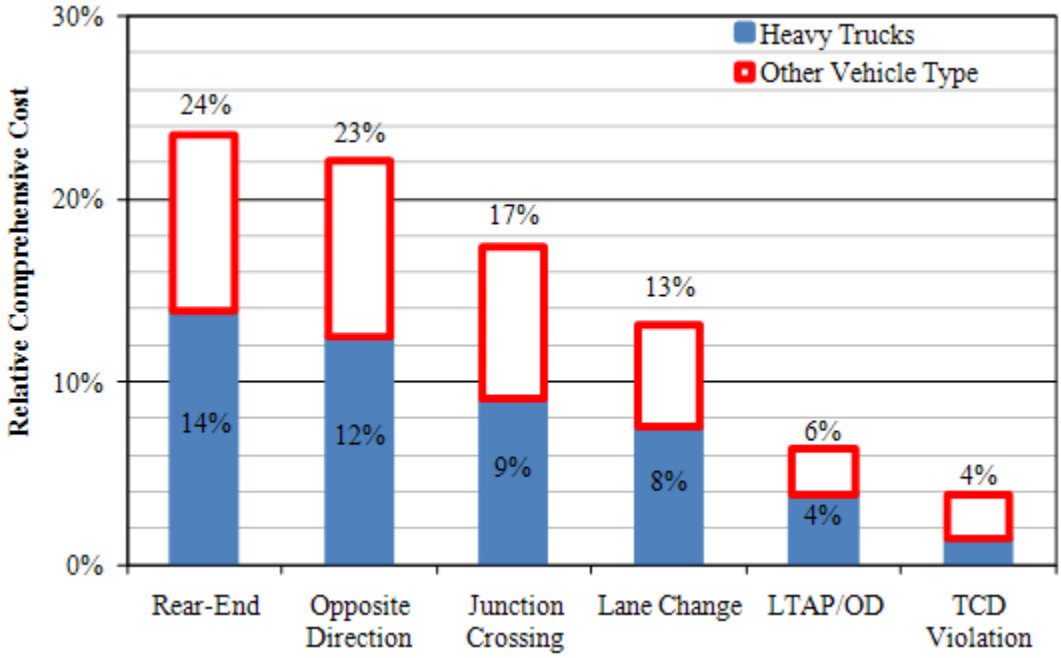


Figure 5. Relative Comprehensive Cost of Target V2V Pre-Crash Scenario Groups

IV. Comparison Between Heavy Truck and Light Vehicle Pre-Crash Scenario Statistics

Target V2V pre-crash scenarios are compared between the heavy truck analysis in this study and the similar light vehicle analysis previously completed in [15]. Table 17 presents the top five pre-crash scenarios for light vehicles (i.e., passenger cars, vans and minivans, sports utility vehicles, and light pickup trucks of GVWR less than or equal to 10,000 pounds) and heavy trucks in descending order in terms of their average annual comprehensive costs. The scenarios common to both vehicle groups are the opposite direction/no maneuver, straight crossing paths at non-signalized junctions, rear-end/lead vehicle stopped, and control loss/no vehicle action.

Table 17. Comparison of Top Five Heavy Truck and Light Vehicle Pre-Crash Scenarios

Light Vehicle		Heavy Truck	
Control loss/no vehicle action	$ 64.74 B	Opposite direction/no maneuver	$ 4.96 B
SCP @ non signal	$ 41.10 B	SCP @ non signal	$ 3.84 B
Rear-end/LVS	$ 29.72 B	Control loss/no vehicle action	$ 2.52 B
Opposite direction/no maneuver	$ 29.56 B	Rear-end/LVS	$ 2.41 B
Running red light	$ 18.27 B	Rear-end/LVM	$ 2.07 B

Table 18 compares the relative societal cost of the six V2V scenario groups between the two vehicle platforms based on 2004-2008 GES statistics. The rear-end, junction crossing, and opposite direction crash scenario groups make up the top three target scenario groups for both light vehicles and heavy trucks.

Table 18. Comparison of Target Scenario Groups for Light Vehicles and Heavy Trucks

Light Vehicle Groups		Heavy Truck Groups	
Rear-End	20.1%	Rear-End	23.5%
Junction Crossing	15.6%	Opposite Direction	22.0%
Opposite Direction	12.0%	Junction Crossing	17.3%
LTAP/OD	11.0%	Lane Change	13.1%
TCD Violation	7.8%	LTAP/OD	6.4%
Lane Change	6.6%	TCD Violation	3.8%

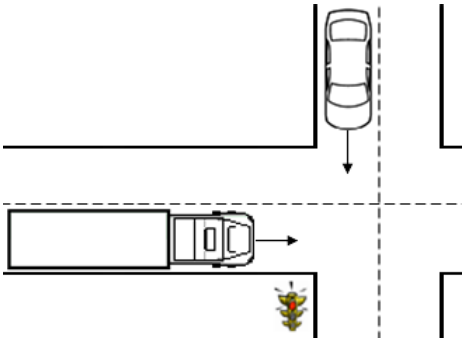
V. Detailed Description of Heavy Truck Pre-Crash Scenarios

This section provides a detailed description of each of the 17 target V2V pre-crash scenarios involving heavy trucks based on data from the 2004-2008 GES and 2001-2003 LTCCS crash databases. Driver/vehicle statistics are provided for the heavy truck/vehicle of interest.

The following descriptions are obtained from 2004-2008 GES statistics:

V.1. Running Red Light

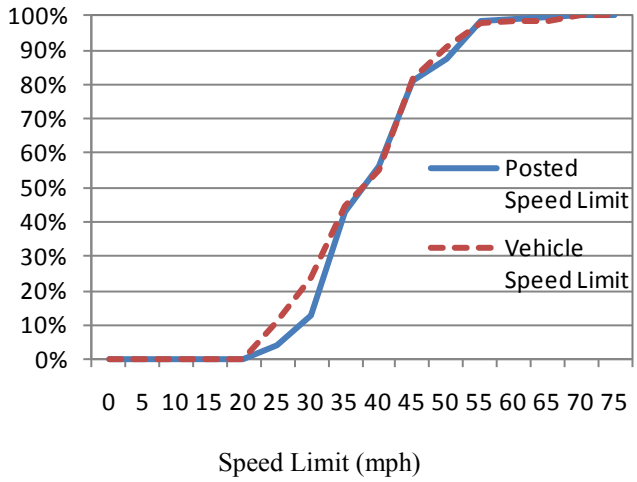
Typical Scenario: Vehicle is going straight, and then runs a red light while straight crossing an intersection and collides with another straight crossing vehicle from a lateral direction.



Societal Cost

Total No. of Crashes	9,404
Total No. of Vehicles Involved	19,813
No. of Vehicles with Injuries	4,525
No. of People Injured	6,609
VSL	$ 820,853,971
FYL	6,058
MAIS 2+ Injuries	909
MAIS 3+ Injuries	338

Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	73.0% - Straight, dry road surface with no adverse weather 13.5% - Straight, slippery road surface with adverse weather 9.0% - Straight, slippery road surface with no adverse weather
Relation to Junction × Traffic Control Device	92.8% - Intersection or intersection-related at 3-color traffic signal
Lighting Condition	80.5% - Daylight 13.6% - Dark but lighted

Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed). *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	8.9% - ≤ 24 years 90.8% - 25 to 64 years < 1.0% - 65 years or older
Gender	99.3% - Male < 1.0% - Female
Driver Contributing Factors	
Alcohol	0.0% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	< 1.0% - Sleepy
Violation Cited	100.0% - Violation cited
Speeding	3.9% - Speeding
Vision Obscured	21.1% - Obscured
Distraction	15.2% - Distracted < 1.0% - Sleepy 31.2% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	6.5% - Contributing factors
Corrective Action Attempted	
Corrective Action	26.1% - Braking (No lockup) 14.8% - Braking (Lockup) 5.9% - Braking (Lockup Unknown) 19.7% - Steering Left 2.8% - Steering Right 2.2% - Braking and Steering Left

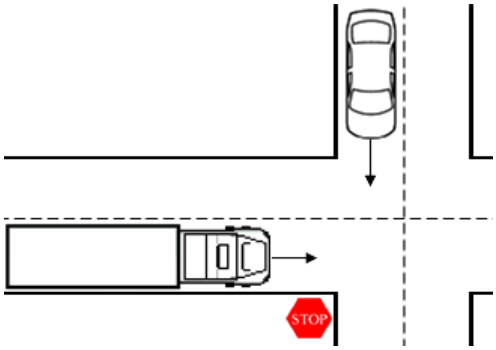
Critical Event	
Conversation	17.1% - Talking on phone
Driver Fatigue	12.1% - Driver fatigued
False Assumptions	6.0% - Assumed that other driver would yield right-of-way
Following Too Closely	0.0% - Following too closely
Inadequate Evasive Action	2.8% - Combination of insufficient steering and braking inputs
Inadequate Surveillance	6.7% - Failed to look far enough ahead 25.4% - Failed to look to side 8.5% - Looked, but did not see
Inattention	30.6% - Unspecified reason
Misjudgment ofGap or Velocity	0.0% - Misjudgment factors
Traveling Too Fast for Conditions	10.6% - Unspecified reason

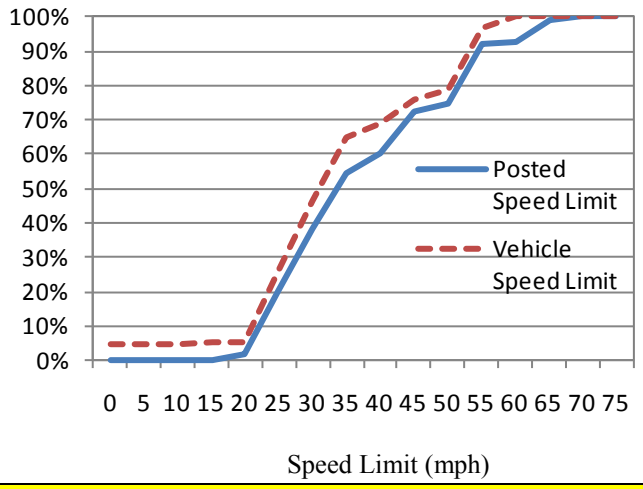
V.2. Running Stop Sign

Typical Scenario: Vehicle is going straight; and then runs a stop sign at an intersection.

Societal Cost

Total No. of Crashes	1,441
Total No. of Vehicles Involved	2,924
No. of Vehicles with Injuries	816
No. of People Injured	1,259
VSL	$ 117,600,253
FYL	865
MAIS 2+ Injuries	169
MAIS 3+ Injuries	56

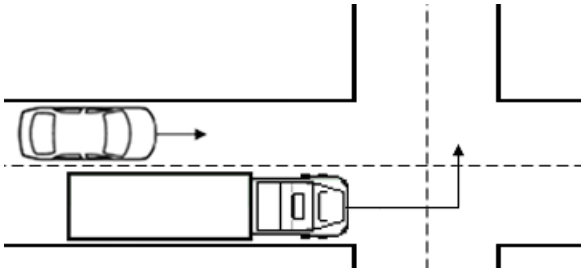


Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	75.3% - Straight, dry road surface with no adverse weather 10.9% - Straight, slippery road surface with adverse weather 8.2% - Curve, dry road surface with no adverse weather
Relation to Junction × Traffic Control Device	98.1% - Intersection or intersection-related at stop sign
Lighting Condition	86.6% - Daylight 7.0% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	11.2% - ≤ 24 years 88.3% - 25 to 64 years < 1.0% - 65 years or older
Gender	95.1% - Male 4.9% - Female

Driver Contributing Factors	
Alcohol	0.0% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	0.0% - Impaired
Violation Cited	100.0% - Violation cited
Speeding	1.2% - Speeding
Vision Obscured	26.6% - Obscured
Distraction	27.2% - Distracted
Vehicle Contributing Factors	
Contributing Factors	< 1.0% - Contributing factors
Corrective Action Attempted	
Corrective Action	2.4% - Braking (No lockup) 17.6% - Braking (Lockup) 49.4% - Steering Left
Critical Event	
Conversation	< 1.0% - Conversing with passenger
Driver Fatigue	47.2% - Driver fatigued
False Assumptions	0.0% - False assumption factors
Following Too Closely	0.0% - Following too closely
Inadequate Evasive Action	0.0% - Inadequate evasive action factors
Inadequate Surveillance	14.3% - Failed to look to either side ahead 10.0% - Failed to look to side 25.2% - Looked, but did not see
Inattention	0.0% - Inattention factors
Misjudgment ofGap or Velocity	0.0% - Misjudgment factors
Traveling Too Fast for Conditions	0.0% - Traveling too fast

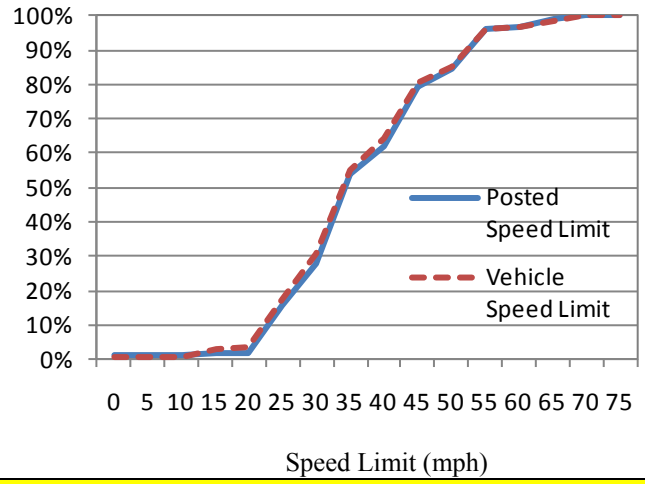
V.3. Turning/Same Direction

Typical Scenario: Vehicle is turning left at an intersection, and then cuts across the path of another vehicle initially traveling in the same direction.



Societal Cost

Total No. of Crashes	27,922
Total No. of Vehicles Involved	56,098
No. of Vehicles with Injuries	4,131
No. of People Injured	6,503
VSL	$ 697,670,814
FYL	5,027
MAIS 2+ Injuries	746
MAIS 3+ Injuries	266

Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	80.4% - Straight, dry road surface with no adverse weather 8.4% - Straight, slippery road surface with adverse weather
Relation to Junction × Traffic Control Device	37.3% - Intersection or intersection-related at RGY traffic signal 22.6% - Intersection or intersection-related without traffic controls 15.6% - Driveway, alley, etc. without traffic controls
Lighting Condition	86.4% - Daylight 8.1% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	7.5% - ≤ 24 years 89.7% - 25 to 64 years 2.8% - 65 years or older
Gender	96.6% - Male 3.4% - Female

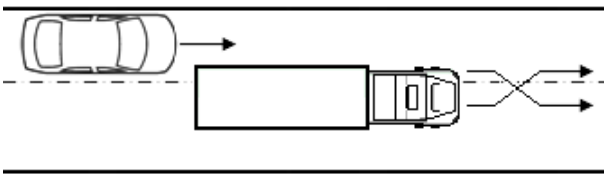
Driver Contributing Factors	
Alcohol	< 1.0% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	3.5% - Unspecified impairment
Violation Cited	21.0% - Violation cited
Speeding	< 1.0% - Speeding
Vision Obscured	27.1 % - Obscured
Distraction	13.0% - Distracted < 1.0% - Sleepy 25.9% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	< 1.0% - Contributing factors
Corrective Action Attempted	
Corrective Action	1.6% - Steering Right
Critical Event	
Conversation	21.8% - Talking on CB radio
Driver Fatigue	0.0% - Driver fatigued
False Assumptions	2.0% - Assumed that other driver would yield right-of-way
Following Too Closely	0.0% - Following too closely
Inadequate Evasive Action	0.0% - Inadequate evasive action factors
Inadequate Surveillance	21.8% - Failed to look to rear (mirrors) 3.1% - Looked, but did not see
Inattention	37.5% - Unspecified reason
Misjudgment Gap or Velocity	2.1% - Misjudgment of gap distance
Traveling Too Fast for Conditions	0.0% - Traveling too fast

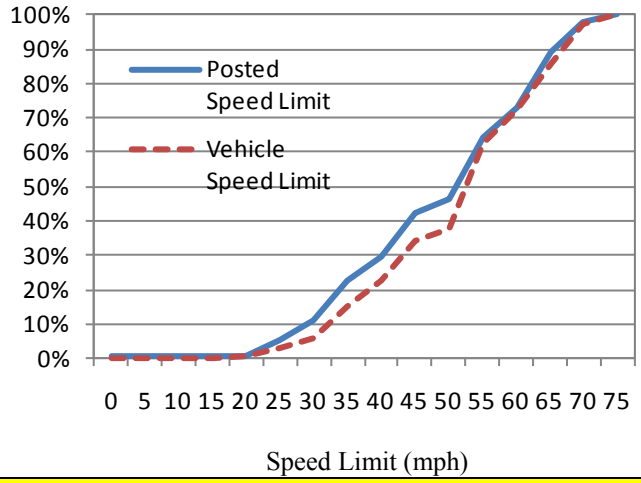
V.4. Changing Lanes/Same Direction

Typical Scenario: Vehicle is changing lanes, and then encroaches into another vehicle traveling in the same direction.

Societal Cost

Total No. of Crashes	50,690
Total No. of Vehicles Involved	104,453
No. of Vehicles with Injuries	8,652
No. of People Injured	12,909
VSL	$1,907,046,063
FYL	13,878
MAIS 2+ Injuries	1,734
MAIS 3+ Injuries	682



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	78.4% - Straight, dry road surface with no adverse weather 8.4% - Straight, slippery road surface with adverse weather
Relation to Junction × Traffic Control Device	66.0% - Non-junction without traffic controls 9.1%- Entrance/exit ramp without traffic controls
Lighting Condition	79.9% - Daylight 10.3% - Dark but lighted 6.9% - Dark
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	13.8% - ≤ 24 years 84.2% - 25 to 64 years 2.1% - 65 years or older
Gender	90.9% - Male 9.1% - Female

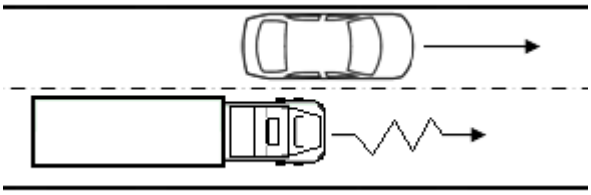
Driver Contributing Factors	
Alcohol	2.1% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	< 1.0% - Sleepy 9.3% - Unspecified impairment
Violation Cited	37.9% - Violation cited
Speeding	2.0% - Speeding
Vision Obscured	38.6% - Obscured
Distraction	24.6% - Distracted < 1.0% - Sleepy 32.2% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	1.1% - Contributing factors
Corrective Action Attempted	
Corrective Action	3.0% - Braking (Lockup) 4.4% - Steering Left 10.4% - Steering Right 1.5% - Braking and Steering Left 1.5% - Braking and Steering Right
Critical Event	
Conversation	7.6% - Talking on CB radio
Driver Fatigue	8.2% - Driver fatigued
False Assumptions	24.4% - Assumed that other driver would yield right-of-way 20.9% - Unspecified false assumption
Following Too Closely	24.7% - Rush hour, heavy traffic
Inadequate Evasive Action	2.6% - Insufficient steering inputs 5.5% - Unspecified inadequate evasive action
Inadequate Surveillance	8.2% - Failed to look to side 22.4% - Failed to look to rear (mirrors) 7.9% - Looked, but did not see
Inattention	0.0% - Inattention factors
Misjudgment Gap or Velocity	21.4% - Misjudgment of gap distance 2.0% - Misjudgment of velocity of other vehicle
Traveling Too Fast for Conditions	2.7% - Keeping up with traffic 2.7% - Unspecified reason

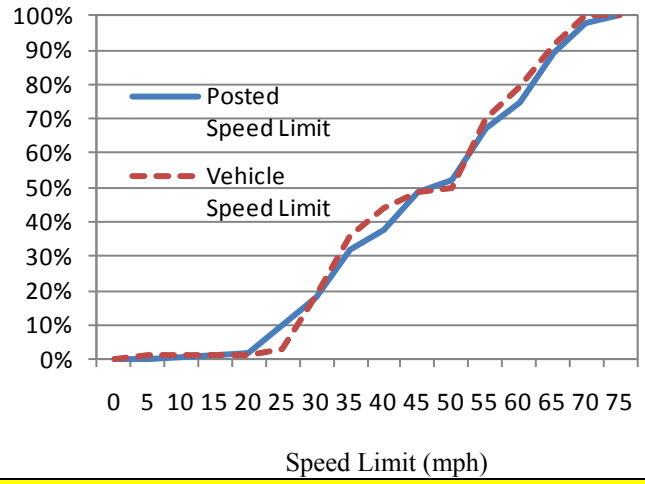
V.5. Drifting/Same Direction

Typical Scenario: Vehicle is going straight, and then drifts into an adjacent vehicle traveling in the same direction.

Societal Cost

Total No. of Crashes	19,703
Total No. of Vehicles Involved	40,501
No. of Vehicles with Injuries	3,181
No. of People Injured	4,560
VSL	$ 638,398,520
FYL	4,595
MAIS 2+ Injuries	586
MAIS 3+ Injuries	222



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	68.2% - Straight, dry road surface with no adverse weather 12.9% - Straight, slippery road surface with adverse weather 9.6% - Curve, dry road surface with no adverse weather
Relation to Junction × Traffic Control Device	68.4% - Non-junction without traffic controls 12.3% - Intersection or intersection-related at 3-color traffic signal
Lighting Condition	76.7% - Daylight 12.5% - Dark but lighted 7.8% - Dark
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	25.5% - ≤ 24 years 72.1% - 25 to 64 years 2.5% - 65 years or older
Gender	92.1% - Male 7.9% - Female

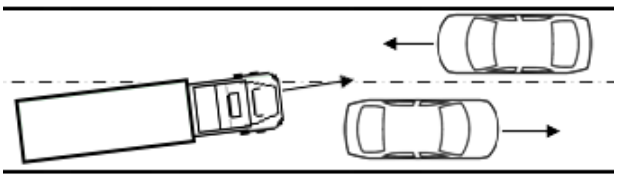
Driver Contributing Factors	
Alcohol	1.4% - Alcohol use
Drugs	< 1.0% - Drug use
Physical Impairment	1.0% - Ill, Blackout < 1.0% - Sleepy 14.1% - Unspecified impairment
Violation Cited	19.2% - Violation cited
Speeding	1.8% - Speeding
Vision Obscured	40.9% - Obscured
Distraction	12.7% - Distracted < 1.0% - Sleepy 35.8% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	< 1.0% - Contributing factors
Corrective Action Attempted	
Corrective Action	1.5% - Braking (Lockup) 1.2% - Braking (Lockup Unknown) 15.0% - Steering right
Critical Event	
Conversation	3.6% - Talking on CB radio
Driver Fatigue	0.0% - Driver fatigued
False Assumptions	< 1.0% - Unspecified false assumption
Following Too Closely	58.8% - Rush hour, heavy traffic
Inadequate Evasive Action	2.9% - Unspecified inadequate evasive action
Inadequate Surveillance	20.5% - Failed to look far enough ahead 30.2% - Failed to look to side 5.2% - Failed to look to rear (mirrors) 39.1% - Looked, but did not see
Inattention	13.5% - Preceding argument 4.2% - Unspecified reason
Misjudgment of Gap or Velocity	0.0% - Misjudgment factors
Traveling Too Fast for Conditions	21.4% - Did not realize caution required 5.6% - Unspecified reason

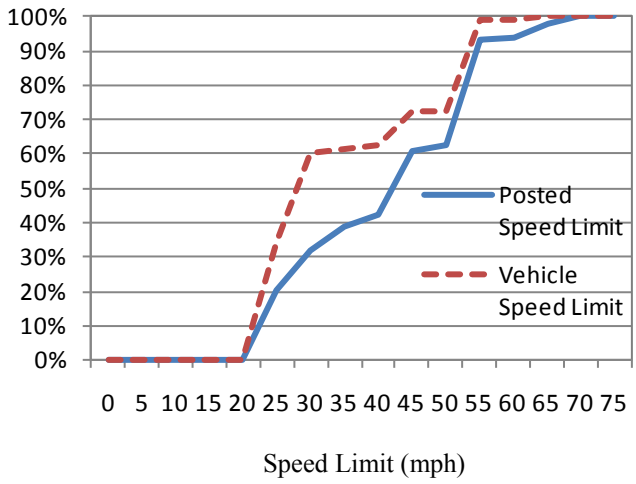
V.6. Opposite Direction/Maneuver

Typical Scenario: Vehicle is passing another vehicle, and encroaches into another vehicle traveling in the opposite direction.

Societal Cost

Total No. of Crashes	978
Total No. of Vehicles Involved	1,900
No. of Vehicles with Injuries	495
No. of People Injured	708
VSL	$ 490,481,792
FYL	3,522
MAIS 2+ Injuries	182
MAIS 3+ Injuries	115



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	62.4% - Straight, dry road surface with no adverse weather 15.3% - Curve, dry road surface with no adverse weather 9.5% - Straight, slippery road surface with no adverse weather
Relation to Junction × Traffic Control Device	70.3% - Non-junction without traffic controls 10.2% - Non-junction with sign other than stop sign
Lighting Condition	79.8% - Daylight 10.1% - Dark 6.6% - Dark but Lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	12.4% - ≤ 24 years 75.6% - 25 to 64 years 12.0% - 65 years or older
Gender	73.6% - Male 26.4% - Female

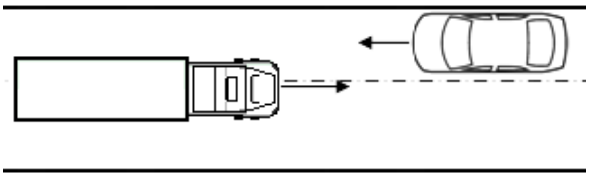
Driver Contributing Factors	
Alcohol	0.0% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	1.5% - Unspecified impairment
Violation Cited	3.6% - Violation cited
Speeding	1.4% - Speeding
Vision Obscured	49.4% - Obscured
Distraction	21.0% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	0.0% - Contributing factors
Corrective Action Attempted	
Corrective Action	2.8% - Braking (Lockup) 40.9% - Steering left 55.9% - Steering right
Critical Event	
Conversation	0.0% - Conversing
Driver Fatigue	0.0% - Driver fatigued
False Assumptions	0.0% - False assumption factors
Following Too Closely	0.0% - Following too closely
Inadequate Evasive Action	58.5% - Unspecified inadequate evasive action
Inadequate Surveillance	5.2% - Failed to look far enough ahead
Inattention	0.0% - Inattention factors
Misjudgment of Gap or Velocity	0.0% - Misjudgment factors
Traveling Too Fast for Conditions	87.4% - Unspecified reason

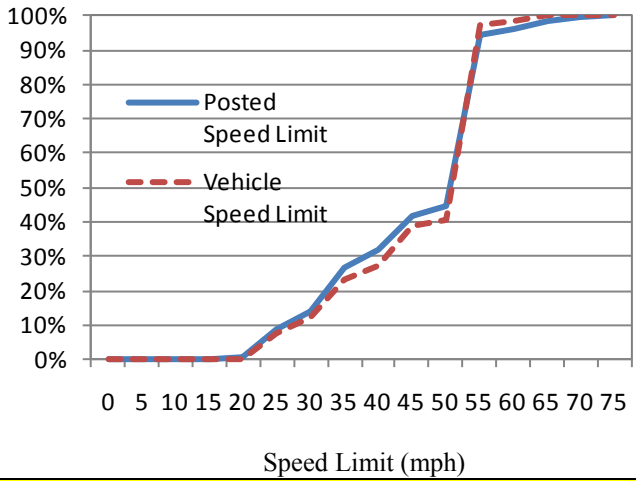
V.7. Opposite Direction/No Maneuver

Typical Scenario: Vehicle is going straight, and then drifts and encroaches into another vehicle traveling in the opposite direction.

Societal Cost

Total No. of Crashes	13,352
Total No. of Vehicles Involved	25,864
No. of Vehicles with Injuries	5,793
No. of People Injured	7,802
VSL	$4,964,239,351
FYL	35,357
MAIS 2+ Injuries	1,878
MAIS 3+ Injuries	1,131

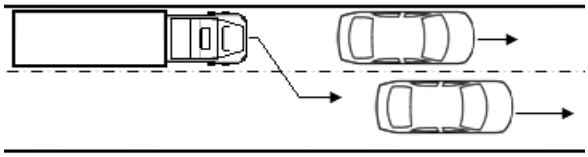


Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	38.6% - Curve, dry road surface with no adverse weather 38.1% - Straight, dry road surface with no adverse weather
Relation to Junction × Traffic Control Device	80.0% - Non-junction without traffic controls
Lighting Condition	80.3% - Daylight 12.0% - Dark
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	11.6% - ≤ 24 years 87.3% - 25 to 64 years 1.0% - 65 years or older
Gender	93.6% - Male 6.4% - Female

Driver Contributing Factors	
Alcohol	1.8 % - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	1.3% - Sleepy 6.4% - Unspecified impairment
Violation Cited	19.9% - Violation cited
Speeding	5.8% - Speeding
Vision Obscured	29.3% - Obscured
Distraction	10.4% - Distracted 1.4% - Sleepy 25.3% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	2.2% - Contributing factors
Corrective Action Attempted	
Corrective Action	2.8% - Braking (No Lockup) 8.7% - Braking (Lockup) 1.8% - Braking (Lockup Unknown) 8.7% - Steering left 54.8% - Steering right 2.4% - Braking and steering left 3.8% - Braking and steering right
Critical Event	
Conversation	13.2% - Talking on CB radio
Driver Fatigue	62.8% - Driver fatigued
False Assumptions	0.0% - False assumption factors
Following Too Closely	0.0% - Following too closely
Inadequate Evasive Action	0.0% - Inadequate evasive action factors
Inadequate Surveillance	0.0% - Additional surveillance factors
Inattention	0.0% - Inattention factors
Misjudgment ofGap or Velocity	0.0% - Misjudgment factors
Traveling Too Fast for Conditions	10.1% - Did not realize caution required 16.9% - Unspecified reason

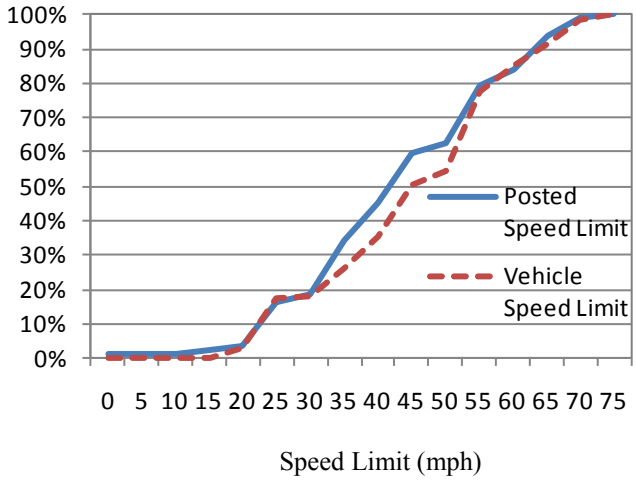
V.8. Rear-End/Striking Maneuver

Typical Scenario: Vehicle is changing lanes or passing, and then closes in on a lead vehicle.



Societal Cost

Total No. of Crashes	4,687
Total No. of Vehicles Involved	9,526
No. of Vehicles with Injuries	1,106
No. of People Injured	1,566
VSL	$ 243,911,145
FYL	1,736
MAIS 2+ Injuries	216
MAIS 3+ Injuries	81

Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	69.5% - Straight, dry road surface with no adverse weather 11.9% - Straight, slippery road surface with adverse weather 9.7% - Curve, dry road surface with no adverse weather 8.1% - Straight, slippery road surface with no adverse weather
Relation to Junction × Traffic Control Device	44.4% - Non-junction without traffic controls 15.6% - Intersection or intersection-related at 3-color traffic signal 8.6% - Unspecified junction type with sign other than stop sign 8.4% - Intersection or intersection-related without traffic controls
Lighting Condition	81.8% - Daylight 9.6% - Dark but lighted 6.7% - Dark
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	15.1% - ≤ 24 years 77.1% - 25 to 64 years 7.8% - 65 years or older
Gender	96.9% - Male 3.1% - Female

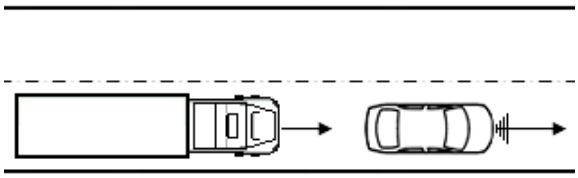
Driver Contributing Factors	
Alcohol	1.8% - Alcohol use
Drugs	< 1.0% - Drug use
Physical Impairment	8.5% - Unspecified impairment
Violation Cited	35.6% - Violation cited
Speeding	12.3% - Speeding
Vision Obscured	38.1% - Obscured
Distraction	31.3% - Distracted 33.3% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	4.0% - Contributing factors
Corrective Action Attempted	
Corrective Action	2.0% - Braking (No Lockup) 9.8% - Braking (Lockup) 1.1% - Braking (Lockup Unknown) 2.3% - Steering left 5.5% - Steering right 7.8% - Braking and steering left 4.2% - Braking and steering right

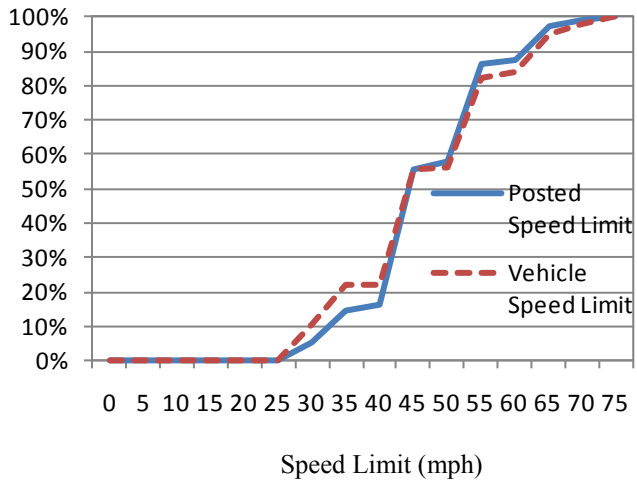
V.9. Rear-End/Lead Vehicle Accelerating

Typical Scenario: Vehicle is going straight, and then closes in on an accelerating lead vehicle.

Societal Cost

Total No. of Crashes	1,222
Total No. of Vehicles Involved	2,743
No. of Vehicles with Injuries	528
No. of People Injured	702
VSL	$ 169,311,746
FYL	1,240
MAIS 2+ Injuries	117
MAIS 3+ Injuries	54



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	79.7% - Straight, dry road surface with no adverse weather
Relation to Junction × Traffic Control Device	45.8% - Intersection or intersection-related at 3-color traffic signal 29.9% - Non-junction without traffic controls 8.5% - Intersection or intersection-related at stop sign
Lighting Condition	89.1% - Daylight
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	20.4% - ≤ 24 years 79.6% - 25 to 64 years 0.0% - 65 years or older
Gender	100.0% - Male 0.0% - Female

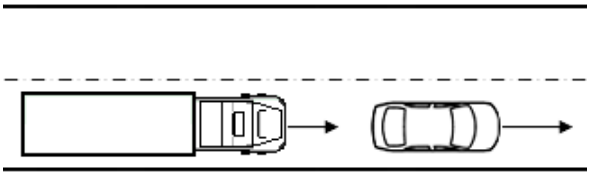
Driver Contributing Factors	
Alcohol	0.0% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	9.5% - Unspecified impairment
Violation Cited	38.9% - Violation cited
Speeding	28.0% - Speeding
Vision Obscured	33.1% - Obscured
Distraction	13.7% - Distracted 28.7% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	0.0% - Contributing factors
Corrective Action Attempted	
Corrective Action	2.2% - Braking (No lockup) 7.4% - Braking (Lockup) 57.1% - Steering Left 1.0% - Steering Right 11.1% - Braking and Steering Left
Critical Event	
Conversation	0.0% - Conversing
Driver Fatigue	15.6% - Driver fatigued
False Assumptions	15.5% - Assumed that other driver would continue to proceed
Following Too Closely	41.2% - Did not realize too close 25.4% - Unspecified reason
Inadequate Evasive Action	15.6% - Insufficient braking inputs
Inadequate Surveillance	59.3% - Failed to look far enough ahead
Inattention	31.1% - Unspecified reason
Misjudgment ofGap or Velocity	0.0% - Misjudgment factors
Traveling Too Fast for Conditions	0.0% - Traveling too fast

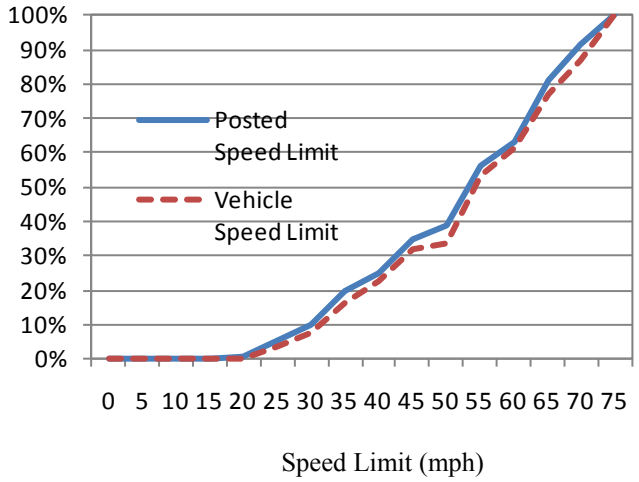
V.10. Rear-End/Lead Vehicle Moving At Slower Constant Speed

Typical Scenario: Vehicle is going straight, and then closes in on a lead vehicle moving at lower constant speed.

Societal Cost

Total No. of Crashes	14,251
Total No. of Vehicles Involved	30,510
No. of Vehicles with Injuries	5,932
No. of People Injured	8,898
VSL	$2,068,165,027
FYL	14,999
MAIS 2+ Injuries	1,397
MAIS 3+ Injuries	633



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	77.8% - Straight, dry road surface with no adverse weather 11.4% - Straight, slippery road surface with adverse weather
Relation to Junction × Traffic Control Device	70.7% - Non-junction without traffic controls 10.1% - Intersection or intersection-related at 3-color traffic signal
Lighting Condition	67.0% - Daylight 16.9%- Dark 13.7% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	16.2% - ≤ 24 years 80.4% - 25 to 64 years 3.4% - 65 years or older
Gender	92.8% - Male 7.2% - Female

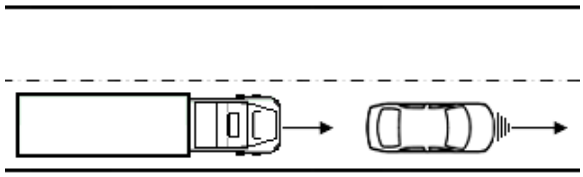
Driver Contributing Factors	
Alcohol	1.0% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	2.2% - Sleepy 12.8% - Unspecified impairment
Violation Cited	47.4% - Violation cited
Speeding	37.5% - Speeding
Vision Obscured	35.5% - Obscured
Distraction	28.4% - Distracted 37.2% - Not distracted 2.1% - Sleepy 32.3% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	2.6% - Contributing factors
Corrective Action Attempted	
Corrective Action	30.4% - Braking (No lockup) 17.6% - Braking (Lockup) 7.5% - Braking (Lockup Unknown) 7.6% - Steering Left 2.6% - Steering Right 2.2% - Braking and Steering Left 6.1% - Braking and Steering Right 3.7% - Unspecified action
Critical Event	
Conversation	0.0% - Conversing
Driver Fatigue	19.2% - Driver fatigued
False Assumptions	12.5% - Assumed that other driver would continue to proceed
Following Too Closely	< 1.0% - Rush hour heavy traffic 31.3% - Did not realize too close 5.3% - Always drive at this gap distance 38.8% - Unspecified reason
Inadequate Evasive Action	11.6% - Insufficient braking inputs 8.9% - Combination of insufficient steering and braking inputs
Inadequate Surveillance	29.9% - Failed to look far enough ahead 6.3% - Looked, but did not see
Inattention	13.3% - Unspecified reason
Misjudgment of Gap or Velocity	12.0% - Misjudgment of velocity of other vehicle 11.3% - Misjudgment of both factors
Traveling Too Fast for Conditions	1.2% - Keeping up with traffic 27.2% - Did not realize caution required 12.5% - Unspecified reason

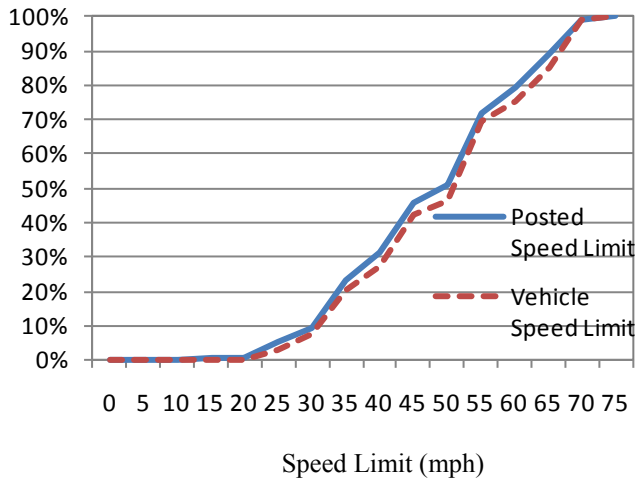
V.11. Rear-End/Lead Vehicle Decelerating

Typical Scenario: Vehicle is going straight and following another lead vehicle, and then the lead vehicle suddenly decelerates.

Societal Cost

Total No. of Crashes	17,568
Total No. of Vehicles Involved	40,237
No. of Vehicles with Injuries	6,307
No. of People Injured	9,468
VSL	$ 923,626,476
FYL	6,612
MAIS 2+ Injuries	1,077
MAIS 3+ Injuries	364



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	72.9% - Straight, dry road surface with no adverse weather 12.6% - Straight, slippery road surface with adverse weather
Relation to Junction × Traffic Control Device	49.3% - Non-junction without traffic controls 14.9% - Intersection or intersection-related at 3-color traffic signal 10.5% - Intersection or intersection-related without traffic controls
Lighting Condition	88.5% - Daylight 6.5% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	11.1% - ≤ 24 years 84.5% - 25 to 64 years 4.4% - 65 years or older
Gender	97.2% - Male 2.8% - Female

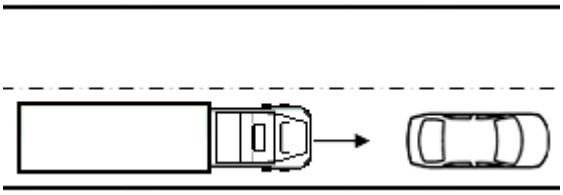
Driver Contributing Factors	
Alcohol	1.2% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	< 1.0% - Ill, Blackout < 1.0% - Sleepy 2.9% - Unspecified impairment
Violation Cited	39.4% - Violation cited
Speeding	36.2% - Speeding
Vision Obscured	18.2% - Obscured
Distraction	23.4% - Distracted < 1.0% - Sleepy 27.9% - Unspecified Distraction
Vehicle Contributing Factors	
Contributing Factors	1.9% - Contributing factors
Corrective Action Attempted	
Corrective Action	19.8% - Braking (No lockup) 11.6% - Braking (Lockup) 13.2% - Braking (Lockup Unknown) 5.9% - Steering Left 10.5% - Steering Right 5.0% - Braking and Steering Left 6.3% - Braking and Steering Right 1.2% - Accelerating
Critical Event	
Conversation	0.0% - Conversing
Driver Fatigue	15.2% - Driver fatigued
False Assumptions	14.6% - Assumed that other driver would continue to proceed 1.1% - Assumed that other driver would yield right-of-way
Following Too Closely	5.9% - Rush hour, heavy traffic 17.2% - Keeping up with traffic 30.4% - Did not realize too close 19.9% - Always drive at this gap distance 13.6% - Unspecified reason
Inadequate Evasive Action	4.0% - Insufficient steering inputs
Inadequate Surveillance	32.6% - Failed to look far enough ahead 4.1% - Looked, but did not see
Inattention	3.2% - Family problem < 1.0% - Future event (vacation, wedding, etc.) 23.5% - Unspecified reason
Misjudgment of Gap or Velocity	5.0% - Misjudgment of gap distance 7.1% - Misjudgment of velocity of other vehicle
Traveling Too Fast for Conditions	13.9% - Keeping up with traffic 18.5% - Did not realize caution required 6.0% - Unspecified reason

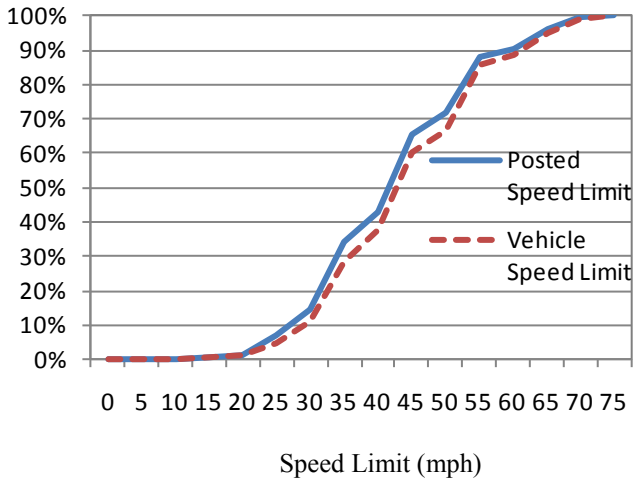
V.12. Rear-End/Lead Vehicle Stopped

Typical Scenario: Vehicle is going straight, and then closes in on a stopped lead vehicle.

Societal Cost

Total No. of Crashes	31,598
Total No. of Vehicles Involved	70,328
No. of Vehicles with Injuries	11,602
No. of People Injured	17,687
VSL	$2,405,070,921
FYL	17,050
MAIS 2+ Injuries	2,058
MAIS 3+ Injuries	773



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	75.2% - Straight, dry road surface with no adverse weather 11.4% - Straight, slippery road surface with adverse weather
Relation to Junction × Traffic Control Device	39.0% - Intersection or intersection-related at 3-color traffic signal 31.0% - Non-junction without traffic controls
Lighting Condition	87.4% - Daylight 7.7% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	12.9% - ≤ 24 years 84.7% - 25 to 64 years 2.4% - 65 years or older
Gender	94.4% - Male 5.6% - Female

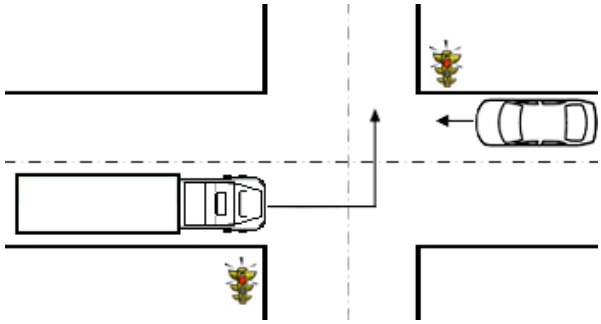
Driver Contributing Factors	
Alcohol	2.0% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	< 1.0% - Sleepy 2.6% - Unspecified impairment
Violation Cited	45.7% - Violation cited
Speeding	30.0% - Speeding
Vision Obscured	25.0% - Obscured
Distraction	29.8% - Distracted 37.1% - Not Distracted < 1.0% - Sleepy 32.9% - Unspecified Distraction
Vehicle Contributing Factors	
Contributing Factors	3.3% - Contributing factors
Corrective Action Attempted	
Corrective Action	13.3% - Braking (No lockup) 16.1% - Braking (Lockup) 12.8% - Braking (Lockup Unknown) 5.1% - Steering Left 6.8% - Steering Right 2.8% - Braking and Steering Left 2.5% - Braking and Steering Right 1.6% - Accelerating
Critical Event	
Conversation	< 1.0% - Conversing with passenger
Driver Fatigue	5.0% - Driver fatigued
False Assumptions	16.6% - Assumed that other driver would continue to proceed
Following Too Closely	16.5% - Keeping up with traffic 11.9% - Did not realize too close
Inadequate Evasive Action	< 1.0% - Insufficient steering inputs 4.5% - Insufficient braking inputs 17.4% - Combination of insufficient steering and braking inputs
Inadequate Surveillance	13.6% - Failed to look far enough ahead 4.6% - Looked, but did not see
Inattention	6.3% - Family problem 8.4% - Unspecified reason
Misjudgment of Gap or Velocity	3.4% - Misjudgment of gap distance 15.7% - Misjudgment of velocity of other vehicle 3.0% - Misjudgment of both factors
Traveling Too Fast for Conditions	1.4% - Keeping up with traffic 45.6% - Did not realize caution required 4.3% - Unspecified reason

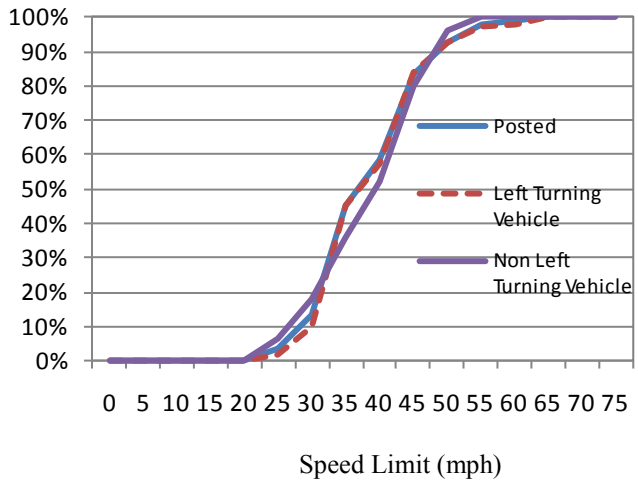
V.13. LTAP/OD at Signal

Typical Scenario: Vehicle is turning left at a signalized intersection, and then cuts across the path of another vehicle straight crossing from an opposite direction.

Societal Cost

Total No. of Crashes	5,430
Total No. of Vehicles Involved	11,473
No. of Vehicles with Injuries	2,525
No. of People Injured	3,733
VSL	$ 778,002,929
FYL	5,685
MAIS 2+ Injuries	604
MAIS 3+ Injuries	260



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	76.4% - Straight, dry road surface with no adverse weather 16.5% - Straight, slippery road surface with adverse weather
Relation to Junction × Traffic Control Device	95.4% - Intersection or intersection-related at 3-color traffic signal
Lighting Condition	78.0% - Daylight 13.9% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	

Driver Characteristics		
	Left Turning Vehicle	**Non-Left Turning Vehicle**
Age	12.2% - ≤ 24 years 86.5% - 25 to 64 years 1.3% - 65 years or older	10.1% - ≤ 24 Years 89.1% - 25 to 64 Years <1.0% - 65 Years or older
Gender	97.0% - Male 3.0% - Female	97.8% - Male 2.2% - Female

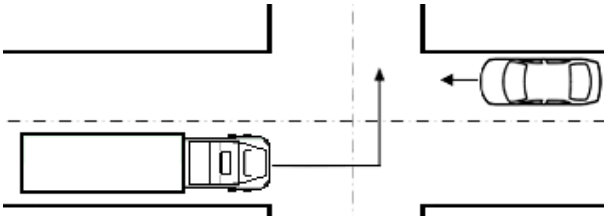
Driver Contributing Factors		
	Left Turning Driver	**Non-Left Turning Driver**
Alcohol	0.0% - Alcohol use	0.0% - Alcohol use
Drugs	0.0% - Drug use	0.0% - Drug use
Physical Impairment	3.2% - Unspecified impairment	7.2% - Unspecified impairment
Violation Cited	36.7% - Violation cited	5.1% - Violation cited
Speeding	0.0% - Speeding	7.8% - Speeding
Vision Obscured	28.8% - Obscured	19.4% - Obscured
Distraction	12.9% - Distracted 37.0% - Unspecified distraction	< 1.0% - Distracted 32.6% - Unspecified distraction
Vehicle Contributing Factors		
	Left Turning Vehicle	**Non-Left Turning Vehicle**
Contributing Factors	< 1.0% - Contributing factors	< 1.0% - Contributing factors
Corrective Action Attempted		
	Left Turning Vehicle	**Non-Left Turning Vehicle**
Corrective Action	9.9% - Braking (No lockup) 3.5% - Braking (Lockup) 1.1% - Braking (Lockup Unknown) 4.7% - Accelerating	24.7% - Braking (No lockup) 12.6% - Braking (Lockup) 8.6% - Braking (Lockup Unknown) 1.7% - Steering Left 15.8% - Steering Right 2.9% - Braking and Steering Left 15.0% - Unspecified action
Critical Event		
Conversation	0.0% - Conversing	0.0% - Conversing
Driver Fatigue	0.0% - Driver fatigued	0.0% - Driver fatigued
False Assumptions	9.9% - Assumed that other driver would yield right-of-way 4.7% - Unspecified false assumption	5.0% - Assumed that other driver would yield right-of-way
Following Too Closely	0.0% - Following too closely	0.0% - Following too closely
Inadequate Evasive Action	0.0% - Inadequate evasive action factors	1.8% - Combination of insufficient steering and braking inputs
Inadequate Surveillance	35.1% - Failed to look far enough ahead 31.7% - Failed to look to side 4.7% - Looked, but did not see	0.0% - Additional surveillance factors
Inattention	14.5% - Family problem 71.3% - Unspecified reason	0.0% - Inattention Factors
Misjudgment of Gap or Velocity	18.6% - Misjudgment of velocity of other vehicle	0.0% - Misjudgment factors
Traveling Too Fast for Conditions	0.0% - Traveling too fast	3.0% - Unspecified reason

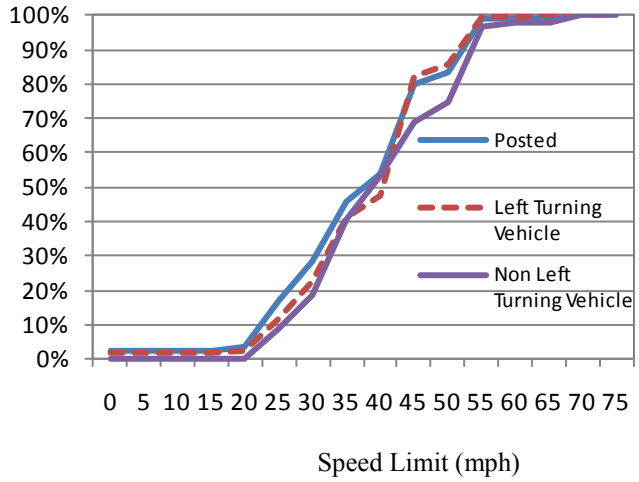
V.14. LTAP/OD at Non-Signal

Typical Scenario: Vehicle is turning left at a non-signalized intersection, and then cuts across the path of another vehicle straight crossing from an opposite direction.

Societal Cost

Total No. of Crashes	5,430
Total No. of Vehicles Involved	11,473
No. of Vehicles with Injuries	2,525
No. of People Injured	3,733
VSL	$ 778,002,929
FYL	5,685
MAIS 2+ Injuries	604
MAIS 3+ Injuries	260



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	75.1% - Straight, dry road surface with no adverse weather 8.0% - Straight, slippery road surface with no adverse weather
Relation to Junction × Traffic Control Device	37.8% - Intersection or intersection-related without traffic controls 32.5% - Driveway, alley, etc. without traffic controls 15.3% - Intersection or intersection-related at stop sign
Lighting Condition	82.0% - Daylight 9.9% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	

Driver Characteristics		
	Left Turning Vehicle	**Non-Left Turning Vehicle**
Age	10.1% - ≤ 24 years 84.7% - 25 to 64 years 5.3% - 65 years or older	9.8% - ≤ 24 years 83.3% - 25 to 64 years 6.9% - 65 years or older
Gender	97.0% - Male 3.0% - Female	99.8% - Male < 1.0% - Female

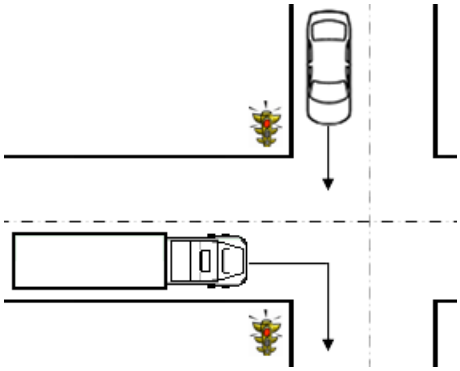
Driver Contributing Factors		
	Left Turning Vehicle	**Non-Left Turning Vehicle**
Alcohol	< 1.0% - Alcohol use	0.0% - Alcohol use
Drugs	0.0% - Drugs use	0.0% - Drugs use
Physical Impairment	< 1.0% - Sleepy 4.1% - Unspecified impairment	4.4% - Unspecified impairment
Violation Cited	41.9% - Violation cited	9.5% - Violation cited
Speeding	0.0% - Speeding	1.2% - Speeding
Vision Obscured	32.8% - Obscured	22.9% - Obscured
Distraction	20.3% - Distracted < 1.0% - Sleepy 32.5% - Unspecified distraction	2.6% - Distracted 0.0% - Sleepy 39.6% - Unspecified distraction
Vehicle Contributing Factors		
	Left Turning Vehicle	**Non-Left Turning Vehicle**
Contributing Factors	0.0% - Contributing factors	< 1.0% - Contributing factors
Corrective Action Attempted		
	Left Turning Vehicle	**Non-Left Turning Vehicle**
Corrective Action	2.4% - Braking (Lockup) 2.1% - Braking (Lockup Unknown) 4.6% - Steering Left	51.9% - Braking (Lockup) 12.3% - Braking (Lockup Unknown) 9.8% - Steering Left 6.4% - Steering Right 5.2% - Braking and Steering Right 3.5% - Unspecified action
Critical Event		
Conversation	0.0% - Conversing	0.0% - Conversing
Driver Fatigue	6.4% - Driver fatigued	0.0% - Driver fatigued
False Assumptions	34% - Assumed that other driver would yield right-of-way	0.0% - False assumption factors
Following Too Closely	0.0% - Following too closely	0.0% - Following too closely
Inadequate Evasive Action	0.0% - Inadequate evasive action factors	16.1% - Unspecified inadequate evasive action
Inadequate Surveillance	6.4% - Looked, but did not see	0.0% - Additional surveillance factors
Inattention	36.0% - Financial problem 6.4% - Unspecified reason	0.0% - Inattention factors
Misjudgment of Gap or Velocity	21.7% - Misjudgment of velocity of other vehicle 36 .0% - Misjudgment of both factors	0.0% - Misjudgment factors
Traveling Too Fast for Conditions	0.0% - Traveling too fast	0.0% - Traveling too fast

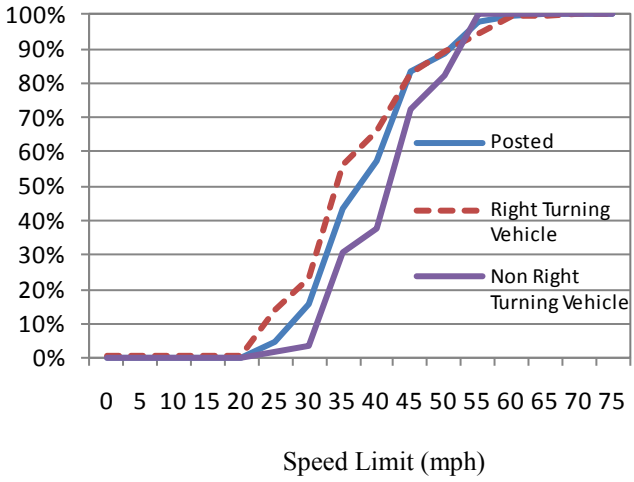
V.15. Turn Right at Signal

Typical Scenario: Vehicle is turning right at a signalized intersection, and then turns into the same direction of another vehicle crossing straight initially from a lateral direction.

Societal Cost

Total No. of Crashes	2,782
Total No. of Vehicles Involved	5,818
No. of Vehicles with Injuries	367
No. of People Injured	450
VSL	$ 376,774,886
FYL	2,617
MAIS 2+ Injuries	96
MAIS 3+ Injuries	68



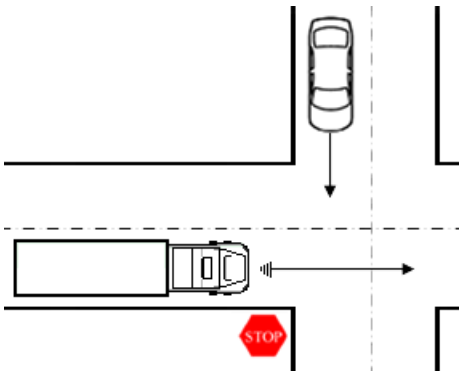
Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	83.9% - Straight, dry road surface with no adverse weather 9.3% - Straight, slippery road surface with adverse weather
Relation to Junction × Traffic Control Device	93.0% - Intersection or intersection-related at 3-color traffic signal
Lighting Condition	79.6% - Daylight 18.1% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	

Driver Characteristics		
	Right Turning Vehicle	**Non-Right Turning Vehicle**
Age	6.2% - ≤ 24 years 92.4% - 25 to 64 years 1.4% - 65 years or older	9.0% - ≤ 24 years 89.9% - 25 to 64 years 1.1% - 65 years or older
Gender	94.2% - Male 5.8% - Female	99.8% - Male < 1.0% - Female

Driver Contributing Factors		
	Right Turning Vehicle	**Non-Right Turning Vehicle**
Alcohol	2.9% - Alcohol use	< 1.0% - Alcohol use
Drugs	0.0% - Drug use	0.0% - Drug use
Physical Impairment	6.6% - Unspecified impairment	14.2% - Unspecified impairment
Violation Cited	22.2% - Violation cited	1.8% - Violation cited
Speeding	10.1% - Speeding	0.1% - Speeding
Vision Obscured	20.4% - Obscured	27.4% - Obscured
Distraction	20.9% - Distracted 20.7% - Unspecified distraction	< 1.0% - Distracted 34.9% - Unspecified distraction
Vehicle Contributing Factors		
	Right Turning Vehicle	**Non-Right Turning Vehicle**
Contributing Factors	< 1.0% - Contributing factors	0.0% - Contributing factors
Corrective Action Attempted		
	Right Turning Vehicle	**Non- Right Turning Vehicle**
Corrective Action	1.4% - Steering Left 14.2% - Steering Right 1.5% - Unspecified action	17.5% - Braking (Lockup) 2.7% - Braking (Lockup Unknown) 23.3% - Steering Left

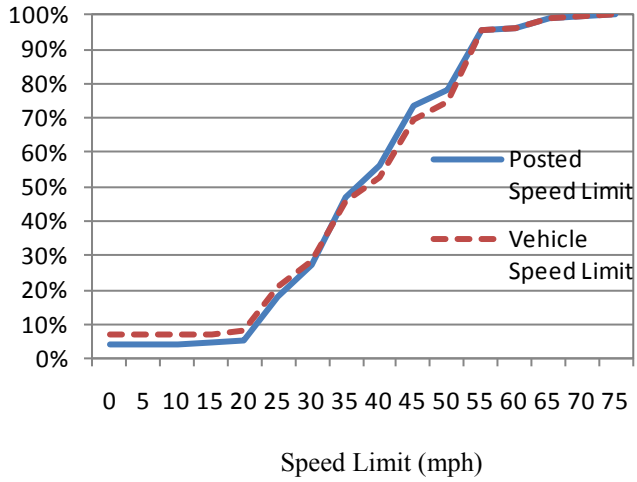
V.16. SCP at Non-Signal

Typical Scenario: Vehicle stops at a stop sign, and then proceeds against lateral crossing traffic.



Societal Cost

Total No. of Crashes	22,452
Total No. of Vehicles Involved	45,562
No. of Vehicles with Injuries	7,599
No. of People Injured	10,929
VSL	$ 3,838,079,400
FYL	27,436
MAIS 2+ Injuries	1,958
MAIS 3+ Injuries	992

Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	78.2% - Straight, dry road surface with no adverse weather 8.5% - Straight, slippery road surface with adverse weather 7.8% - Straight, slippery road surface with no adverse weather
Relation to Junction × Traffic Control Device	47.8% - Intersection or intersection-related at stop sign 24.5% - Driveway, alley, etc. without traffic controls 10.9% - Intersection or intersection-related without traffic controls
Lighting Condition	83.7% - Daylight 8.7% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	7.3% - ≤ 24 years 87.4% - 25 to 64 years 5.3% - 65 years or older
Gender	94.7% - Male 5.3% - Female

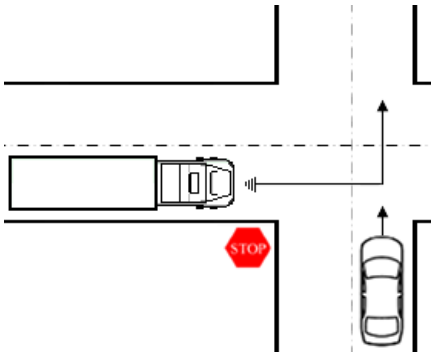
Driver Contributing Factors	
Alcohol	< 1.0% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	3.8% - Unspecified impairment
Violation Cited	19.8% - Violation cited
Speeding	1.3% - Speeding
Vision Obscured	23.9% - Obscured
Distraction	7.5% - Distracted 26.9% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	< 1.0% - Contributing factors
Corrective Action Attempted	
Corrective Action	5.9% - Braking (No lockup) 11.2% - Braking (Lockup) 3.6% - Braking (Lockup Unknown) 13.7% - Steering Left 7.5% - Steering Right 8.6% - Braking and Steering Left 2.2% - Braking and Steering Right
Critical Event	
Conversation	0.0% - Conversing
Driver Fatigue	< 1.0% - Driver fatigued
False Assumptions	20.5% - Assumed that other driver would yield right-of-way 5.1% - Unspecified false assumption
Following Too Closely	0.0% - Following too closely
Inadequate Evasive Action	2.1% - Insufficient braking inputs 12.0% - Combination of insufficient steering and braking inputs 1.1% - Unspecified inadequate evasive action
Inadequate Surveillance	1.9% - Failed to look to side 17.7% - Looked, but did not see
Inattention	3.3% - Unspecified reason
Misjudgment ofGap or Velocity	1.2% - Misjudgment of velocity of other vehicle 4.0% - Misjudgment of both factors
Traveling Too Fast for Conditions	17.7% - Unspecified reason

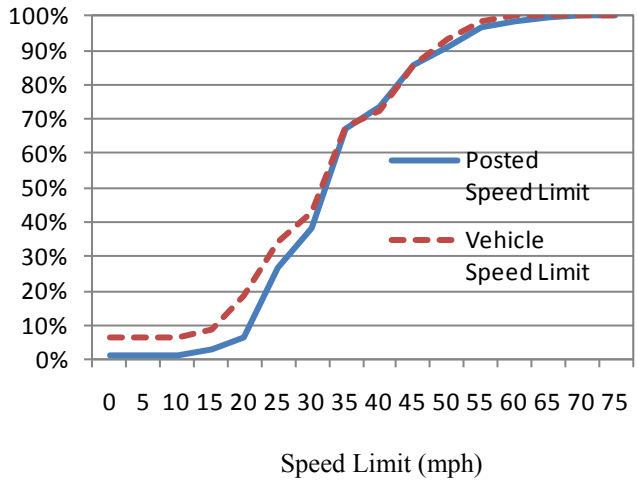
V.17. Turn at Non-Signal

Typical Scenario: Vehicle stops at a stop sign, and then proceeds to turn left against lateral crossing traffic.

Societal Cost

Total No. of Crashes		4,299
Total No. of Vehicles Involved		8,045
No. of Vehicles with Injuries		362
No. of People Injured		458
VSL	$	77,373,668
FYL		530
MAIS 2+ Injuries		52
MAIS 3+ Injuries		20



Driving Environment	
Roadway Alignment × Roadway Surface Condition × Atmospheric Condition	78.0% - Straight, dry road surface with no adverse weather 7.8% - Curve, dry road surface with no adverse weather 7.6% - Straight, slippery road surface with adverse weather
Relation to Junction × Traffic Control Device	27.3% - Intersection or intersection-related without traffic controls 23.3% - Intersection or intersection-related at stop sign 21.9% - Driveway, alley, etc., without traffic controls
Lighting Condition	81.9% - Daylight 12.5% - Dark but lighted
Speed Limit (Cumulative distributions of crashes/vehicles of interest by speed) *Posted Speed Limit* indicates the highest posted speed limit of all roads involved in a crash. *Vehicle Speed Limit* refers to the posted speed limit of the road that the heavy truck was on.	
Driver Characteristics	
Age	6.7% - ≤ 24 years 87.9% - 25 to 64 years 5.4% - 65 years or older
Gender	95.3% - male 4.7% - female

Driver Contributing Factors	
Alcohol	0.0% - Alcohol use
Drugs	0.0% - Drug use
Physical Impairment	3.0% - Unspecified impairment
Violation Cited	13.2% - Violation cited
Speeding	3.2% - Speeding
Vision Obscured	22.9% - Obscured
Distraction	17.8% - Distracted 22.1% - Unspecified distraction
Vehicle Contributing Factors	
Contributing Factors	0.0% - Contributing factors
Corrective Action Attempted	
Corrective Action	9.5% - Steering Left 14.0% - Steering Right 5.4% - Braking and Steering Right 4.8% - Unspecified Action

VI. Conclusion

This report updated and built upon the statistics of the 37 pre-crash scenario typology for heavy truck crash avoidance research, which was developed in the past based on 1996-2005 GES data involving at least one heavy truck (GVWR > 10,000 pounds) in police-reported crashes. The update consisted of the use of 2004-2008 GES data as well as additional data from the LTCCS database. Moreover, comprehensive economic costs based on 2007 economics were used to quantify the societal cost of pre-crash scenarios. This new analysis focused on pre-crash scenarios that might be addressed with crash countermeasure systems based on short range V2V communication countermeasures. Thus, target pre-crash scenarios must involve at least two vehicles. As a result, a total of 22 out of the 37 pre-crash scenarios were analyzed. By taking into account that the crash countermeasure systems must warn the driver in crash-imminent situations, 17 pre-crash scenarios remained as target V2V scenarios. These 17 pre-crash scenarios were statistically described in terms of their societal cost, driving environment, driver characteristics, contributing factors, and causes.

A set of five rear-end, pre-crash scenarios accounted for the most harm at about 24 percent of the societal costs of all 22 applicable V2V pre-crash scenarios. This was followed by a set of two opposite direction pre-crash scenarios that made up 22 percent the total societal cost. The third most harmful pre-crash scenarios were the junction crossings at 17 percent.

The 2004-2008 GES statistics about the driving environment revealed that most crashes occurred on a straight road, dry surface, in clear weather, during daylight. The rear-end lead vehicle moving pre-crash scenario occurred more often in dark conditions than any other target pre-crash scenario. A large portion of crashes associated with changing lanes/drifting in same direction, lead vehicle moving, and lead vehicle decelerating pre-crash scenarios occurred at speed limits greater than or equal to 55 mph. In contrast, a large portion of running stop sign, opposite direction with maneuver, and turning at non-signalized junctions pre-crash scenarios were reported at speed limits less than or equal to 35 mph.

The breakdown of heavy-truck drivers of interest by age was 12 percent by younger drivers, 85 percent by middle-age drivers, and only 3 percent by older drivers. This age distribution was expected to coincide with the predominance of professional drivers who operated heavy trucks. Higher rates of involvement by older drivers showed up in opposite direction/maneuver pre-crash scenarios. Younger drivers were more involved in drifting in the same direction, and rear-end/lead vehicle accelerating pre-crash scenarios than in other scenarios. In terms of gender, the breakdown of heavy-truck drivers was about 94 percent by male drivers and 6 percent by female drivers.

Based on 2004-2008 GES statistics, 31 percent of all heavy-truck drivers of interest were cited with violations and 27 percent were distracted. Alcohol and drug involvement was reported in only 1 percent of drivers. Speeding was attributed to ten percent of all heavy trucks of interest, mostly in rear-end pre-crash scenarios. Obscured vision was reported by 5 percent of all heavy-truck drivers, mostly in rear-end/lead vehicle accelerating and opposite direction pre-crash scenarios.

The attempted corrective action recorded in the 2004-2008 GES database indicated that 59 percent of heavy-truck drivers did not attempt any avoidance maneuver. In responding to the critical event, steering was the most frequent attempted avoidance maneuver by 16 percent of all drivers of interest, mostly in the opposite direction and rear-end/lead vehicle accelerating pre-crash scenarios. Braking only was coded for 9 percent of drivers, primarily in running red light, rear-end/lead vehicle moving, and Left turn across path/opposite direction (LTAP/OD) pre-crash scenarios.

LTCCS data showed that inadequate surveillance was cited in 35 percent of all drivers of interest with higher rates showing in opposite direction/maneuver, and rear-end/lead vehicle moving and lead vehicle stopped pre-crash scenarios. Following too closely was a factor in 33 percent of all drivers of interest with higher rates observed in the rear-end pre-crash scenarios. Traveling too fast was reported in 27 percent of all drivers, and was noted in 87 percent of the opposite direction/maneuver scenario. Fatigue was a factor in 11 percent of all drivers with higher rates observed in opposite direction/maneuver, running stop sign, and rear-end/lead vehicle moving pre-crash scenarios. False assumptions were cited in 15 percent of drivers, with the most occurence in the changing lanes/same direction pre-crash scenario. About 11 percent of drivers performed an inadequate evasive action with the greatest frequency observed in the opposite direction/maneuver scenario followed by rear-end/lead vehicle moving and lead vehicle stopped scenarios. Driver inattention was most significant in the LTAP/OD scenario for the driver who was executing the left turn; overall, inattention played a role in 15 percent of all drivers of interest. Misjudgement of the gap or velocity between vehicles was mentioned in 11 percent of all heavy-truck drivers, mostly in the LTAP/OD at non-signalized junctions pre-crash scenario for the turning driver.

The 2004-2008 GES data enabled the detailed description of all 17 target V2V pre-crash scenarios. Data from the LTCCS database were limited in some pre-crash scenarios but were sufficient to describe the majority of the target V2V pre-crash scenarios.

The results of this report feed into the crash scenario framework that will be used to identify intervention opportunities and define crash countermeasure profiles based on V2V communications for heavy trucks. The statistical and kinematical depiction of target pre-crash scenarios will enable the development of countermeasure functional requirements and minimum performance specifications as well as the estimation of potential safety benefits.

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Appendix A. GES Coding Schematic for Pre-Crash Scenarios (GES 2004-2008)

No	Scenario	Single-Vehicle Crashes (VEH_INVL = 1)	Multi-Vehicle Crashes (VEH_INVL >= 2), First Event
1	No driver present	MANEUV_I = 0	
2	Vehicle failure	P_CRASH2 = 1 - 4	P_CRASH2 = 1 - 4 (at least one vehicle)
3	Control loss/vehicle action	P_CRASH2 = 5 - 9 AND MANEUV_I = 2 - 4, 6, 8 - 13, 15 - 97; ACC_TYPE = 2, 7 AND MANEUV_I = 2 - 4, 6, 8 - 13, 15 - 97	Vx_P_CRASH2 = 5 - 9 AND Vx_MANEUV_I = 2 - 4, 6, 8 - 13, 15 - 97; Vx_ACC_TYPE = 34, 36, 54, 56 AND Vx_MANEUV_I = 2 - 4, 6, 8 - 13, 15 - 97; Vx_ACC_TYPE = 2, 7 AND Vx_MANEUV_I = 2 - 4, 6, 8 - 13, 15 - 97
4	Control loss/no vehicle action	P_CRASH2 = 5 - 9 AND MANEUV_I = 1, 14; ACC_TYPE = 2, 7 AND MANEUV_I = 1, 14	Vx_P_CRASH2 = 5 - 9 AND Vx_MANEUV_I = 1, 14; Vx_ACC_TYPE = 34, 36, 54, 56 AND Vx_MANEUV_I = 1, 14; Vx_ACC_TYPE = 2, 7 AND Vx_MANEUV_I = 1, 14
5	Running red light	TRAF_CON = 1, 4 AND MVIOLATN = 7	TRAF_CON = 1 AND ACC_TYPE = 76, 77, 82, 83, 86 - 91; TRAF_CON = 1, 4 AND MVIOLATN = 7
6	Running stop sign	TRAF_CON = 21 AND MVIOLATN = 7	TRAF_CON = 21 AND MVIOLATN = 7
7	Road edge departure/maneuver	P_CRASH2 = 10 - 14 AND MANEUV_I = 6, 8 - 12, 15 - 97; ACC_TYPE = 1, 6, 14 AND MANEUV_I = 6, 8 - 12, 15 - 97	Vx_ACC_TYPE = 1, 6, 14 AND Vx_MANEUV_I = 6, 8 - 12, 15 - 97
8	Road edge departure/no maneuver	P_CRASH2 = 10 - 14 AND MANEUV_I = 1 - 5, 7, 14; ACC_TYPE = 1, 6, 14 AND MANEUV_I = 1 - 5, 7, 14	Vx_ACC_TYPE = 1, 6, 14 AND Vx_MANEUV_I = 1 - 5, 7, 14
9	Road edge departure/backing	P_CRASH2 = 10 - 14 AND MANEUV_I = 13; ACC_TYPE = 1, 6, 14 AND MANEUV_I = 13; ACC_TYPE = 92	Vx_ACC_TYPE = 1, 6, 14 AND Vx_MANEUV_I = 13
10	Animal/maneuver	EVENT1_I = 24 AND MANEUV_I = 6, 8 - 13, 15 - 97; P_CRASH2 = 87 - 89 AND MANEUV_I = 6, 8 - 13, 15 - 97	Vx_P_CRASH2 = 87 - 89 AND Vx_MANEUV_I = 6, 8 - 13, 15 - 97
11	Animal/no maneuver	EVENT1_I = 24 AND MANEUV_I = 1 - 5, 7, 14; P_CRASH2 = 87 - 89 AND MANEUV_I = 1 - 5, 7, 14	EVENTNUM = 1 AND VEHNUM = x AND OBJCONT = 124 AND Vx_MANEUV_I = 6, 8 - 13, 15 - 97; Vx_P_CRASH2 = 87 - 89 AND Vx_MANEUV_I = 1 - 5, 7, 14
12	Pedestrian/maneuver	EVENT1_I = 21 AND MANEUV_I = 6, 8 - 13, 15 - 97; P_CRASH2 = 80 - 82 AND MANEUV_I = 6, 8 - 13, 15 - 97	EVENTNUM = 1 AND VEHNUM = x AND OBJCONT = 124 AND Vx_MANEUV_I = 1 - 5, 7, 14; Vx_P_CRASH2 = 80 - 82 AND Vx_MANEUV_I = 6, 8 - 13, 15 - 97
13	Pedestrian/no maneuver	EVENT1_I = 21 AND MANEUV_I = 1 - 5, 7, 14; P_CRASH2 = 80 - 82 AND MANEUV_I = 1 - 5, 7, 14	EVENTNUM = 1 AND VEHNUM = x AND OBJCONT = 121 AND Vx_MANEUV_I = 6, 8 - 13, 15 - 97; Vx_P_CRASH2 = 80 - 82 AND Vx_MANEUV_I = 1 - 5, 7, 14
14	Cyclist/maneuver	EVENT1_I = 22 AND MANEUV_I = 6, 8 - 13, 15 - 97; P_CRASH2 = 83 - 85 AND MANEUV_I = 6, 8 - 13, 15 - 97	EVENTNUM = 1 AND VEHNUM = x AND OBJCONT = 121 AND Vx_MANEUV_I = 1 - 5, 7, 14; Vx_P_CRASH2 = 83 - 85 AND Vx_MANEUV_I = 6, 8 - 13, 15 - 97

No	Scenario	Single-Vehicle Crashes (VEH_INVL = 1)	Multi-Vehicle Crashes (VEH_INVL >= 2), First Event
15	Cyclist/no maneuver	EVENT1_I = 22 AND MANEUV_I = 1 - 5, 7, 14; P_CRASH2 = 83 - 85 AND MANEUV_I = 1 - 5, 7, 14	EVENTNUM = 1 AND VEHNUM = x AND OBJCONT = 122 AND Vx_MANEUV_I = 6, 8 - 13, 15 - 97; Vx_P_CRASH2 = 83 - 85 AND Vx_MANEUV_I = 1 - 5, 7, 14
16	Backing into vehicle	P_CRASH2 = 56	EVENTNUM = 1 AND VEHNUM = x AND OBJCONT = 122 AND Vx_MANEUV_I = 1 - 5, 7, 14
17	Turning/same direction		ACC_TYPE = 92, 93 AND EVENT1_I = 25;ACC_TYPE = 44 - 49, 70 - 73 AND MANEUV_I = 10 - 12;ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 2 AND Vx_MANEUV_I = 10 - 12
18	Parking/same direction	P_CRASH2 = 64	MANEUV_I = 10 -12 AND P_CRASH2 = 60, 61; ACC_TYPE = 44 - 49, 70 - 73 AND MANEUV_I = 8, 9; ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 2 AND Vx_MANEUV_I = 8, 9; MANEUV_I = 8, 9 AND P_CRASH2 = 60, 61
19	Changing lanes/same direction	P_CRASH2 = 60, 61	P_CRASH2= 64; ACC_TYPE = 44 - 49, 70 - 73 AND MANEUV_I = 6, 15, 16; ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 2 AND Vx_MANEUV_I = 6, 15, 16
20	Drifting/same lane		MANEUV_I = 6, 15, 16 AND P_CRASH2 = 60, 61; ACC_TYPE = 44 - 49, 70 - 73 AND MANEUV_I = 1 - 5, 7, 14; ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 2 AND Vx_P_CRASH2 = 10, 11
21	Opposite direction/maneuver	P_CRASH2 = 54, 62, 63 AND MANEUV_I = 6, 8 - 13, 15 - 97	ACC_TYPE = 50 - 67 AND MANEUV_I = 6, 8 - 13, 15 - 97
22	Opposite direction/no maneuver	P_CRASH2 = 54, 62, 63 AND MANEUV_I = 1 - 5, 7, 14	ACC_TYPE = 50 - 67 AND MANEUV_I = 1 - 5, 7, 14
23	Rear-end/striking maneuver	P_CRASH2 = 50 - 52 AND MANEUV_I = 6, 8 - 13, 15 - 97	ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 1 AND Vx_MANEUV_I = 6, 8 - 13, 15 - 97; Vx_VROLE_I = 1 AND Vx_MANEUV_I = 6, 8 - 13, 15 - 97 AND Vx_P_CRASH2 = 50, 51, 52
24	Rear-end/LVA		ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 2 AND Vx_MANEUV_I = 3, 4; Vx_MANEUV_I = 3, 4 AND Vx_P_CRASH2 = 53
26	Rear-end/LVD	P_CRASH2 = 52	ACC_TYPE = 29 - 31; ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 2 AND Vx_MANEUV_I = 2; ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 1 AND Vx_P_CRASH2 = 52; P_CRASH2 = 52; Vx_MANEUV_I = 2 AND Vx_P_CRASH2 = 53
27	Rear-end/LVS	P_CRASH2 = 50	ACC_TYPE = 21 - 23; ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 2 AND Vx_MANEUV_I = 5, 7; ACC_TYPE = 20 - 43 AND Vx_VROLE_I = 1 AND Vx_P_CRASH2 = 50; P_CRASH2 = 50; Vx_MANEUV_I = 5, 7 AND Vx_P_CRASH2 = 53; ACC_TYPE = 20 - 43 AND Vx_MANEUV_I = 1 AND Vy_MANEUV_I = 0

No	Scenario	Single-Vehicle Crashes (VEH_INVL = 1)	Multi-Vehicle Crashes (VEH_INVL >= 2), First Event
28	LTAP/OD @ signal		TRAF_CON = 1 AND ACC_TYPE = 68, 69;TRAF_CON = 1 AND MANEUV_I = 11 AND P_CRASH2 = 54, 62, 63;TRAF_CON = 1 AND Vx_P_CRASH2 = 15 AND Vy_P_CRASH2 = 54, 62, 63;TRAF_CON = 1 AND Vx_MANEUV_I = 11 AND Vy_MANEUV_I not 10 AND ACC_TYPE = 74, 75
29	Turn right @ signal		TRAF_CON = 1 AND ACC_TYPE = 78 - 81; TRAF_CON = 1 AND MANEUV_I = 10 AND P_CRASH2 = 65 - 68; TRAF_CON = 1 AND Vx_P_CRASH2 = 16 AND Vy_P_CRASH2 = 65 - 68; TRAF_CON = 1 AND V_MANEUV_I = 10 AND ACC_TYPE = 74, 75, 84, 85
30	LTAP/OD @ non signal		TRAF_CON not 1 AND ACC_TYPE = 68, 69; TRAF_CON not 1 AND MANEUV_I = 11 AND P_CRASH2 = 54, 62, 63; TRAF_CON not 1 AND Vx_P_CRASH2 = 15 AND Vy_P_CRASH2 = 54, 62, 63
31	SCP @ non signal	TRAF_CON not 1 AND P_CRASH2 = 66, 71	TRAF_CON not 1 AND ACC_TYPE = 86 - 91; TRAF_CON not 1 AND MANEUV_I not 10 -12 AND P_CRASH2 = 65 - 68, 70 - 78; TRAF_CON not 1 AND Vx_P_CRASH2 not 15, 16 AND Vy_P_CRASH2 = 65 - 68, 70 - 78
32	Turn @ non signal	TRAF_CON not 1 AND P_CRASH2 = 65, 67, 68, 70, 72, 73	TRAF_CON not 1 AND ACC_TYPE = 74 - 85; TRAF_CON not 1 AND MANEUV_I = 10 -12 AND P_CRASH2 = 65 - 68, 70 - 78; TRAF_CON not 1 AND Vx_P_CRASH2 = 15, 16 AND Vy_P_CRASH2 = 65 - 68, 70 - 78
33	Avoidance/maneuver	ACC_TYPE = 3, 8 AND MANEUV_I = 6, 8 - 13, 15 - 97; P_CRASH2 = 50 - 78 AND MANEUV_I = 6, 8 - 13, 15 - 97	
34	Avoidance/no maneuver	ACC_TYPE = 3, 8 AND MANEUV_I = 1 - 5, 7, 14; P_CRASH2 = 50 - 78 AND MANEUV_I = 1 - 5, 7, 14	
35	Rollover	ROLLOVER=10 OR EVENT1_I=1	
36	Noncollision - No Impact	EVENT1_I=2 - 10; ACC_TYPE = 00	
37	Object/maneuver	P_CRASH2 = 90, 91, 92 AND MANEUV_I = 6, 8 - 13, 15 - 97; ACC_TYPE = 12 AND MANEUV_I = 6, 8 - 13, 15 - 97; ACC_TYPE = 11 AND MANEUV_I = 6, 8 - 13, 15 - 97; EVENT1_I = 21 - 29, 31 - 59 AND MANEUV_I = 6, 8 - 13, 15 - 97	
38	Object/no maneuver	P_CRASH2 = 90, 91, 92 AND MANEUV_I = 1 - 5, 7, 14; ACC_TYPE = 12 AND MANEUV_I = 1 - 5, 7, 14; ACC_TYPE = 11 AND MANEUV_I = 1 - 5, 7, 14; EVENT1_I = 21 - 29, 31 - 59 AND MANEUV_I = 1 - 5, 7, 14	
39	Hit and run	HITRUN_I = 1	
40	Other - Rear-End		ACC_TYPE = 20 - 43
41	Other - Sideswipe		ACC_TYPE = 44 - 49
42	Other - Opposite Direction		ACC_TYPE = 50 - 67

No	Scenario	Single-Vehicle Crashes (VEH_INVL = 1)	Multi-Vehicle Crashes (VEH_INVL >= 2), First Event
43	Other - Turn Across Path		ACC_TYPE = 68 - 75
44	Other - Turn Into Path		ACC_TYPE = 76 - 85
45	Other - Straight Paths		ACC_TYPE = 86 - 91
46	Other		

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