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Interim Report

Development of Performance Specifications for Collision Avoidance Systems for Lane Change, Merging and Backing

Task 1 -Crash Problem Analysis

Preface

This is the first interim report of a project whose goal is the development of performance specifications for crash avoidance systems for lane change, merging, and backing. The project is subdivided in three phases -- Phase I, which will lay the foundation; Phase II, which will conduct a detailed investigation of the state-of-the-art of crash countermeasure; and Phase III, which will establish the performance specifications. The current schedule calls for the completion of this research project in the third quarter of 1997.

This interim report summarizes the work conducted under Task 1 of the project, Specifically, it presents the results of an overall analysis of the crash problems pertaining to the indicated type of accidents. This analysis will be the basis for all the foundation work of Phase I, which will conclude with a presentation of preliminary performance specifications in the summer of 1995. The results shown in this interim report may call for their refinement during the duration of the whole project.

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16. Abstract

Crashes associated with lane change, merging and backing maneuvers were studied. A taxonomy for classifying vehicle crashes was developed based on the maneuver in progress, vehicle role and manner and nature of the collision. Using the 1992General Estimates System database, the population of each crash category was identified. For each category, theambient conditions surrounding the crashes, including driver and vehicle variables, are tabulated.

Statistical tests were perfonned on a variety of category populations to identify possible associaton between variables from which crash causes could be inferred, but little association was found. Statistical tests were also performed to determine possible correlation between crash severity and external variables, such as lighting, road conditions, etc. Here again, no compelling correlation was found.

The hardcopy data from 143casesoflane change/merge crashes in the 1992 Crashowrthiness Data System were studied and acident scenarios were developed. Approximately 200 police accident reports were studied to develop accident scenarios for backing crashes.

17. Key Words
Collision Avoidance System, Lane Change, Merging, Backing, Populations, Accident Scenarios

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1.0 INTRODUCTION

Recent innovations in sensor technologies and digital processing have led to the potential for crash avoidance systems to be utilized on vehicles. This program specifically addresses the avoidance of backing and lane change/merging crashes. To evaluate the capabilities of various approaches, an understanding of the circumstances that surround the occurrence of different accident types must be attained. After this information has been gathered, simulations both with and without humans in the loop and laboratory and field testing can be performed against a variety of scenarios derived from the accident analysis. Finally, the performance specifications can be ascertained for the optimal sensor against each type of crash. This report describes our efforts on the first part of this study, namely the accident analysis.

The Government maintains a variety of data bases on police reported accidents. In those data bases, details on representative accident types can be found. We have studied these data bases, and sorted the accidents into a variety of representative backing and lane change/merging accident categories. The taxonomy and classification system devised here is more complete than previous ones, incorporating pulling out from parallel parking and drifting crashes into the lane change/merge category. This has uncovered new opportunities for a CAS to assist the driver but may also impose new requirements on the system. Each of these classes has been investigated to determine the circumstances surrounding that category of accident.

Of great importance to the design of a collision avoidance system is the relative speed, orientation, and distance between the instrumented vehicle and the object struck. Weather and roadway conditions must also be noted since some sensor technologies are more susceptible to certain environments (dark, rain, fog, etc.) than others. Another important factor in designing the system is to be aware of the driver and vehicle's state. The database contain five precrash variables for each involved vehicle which describe the vehicle movement prior to the critical event (Precrash l), the critical event (Precrash 2), the corrective action attempted (Precrash 3), the vehicle control after corrective action (Precrash 4) and the vehicle path after corrective action (Precrash 5). Precrash 1 and Precrash 2 are valuable in characterizing the events leading up to the crash. However, at present Precrash 3 indicates that in a vast majority of cases no corrective action was initiated. In those cases, Precrash 4 and Precrash 5 do not add any further information. As Crash Avoidance Systems (CAS) are incorporated into vehicles, the opportunities for corrective procedures to be initiated will increase as well. At that time, the variables Precrash 4 and Precrash 5 will become valuable in determining the effectiveness of the corrective actions.

Also the driver characteristics have been investigated as fully as the database permits. The conditions and actions of each driver involved in the crash as reported in the police accident report are tabulated. These include "driver's vision obscured by", "driver maneuvered to avoid", "driver distracted by" and driver's " physical impairment". These indicated that, in general, the driver was not distracted nor was his vision obscured nor did the driver maneuver to avoid anything. Driver fatigue was noted only in a very few cases. Certain warnings may be more successful for alerting a distracted or sleepy or inebriated driver, for example.

After the accidents are sorted by type, then a variety of relevant factors can be tabulated and analyzed statistically. In addition, a clinical study can be performed on a smaller set of representative accidents that are investigated in greater detail. This is done by either studying the actual police report that was the source of the data in the electronic data base or by acquiring follow-up investigation data that is generated on a selected number of police reported accidents. The combination of the statistical distributions of causal and other factors deduced from the data bases and the specifics gleaned from the clinical studies both go into defining the crash scenarios. In general, our studies of the 1992 databases yield results which are in good agreement with previous studies conducted on earlier databases.

The current study attempts to go beyond descriptive statistics, which has been the purview of past studies. While it is reassuring, and indeed critical, that results from the descriptive statistical analysis presented here are in general agreement with past findings, it is our goal to discover significant causal factors, if any, from the 1992 GES data.

In the next sections of this report, we will describe our methodology, introduce the various electronic data bases and other sources of data, and present our results. Those results include the description and formal definition of the crash categories, the tabulation of the sorted data and its statistical analysis, a description of possible causal factors, and a preliminary discussion of the various scenarios created. Finally, the conclusions of this study and an introduction to the upcoming tasks will be given.

2.0 PLANNING

The first task under the Crash Avoidance System Performance Specification (CASPS) Program is the crash problem analysis. This section contains the approach taken by TRW and its subcontractors, STI and the University of Texas at San Antonio (UTSA), to address this task. The products of this effort are a clear understanding of the frequency and severity of the various types of backing, lane changing and merging crashes, and more importantly, sets of representative crash scenarios to be utilized in the analyses and simulations to be performed during the remainder of the program.

2.1 Acquisition of Databases

The data contained in the General Estimates System (GES) and Crashworthiness Data System (CDS) databases for the years of 1989 through 1992 are available for use in this task, However, after a review of several NHTSA crash analysis documents and discussions with various NHTSA personnel, we decided to concentrate our effort on the data contained in the GES and CDS databases for the year of 1992. The data for 1992 are especially useful due to the introduction of several new precrash variables which were previously unavailable and also due to the separation of lane changing from merging crashes which in previous years had been aggregated together.

Data from 46,197 crashes are collected in the GES database. In order that the GES accurately reflect the distribution of 5,982,606 police reported crashes in 1992, each crash is assigned a weighting factor based on the probability of that crash being sampled. These weights vary from less than 10 to over 300 and depend strongly on the geographic location in which the crash took place.

The CDS database is far smaller. Data from only 4,956 crashes are collected here. Again, to accurately reflect the distribution of police reported crashes in 1992, each crash is assigned a weighting factor based on the probability of that crash being sampled. These weights vary drastically, from about 4.0 to over 3000.

A number of cases representative of backing and lane change/merge crashes are chosen for detailed “hard copy” or clinical analysis. In each of these cases, the detailed file from which the electronic database was distilled is once more examined for specific data not passed on through the electronic database. The hard copies contain narratives of the crash sequence and frequently contain interviews with drivers and/or witnesses. This analysis is done to better understand all of the contributing circumstances surrounding the crash. For example, one witness stated that the driver of vehicle 1 was "wearing headphones and moving to the music." While this information is not contained in the database, it nevertheless may be useful in the design of a backing CAS alarm display unit.

The hard copy analysis is routinely performed on specific cases taken from the CDS database. However, for a crash to be considered for inclusion in the CDS sampling system, there is the requirement that at least one vehicle must be damaged sufficiently to require towing. Since backing crashes frequently occur at low speeds with little vehicle damage, we did not anticipate finding enough backing crashes in the CDS to use for clinical analysis. This indeed was the case. For this reason, an analysis of the police accident reports (PARs) corresponding to specific GES entries was required.

Analysis of the Fatal Accident Reporting System (FARS) was also considered. Since FARS only deals with the relatively few crashes in which there is a fatality, the decision was made to concentrate the efforts on the broader information contained in the GES and CDS databases.

2.2 Methodology

Concurrently with the acquisition of the appropriate databases and software tools, we developed the general methodology for the crash data analyses. However, the following caveat should be observed: Not all of the following steps are part of Task 1. Some are part of Task 2 and Task 4.

Step 1 Quantify baseline target crash problem size and describe target crash characteristics. Previously this issue has been addressed in the following NHTSA Reports: "Backing Crashes: Problem Size Assessment and Statistical Description" and "Lane Change/Merge Crashes: Problem Size Assessment and Statistical Description". These reports dealt with results obtained from the analysis of 1990 and 199 1 GES databases.

Step 2 Describe, analyze. and model target crash scenarios. The crash scenarios are the products of the detailed hard copy analyses of the CDS cases and the PARs. This analysis leading to scenarios is done with the goal of developing effective countermeasures to the accident types considered. Enough detail is included to permit the understanding of causes, time and motion sequences, and potential interventions. This is described as developing the "accident scenarios" for simulation inputs.

Step 3 Assess countermeasure mechanisms of action and technology status. This is performed to identify candidate solutions (primarily vehicle based) to the crash problems analyzed and is described as developing the "sensor parameters" for simulation inputs.

Step 4 Assess relevant human factors. Human factors and other constraints affecting the crash scenarios and potential countermeasures' effectiveness are assessed. This is described as developing "human/vehicle responses" for simulation inputs.

Step 5 Model countermeasure action. Numerical simulations which incorporate the accident scenario, the sensor parameters, and the human/vehicle responses are made to predict the effectiveness and identify critical countermeasure functional requirements. In addition, human-machine testing in the instrumented simulator is done to verify and expand on the human/vehicle responses. There will be as much commonalty between these two forms of simulation as possible.

Step 6 Identify specific priority technological human factors, and other R&D issues. These issues are identified to ensure that the countermeasures' full potential is reached. These issues are derived from the results of the sensor testing and simulations.

A top-level flowchart depicting the methodology for obtaining scenarios for the computer simulations is displayed in Figure 2.2-l.

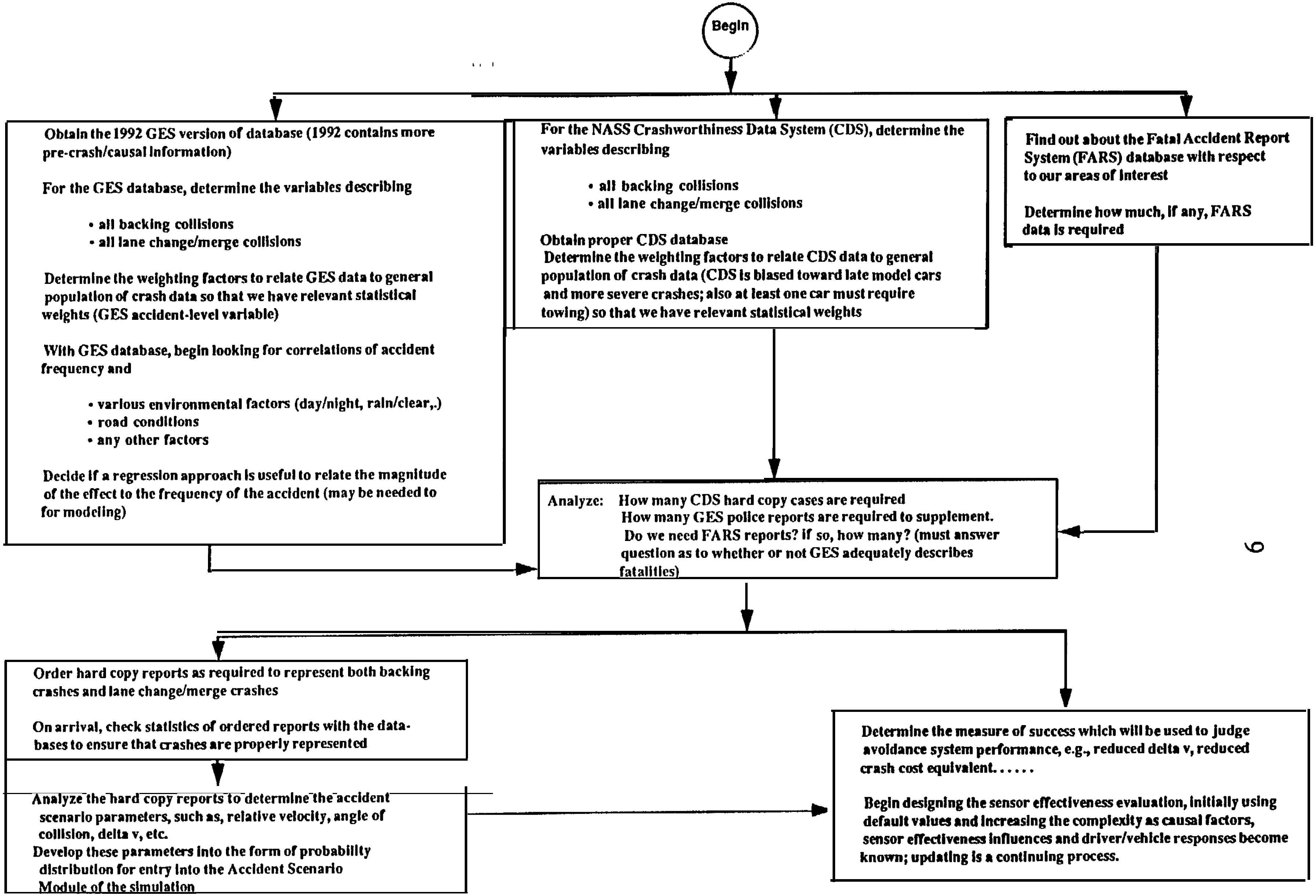


FIGURE 2.2-1: Tasks Leading to Accident Scenarios for Simulation

2.3 Simulation Architecture

The envisioned simulation brings together the accident scenarios, the sensor parameters and the human/vehicle responses to model the effectiveness of a particular sensor in a particular situation (scenario type). For a given scenario type, the values of the relative speeds and distances (scenario parameters), the reaction times (human factors) and the detection probabilities and times (sensor parameters) can be sampled from appropriate distributions using Monte Carlo techniques. In this way a large number of cases can be run in a reasonable amount of time, and the low-probability tails of the distributions can be sampled appropriately. This can be done for a matrix of various scenarios and sensors.

3.0 REVIEW OF PAST WORK

As part of the Task 1 effort, Crash Problems Analysis, we have reviewed the relevant probIem analysis reports provided by the Government. These documents include: "Backing Crashes: Problem Size Assessment and Statistical Description", "Examination of Backing Crashes and Potential IVHS Countermeasures", "Lane Change/Merge Crashes: Problem Size Assessment and Statistical Description", and "Analysis of Lane Change Crashes". (References 1 through 4, respectively) These will be referred to as Backing I, Backing II, Lane Change I, and Lane Change II, respectively.

3.1 Problem Size Assessments and Statistical Descriptions

The first and third documents, Backing I and Lane Change I contain analyses of the various data available to statistically determine the classification and occurrence of a well-defined set of collisions. These accidents are identified by key fields in the data bases which allow for backing and lane change/merge collisions to be sorted. Beyond that general classification, there are a variety of subdivisions that can be performed by analysis. Once these subsets are identified and isolated, then analyses are performed to determine the frequency and severity of these accident types. In addition, investigation of the vehicle types, weather conditions, roadway geometries, driver ages, etc. can be performed. These efforts to categorize the various crash types are an important first step in any approach to develop performance specifications for collision avoidance countermeasures. Clearly, information about the causal factors that contributed to the accident and about the physical arrangement of the vehicle(s) involved is crucial to designing an effective countermeasure.

The two assessment reports take this first step, but not with the appropriate level of detail necessary for countermeasure performance specification. With the goal of devising the requirements for the most effective countermeasure, we believe that the sorting and statistical analyses must provide as much detail as available to recreate representative crash scenarios. Those scenarios can provide realism to simulations used to evaluate sensor performance if they provide the kinematics of the crash, the driver responses, if any, the weather and roadway conditions, and other pertinent causal factors. We believe that every effort must be made to identify crash reports where as many useful artifacts as possible are available. In addition, the coded data on weather, traffic conditions, and roadway characteristics will be employed.

3.2 IVHS Countermeasures Assessments

To determine the efficacy of a crash countermeasure, simulations of realistic scenarios are necessary. In a clinical approach, a number of specific crash reports are analyzed and the performance of a countermeasure against each of the specific accidents is determined. This can be done as a function of one or more parameters which describe the sensor (e.g., detection range, field of regard, etc.).

A more statistical approach involves parameterizing a class of accidents, Distributions of values for several key input variables are created from the analysis of the data base entries. For example, for lane change/merging crashes, the speeds of the vehicles involved, as well as the lateral distance between them would be tabulated.

It would not be appropriate to use distributions associated with normal driving distributions. Accidents may occur much more frequently for certain combinations of conditions that are not associated with the peaks of the distributions derived from studies of normal driving situations. For example, backing collisions may occur more often during higher speed and/or higher acceleration backing maneuvers. Only a clinical study based on hard copies of accident reports, or an analysis based on distributions derived from accident data bases would reveal these facts.

Individual cases that have been sorted on as above will provide for clinical tests to ascertain the performance of various countermeasures in terms of such variables, as field of view, detection range and probability, clutter rejection, interference, and sensitivity to weather and ambient lighting, for example. In addition, a careful sorting of the large data bases, such as GES, can provide for distributions of crash factors that can be simulated in a Monte Carlo approach. This approach of utilizing two forms of simulation follows closely what was done on the effort reported in the document: "Assessment of IVHS Countermeasures for Collision Avoidance: Rear-End Crashes" (Reference 5). We feel that the combination of clinical cases and statistically sampled scenarios will be superior to the factorial approach employed in the work reported in Backing II and Lane Change II. The factorial approach utilizes single variable values to represent the wide variation of parameters that can occur in the tails of these distributed values. On the other hand, the Monte Carlo approach allows for a variety of values to be sampled while maintaining the correct probability distribution.

We will depart from the Rear-End report just referenced in that we will take a more detailed look at the human factors involved in any type of countermeasure. Through both driver simulation and use of the actual vehicle testbed, the reactions of a variety of drivers to various warning modalities will be ascertained. These will include, visual, auditory, and haptic signals. In addition, the effects of nuisance and false alarms will be evaluated as to their frequency and distribution. The positioning, intensity, and information-content of these warnings will also be addressed.

Another factor to be considered when performing the clinical studies involves the statistical sampling accuracy of the hard copies. Results based on that small sampling must be confirmed by analyzing the large data bases for confirmation. Clearly, a result derived from a non-representative set of accidents is suspect. Only statistically sound approaches to data sampling are employed during our study. In addition, cross-checking with the large data bases is made.

3.3 Conclusion

We believe that these reports (References 1 through 4) have laid a very useful foundation for the planned tasks in this program. The preliminary sorting of the various collision types has established the first-cut distributions and taxonomies. In an attempt to include all possible accident types that could be avoided by a lane change/merge or backing CAS, we have expanded the scope and refined the categories of the taxonomies already developed. Our taxonomies are discussed in Sections 4.3 and 4.4 with size assessments and standard errors. In order to compare vehicle- and driver-level characteristics between striking and struck vehicles, we have restricted our studies to two-vehicle crashes. With this restriction, the numbers and percentages quoted here may be somewhat less than those quoted in other studies with no restrictions on the number of vehicles involved. Lane Change I identifies lane change/merge crashes as 4.0 % of the GES total while the similar subset of crashes in our study is 3.4 %. In our study, lane change/merge crashes with no injury range between 64 and 99 % of the totals with a weighted average of 83.8 % compared with 82.8 % found in Lane Change I. For the backing crashes, direct detailed comparisons are difficult due to differences in backing categories. The total in our study is 232,844 or 3.9 % of the total compared to 181,500 or 2.8 % found in Backing I. Directly comparable are the categories of striking a pedestrian or pedacyclist. In our study the total is 3,992 or 0.07 % of the GES total compared with the 3000 or 0.04 % found in Backing I. Various causal factors have been identified in these reports, but their statistical significance has not been evaluated. Detailed discussions of our analyses are presented in Sections 5.1 and 5.2. The clinical study performed for the rear-end case has established an informative methodology. We have adopted that approach for our analyses of the CDS hard copies, as presented in Section 6.0.

4.0 DATABASES AND ANALYSIS

Each database consists of several electronic data files containing numerous observations that can be processed using the SAS System. Each observation contains a succession of fixed data fields, each data field containing integer information pertaining to the variable assigned to that field.

The SAS System is a software system for data analysis specifically developed for the statistical analysis of database information. The SAS language and procedures are structured to provide the processes required for multilevel and multivariate data processing, statistical analysis, summarizing and reporting.

4.1 The GES database

In the 1992 GES data set, there are 237,927 observations, each observation corresponding to an involved person (driver, occupant, pedestrian, etc.). These observations correspond to 46,197 crashes involving 80,566 vehicles. When weighting factors are applied, these 46,197 crashes are representative of 5,982,606 police reported accidents (standard error 433,760). Thus when taken with the weighting factors, the observations in the 1992 GES can be considered to be a summary of the nation's traffic crash experiences in 1992.

Initially, each observation contains 23 accident level variables, 34 vehicle level variables, 6 driver level variables and 18 person level variables. Thus there is a minimum of 81 variables in addition to the case number identifier and the appropriate case weighting factor. Also there may be several other derivative variables, such as STYLE which is derived from bodytype. Not all of these variables are directly useful to the analysis required. For this reason, a smaller database was created in which a number of variables were dropped. The number of observations, however, remains the same. This smaller database was transferred from the computer at UTSA to the computer at TRW and much of the subsequent analysis was performed at TRW. The list of backing crash case numbers used in the clinical study is also generated using this database.

The list of remaining variables with definitions is found in Table 4.1-1.

TABLE 4.1-1: Variables Remaining in the Partitioned GES Database. The levels A, V, P and D refer to accident level, vehicle level, person level and driver level variables respectively.

Variable	Level	Label
ACC_TYPE	V	ACCIDENT TY-PE
ACTION	P	NON-MOTORISTS ACTION
AGE-H	P	HOTDECK IMPUTED AGE
ALCH_H	P	HOTDECK IMPUTED POLICE REPORTED ALCOHOL INVOLVEMENT
ALCHL_I	A	IMPUTED ALCOHOL INVOLVED IN CRASH (DERIVED)
ALIGN-I	A	IMPUTED ROADWAY ALIGNMENT
BDYTYP_H	V	HOTDECK IMPUTED BODY TYPE
CASENUM	A	CASE NUMBER
DAM-AREA	V	DAMAGE AREAS
DEFECT	V	VEHICLEDEFECTS
DR_DSTRD	D	DRIVER DISTRACTED BY
DRMAN_AV	D	DRIVER MANEUVERED TO AVOID
EVENT1_I	A	IMPUTED FIRST HARMFUL EVENT
HOUR-I	A	IMPUTED HOUR OF CRASH
IMPACT-H	V	HOTDECK IMPUTED INITIAL POINT OF IMPACT
IMPAIRMT	P	PERSONS PHYSICAL IMPAIRMENT
INJSEV_H	P	HOTDECK IMPUTED INJURY SEVERITY
INT_HWY	A	INTERSTATE HIGHWAY
LAND-USE	A	POPULATION OF IMMEDIATE AREA
LGTCON_I	A	IMPUTED LIGHT CONDITION
LOCATN	P	NON-MOTORIST LOCATION
MANCOL_I	A	IMPUTED MANNER OF COLLISION
MAXSEV_I	A	IMPUTED MAXIMUM INJURY SEVERITY (DERIVED)
MINUTE-I	A	IMPUTED MINUTE OF THE CRASH
NON_INVL	A	NUMBER OF NON-MOTORISTS
NUM_LAN	A	NUMBER OF TRAVEL LANES
P_CRASH1	V	MOVEMENT PRIOR TO CRITICAL EVENT
P-CRASH2	V	CRITICAL EVENT
P-CRASH3	V	CORRECTIVE ACTION ATTEMPTED
P-CRASH4	V	VEHICLE CONTROL AFTER CORRECTIVE ACTON
P_CRASH5	V	VEHICLE PATH AFTER CORRECTIVE ACTION
PED_ACC	A	PEDESTRIAN/CYCLIST ACCIDENT TYPE
PER-DRUG	P	POLICE REPORTED DRUG INVOLVEMENT
PER-TYPE	P	PERSON TYPE

PERNO	P	OCCUPANT PERSON NUMBER
PROFIL_I	A	IMPUTED ROADWAY PROFILE
REL_RWY	A	RELATION TO ROADWAY
RELJCT_I	A	IMPUTED RELATION TO JUNCTION
RES_SYS	P	RESTRAINT SYSTEM USE
RUR_URB	A	PERCENT RURAL
SEX-H	P	HOTDECK IMPUTED SEX
SPDLIM_H	A	HOTDECK IMPUTED SPEED LIMIT
SPEED	V	TRAVEL SPEED.OF VEHICLE
STYLE	V	DERIVED VARIABLE BASED ON BODY TYPE
SURCON_I	A	IMPUTED ROADWAY SURFACE CONDITION
TRAF_WAY	A	TRAFFICWAY FLOW
TRAILER	V	VEHICLE TRAILING
TRFCON_I	A	TRAFFIC CONTROL DEVICE
V_ALCH_I	V	IMPUTED DRIVER DRINKING IN VEHICLE
V_EVNT_H	V	HOTDECK IMPUTED MOST HARMFUL EVENT
VEH_INCL	A	NUMBER VEHICLES INVOLVED
VEH_SEV	V	DAMAGE SEVERITY
VEHNO	V	CODED VEHICLE NUMBER
VIS_OBSC	D	DRIVERS VISION OBSCURED BY
VLTN_I	D	UNIVARIATE IMPUTED VIOLATIONS CHARGED
VROLE-I	V	UNIVARIATE IMPUTED VEHICLE ROLE
WEATHR_I	A	IMPUTED ASMOSPHERIC CONDITIONS
WEIGHT	A	CASE WEIGHT
WKDY_I	A	IMPUTED DAY OF WEEK

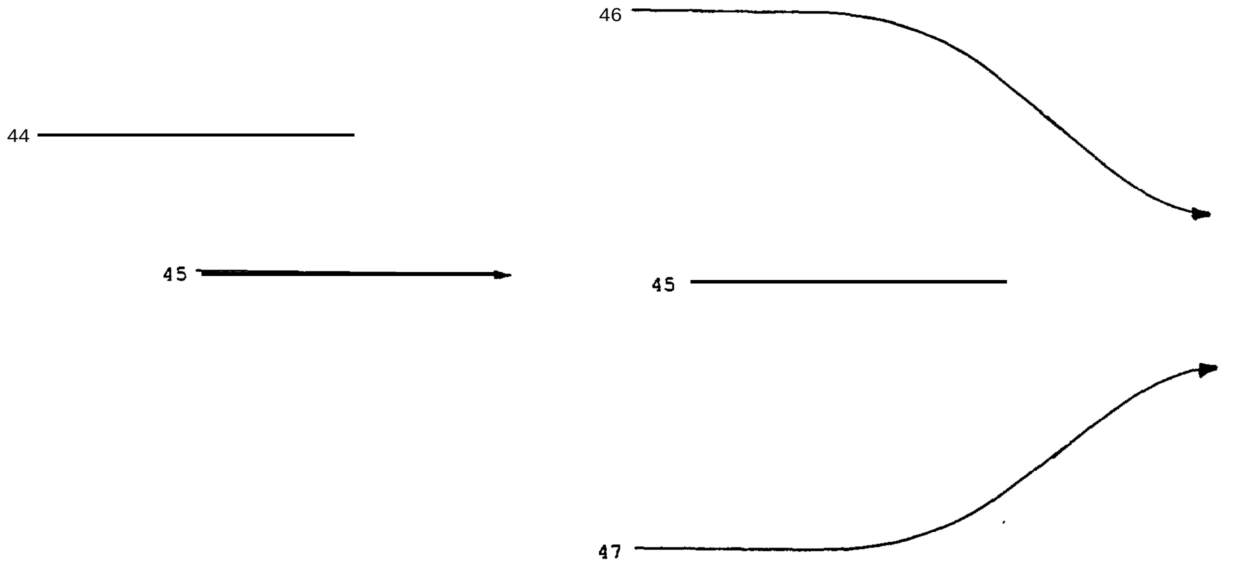
Some of the above variables are extensively used for the purposes of classification. However, most are used only in the descriptive sense. The classification variables are EVENTl_I, V_EVNT_H, MANCOL_I, VROLE_I, P_CRASH1 and ACC_TYPE. The variables coded into the 1992 GES database are tabulated with all possible values in the 1992 GES Data Coding Manual (Reference 6). Useful values of the classification variables are shown in Table 4.1-2.

TABLE 4.1-2: Classification Variables and the Meanings of the Codes.

Variable	Value	Meaning
EVENT1_H	21	Collision with pedestrian
or	22	Collision with cycle or cyclist (pedacycle/pedacyclist)
V_EVNT_H	25	Collision with motor vehicle in transport
	26	Collision with parked motor vehicle
	31-59	Collision with various fixed objects
VROLE_I	1	Vehicle striking
	2	Vehicle struck (Other values are disregarded and the observation is deleted.)
MANCOL_I	1	Rear-end
	4	Angle
	5	Sideswipe, same direction (Other values are not used.)
P-CRASH1	1	Going straight
	7	Leaving a parked position
	13	Backing up (other than for parking purposes)
	16	Changing lanes
	17	Merging (Other values of P_CRASH1 occur in the descriptive statistics section and are explained there.)
ACCTYPE	92	Backing vehicle strikes other vehicle or object

A diagram of the accident types associated with lane change/merge crashes is shown in Figure 4.1-l.

FIGURE 4.1-1: Accident Types Associated with LCM Crashes.



The five vehicle-level precrash variables are designed to describe the sequence of events and responses from the perspective of each vehicle. These precrash variables are

Precrashl: Movement prior to critical event,
Precrash2: Critical event (gives location, nature and responsibility for initiating the critical event),
Precrash3: Corrective action attempted,
Precrash4: Vehicle control after corrective action, and
Precrash5: Vehicle path after corrective action.

In Table 4.1-l a number of variables, such as first harmful event and age, are shown as "imputed" or "hotdeck imputed". Imputation is the process in which missing information is supplied by the means of deducing the most probable value based on one of two methods, namely univariate imputation and hotdeck imputation. (Reference 7 - "Imputation in the NASS General Estimates System") The information may be missing for a variety of reasons: it was not present in the original police report or the information was not available from the statements or diagrams. Frequently it is necessary to make the most reasonable estimate of the missing data.

Imputation has been defined as "the process of assigning values for the missing values to produce a complete data set." Imputation fabricates data when data are unknown. There are two primary reasons to impute data in the GES besides historical precedence: . to provide convenience and consistency to the user by eliminating unknowns where possible and to potentially reduce bias by making intelligent "guesses" about the unknowns. For example, the process of imputation is used to provide the gender of the driver even in hit and run cases for which there is no specific information. Some variables, such as TRAVEL SPEED or SPEED, are not imputed and the unknowns remain in the record.

Univariate imputation refers to the process of randomly substituting values for the unknown variable based on the distribution of known values for the same variable.

"Hotdecking" replaces unknown values with known values from similar records. The process is performed on a case by case basis. For each variable to be imputed, a group of classification variables which do, when matched, identify a nearly identical situation are determined. When such a variable is designated unknown, the system begins looking for a similar case by means of comparing the current values of the classification variables with the values of a those of previously identified set of classification variables for which the variable is known. When the best match is found among the classification variables, the unknown variable is replaced with the value from the matching set. This process may involve several iterations until all the unknowns are replaced.

In the variable list of Table 4.1-1, hotdecked variables have a following H designation and univariate imputed variables have a following I designation. Not all variables are imputed and these maintain the unknown values.

The effects of using data in which missing or unknown values are replaced by imputation serves to dilute the effects of the unusual cases. For hotdeck imputation methods, the value is replaced by one which has already occurred in similar circumstances. In univariate imputation, missing or unknown values are replaced by comparison with existing distributions. Unfortunately, neither method can really replace the missing data with 100 % accuracy, and one can only wonder how much of the database is generated by imputation. Fortunately, imputation is not used with the precrash variables and accident type. Also of the variables used in this study, damage area, vehicle damage severity and travel speed are not imputed values. Unfortunately, generally more than two-thirds of the speeds are missing.

It is possible to encounter a number of unusual artifacts when studying a large database such as the GES database. It should be noted that the numbers reported in the descriptive statistics are those obtained from the database. No effort has been made to "interpret" them or rationalize them. For this reason, the accident type "Forward Impact with Pedestrian" has not been changed, even though the vehicle was backing at the time, based on the value of the Precrashl variable and the police accident reports (PARs). Similarly, when the corrective action is quoted as "backed" for some accidents, this is not interpreted, even though backing might seem like an illogical corrective action for that case.

In the tables of descriptive statistics found in Appendix A, the per cent numbers have been rounded up or down according to the standard procedures. For this reason, the sum may sometimes be 101 or 99 when all contributions are listed. This does not represent inconsistency, only rounding artifacts. In some cases, only the major contributors to any given list are enumerated.

The designation "Other" does not mean that the variable in question is unknown. "Other" means that the variable is known but it is not one of those actions/conditions specifically enumerated in the detailed listing of the possible values of the variable. Ocassionally, "unknown" and "hit and run" are added together, since in both cases, the value of the variable is not known.

The variable LAND-USE is supplied by the GES automated data entry system and indicates if the location of the accident is within a city or town. The value 8 (for "other area") is entered if the accident's location is known to be within a city or town not matched with the codes of 1 through 3 (which indicate various population limits between 25,000 and 100,000+). The value 9 is entered if the accident's location is unclear or no information is available.

The variables ALCHL-I and ALCH-H shown in Table 4.1-1 are in some sense redundant. ALCHL-I is a derived variable reflecting the ALCH-H of the driver of the striking or "at fault" car.

The "police reported drug involvement", a person-level variable, is also examined in each classification of lane change/merge and backing crash. In only three instances is any involvement cited in the weighted 1992 GES statistics: 0.1 % in LCM8, 0.6 % in BACKl, and 2.8 % in BACK8. Details of the type or degree of involvement are not available from the database.

The variable "Driver Maneuvered To Avoid" attempts to identify an action taken by the driver to avoid something or someone in the road before the crash. The maneuver may have subsequently contributed to the cause of the accident. The appropriate value is entered into the GES database, whether or not the maneuver successfully avoided the person or object. The variable "Corrective Action Attempted (Precrash3)" is the movements/actions attempted by the driver to avoid an impending impact after realization of an impending danger, but before the actual event.

The injuries incurred in an accident are described by the person-level variable "Injury Severity". The "Injury Severity" of the driver is taken in order to quantify the severity of the crash. The maximum severity injury associated with the crash is recorded as "MAXSEV" and is a derived accident level variable. In the cases of backing crashes with a pedestrian or pedacyclist, MAXSEV reflects the injury of the pedestrian or pedacyclist, while the driver's injury severity would not reflect the seriousness of the crash. Both driver's injury and MAXSEV are coded by the "KABCO" scheme as shown below:

K = Killed (4)
A = Incapacitating Injury (3)

B = Nonincapacitating Injury (2)
C = Possible Injury (1)
O = No Injury (0)

In addition, driver's injury may be coded as
5 for "injured, severity unknown",
6 for "died prior to accident", and
9 for "unknown".

In the "KABCO" scheme, the numbers in parentheses indicate the integer values of the variable corresponding to that level of injury.

Another method of quantifying the severity of the crash is the vehicle-level variable "Damage Severity". The allowed values of "Damage Severity" are taken from the PAR and range from 0 (No damage) to 3 (Disabling or Severe) with 9 for the unknown vehicle damage severity. These levels are defined as follows:

0 None (No damage indicated on PAR)
1 Minor (e.g., dented fenders, bumpers, grills, body panels, etc.)
2 Functional (Moderate; when the damage is other than disabling but would prevent the vehicle from passing an official inspection: e.g., doors and windows which do not operate properly, broken glass obscuring vision, etc.)
3 Disabling (Severe; when the damage precludes the departure of this vehicle from the scene of the accident in its usual operating manner by daylight after simple repairs.)

The variable "Damage Areas" is a vehicle level variable describing the location(s) of damage on the vehicle. The totality of the damage is used when determining the specific areas.

The vehicle-level variable SPEED refers to the vehicle travel speed which may range from 0 to 97 miles per hour. Unknown travel speeds are coded as 99 or left blank (missing). The posted speed limit is coded as SPDLMT_H in miles per hour. This is a hotdeck imputed, accident-level variable.

Restraint system use is coded in the person-level variable RES-SYS. This is available for the driver of each vehicle involved. The variable RES-SYS may take values from 0, indicating no restraint system use, to 9, indicating "unknown if used". Values from 1 to 8 indicate that some kind of safety equipment was in place at the time of the accident. In the descriptive statistics, the percent of drivers using no restraints is noted and the percent of drivers for which restraint usage is unknown is noted. All restraint types are collected into the one category "restraint system used".

The variable STYLE is derived from the bodytype. Automobiles, light trucks and vans, that is, (15 BDYTYP # 49), are classified STYLE = 1. Trailering trucks, (BDYTYP = 60 or 66 or 79) and (1 TRAILER # 4) , are classified STYLE = 2. Straight trucks, that is, (BDYTYP = 64 or 78) and (TRAILER = 0 or 9) are classified STYLE = 3. Step vans are classified STYLE = 4 and all other vehicles not already classfied are STYLE = 5. The STYLE of both the striking and struck vehicles are noted in the descriptive statistics. The classifications STYLE = 4 or 5 occur very rarely.

4.2 The CDS database

In the 1992 CDS database, there are observations corresponding to 4,956 accidents involving 8,504 vehicles. The CDS database is designed to provide extensive crashworthiness information, such as deformations and penetrations of the passenger compartment, glass breakage, etc. and occupant data, such as location and severity of injuries, condition of driver, etc. Estimates based on the CDS, when weighted, are used to quantify the losses due to motor vehicle crashes.

In an effort to assess the effectiveness of design modifications to improve safety, the CDS concentrates on later model vehicles. Therefore, the contents of the CDS is biased toward more severe crashes and toward crashes involving later model vehicles. Each observation in the CDS has a derived weighting factor which may vary from values on the order of 10 to several thousand. The list of case numbers studied for lane change/merge maneuvers was taken from this data.

Although many of the variables in the CDS are completely equivalent to those in the GES, there are differences in some of the most important ones. The CDS contains no vehicle role variable, so that it is not obvious whether the lane change/merge vehicle is striking or struck. In some cases it is possible to deduce the vehicle role from the vehicle accident type. In addition, the manner of collision variable is derived, not entered.directly. Finally, the numbering of similar variables - for example, GV64 (Pre-event movement) which corresponds to Precrashl in the GES - is not quite the same (that is, GV64 = 16 in the CDS corresponds to successful avoidance maneuver to a previous critical event while in the GES Precrashl = 16 corresponds to changing lanes, etc.). The variable GV65 (critical precrash event) which is similar to Precrash2 does not assign responsibility for the initiation of the critical event; Precrash2 does. Fortunately, accident type remains precisely the same in both the GES and CDS.

As a point of comparison, the weighted number of two-vehicle crashes (no other restrictions) in the GES is 3,795,707 (standard error 267,033), and the weighted number of two-vehicle crashes in the CDS is 1,185,824. The ratio of the two numbers is 3.2 to 1.

4.3 Lane Change/Merge Crash Classifications

After studying the types of lane change/merge maneuvers, eight classifications are identified. Some of these classifications are further divided by the manner of collision (a taxonomy). The manner of collision - typically same-direction sideswipe, angle or rearend, etc. - is identified by the investigating police officer who completes the PAR. Since it is a matter of judgment in many cases, all possibilities should be examined. For this reason the eight classifications are in some cases further divided by the manner of collision. A summary of the classifications and the weighted number populations follows in Table 4.3-l. Detailed diagrams of each classification may be found in the accompanying Figure 4.3-l.

TABLE 4.3-l : Summary of Lane Change/Merge Crash Classifications (Standard errors appear in parentheses.)

Number	Name	Description
86,055 (8,222)	LCM1	the vehicle changing lanes or merging strikes another vehicle going straight; the manner of collision is “angle”; should be considered in conjunction with LCM7
25,201 (3,292)	LCM2	the vehicle changing lanes or merging is struck by another vehicle going straight; the manner of collision is “angle”
7,986 (1,537)	LCM2A	the vehicle changing lanes or merging ‘is struck by another vehicle going straight; the manner of collision is “sideswipe”
22,614 (3,052)	LCM3 (DRIFTING)	neither vehicle intends to change lanes or merge; both vehicles are going straight but they drift together in a “sideswipe” collision
26,003 (3,365)	LCM3A (DRIFTING)	neither vehicle intends to change lanes or merge; both vehicles are going straight but they drift together in an “angle” collision

10,656 (1,845)	LCM4	the vehicle changing lanes or merging is struck in the rear by the car going straight
21,805 (2,976)	LCM5	a vehicle leaves a parking place and strikes or is struck by another vehicle; the following three classifications are included.
	LCM51	vehicle leaving a parked position strikes another vehicle (angle or sideswipe, same direction) - 14,673 crashes
	LCM52	vehicle leaving a parked position is struck by another vehicle (angle or sideswipe, same direction) - 6,444 crashes
	LCM53	vehicle leaving a parked position is struck by another vehicle in a rearend crash - 688 crashes
4,790 (1,128)	LCM6	both vehicles are changing lanes or merging
78,859 (7,677)	LCM7	the vehicle changing lanes or merging strikes another vehicle going straight; the manner of collision is sideswipe; should be considered in conjunction with LCM1
16,351 (2,445)	LCM8	the vehicle changing lanes or merging strikes another vehicle in the rear end

In 1992, there are a total of 300,320 lane change/merge crashes (standard error 23,236) as determined from the GES analysis described above. This is 5.0 % of the 5,982,606 police reported crashes represented by the GES. The set corresponding to dual lane changers which would otherwise be included in several categories has been removed. Please note that LCM3, LCM3A, LCM5 and LCM8 have not previously been included as lane change/merge maneuvers. Without these categories, the total is 213,547 crashes (standard error 17,314) which is 3.4 % of the total. A detailed discussion of the descriptive statistics of lane change/merge crashes as determined from the GES is found in Apppendix A.I.

Figure 4.3- 1: Diagrams of the Classifications of Lane Change/Merge Crashes

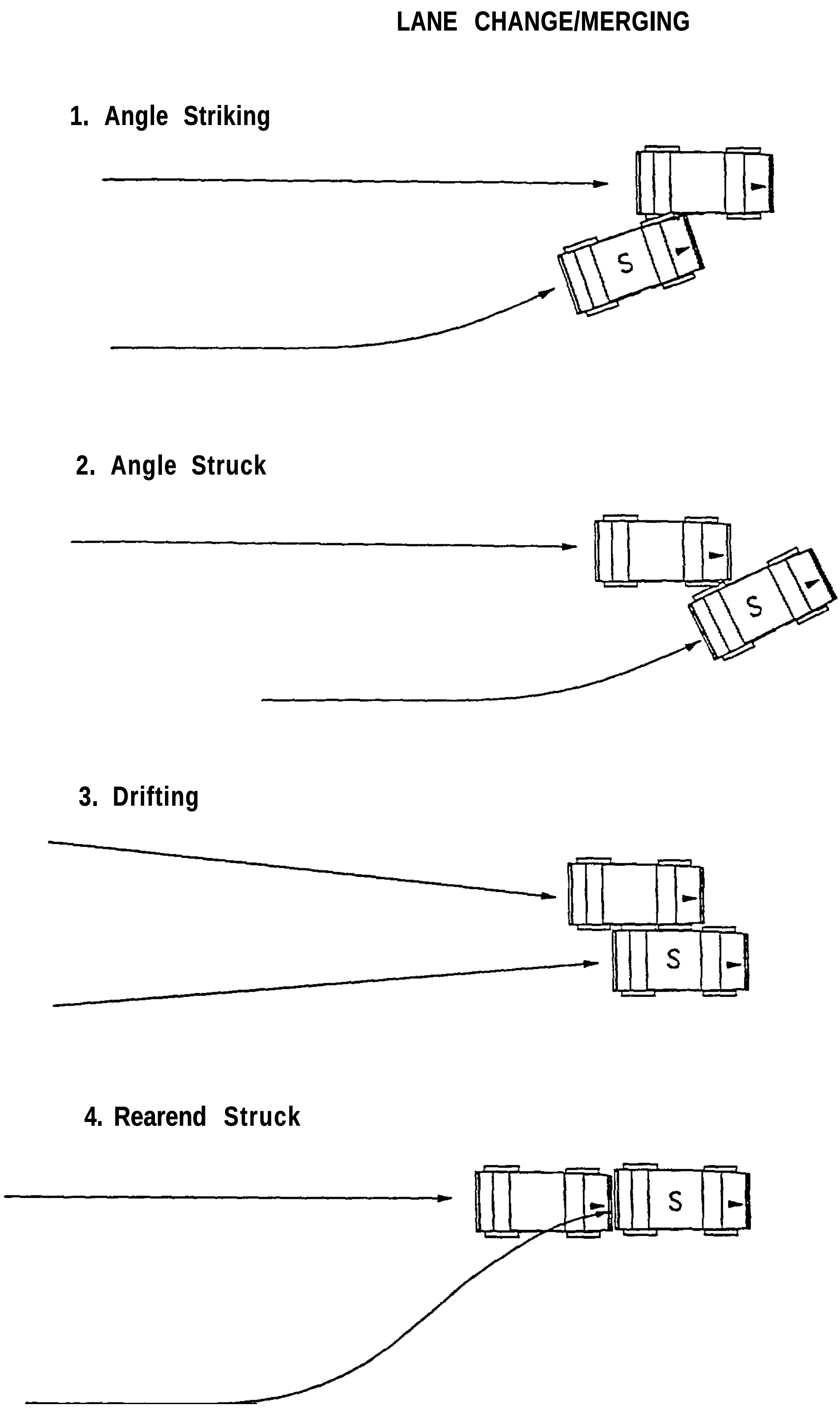
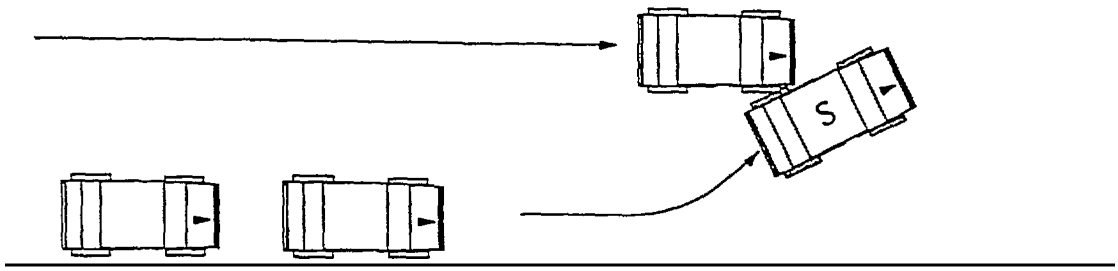


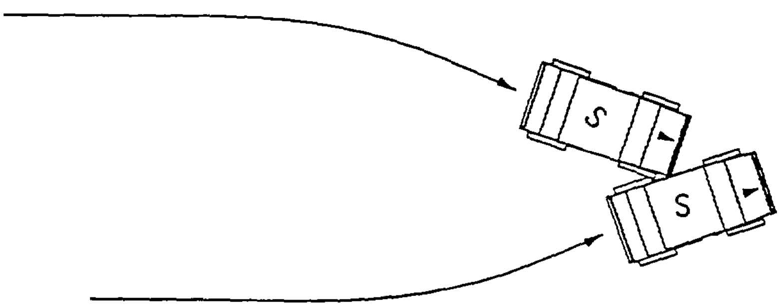
FIGURE 4.3-l (continued):

LANE CHANGE/MERGING

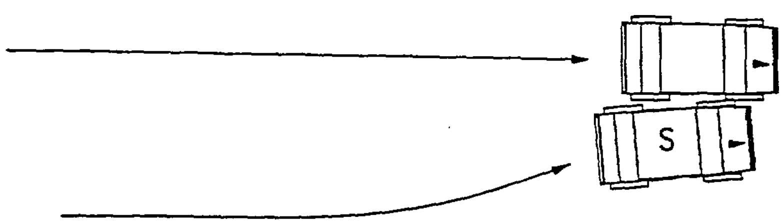
5. Leaving A Parking Place



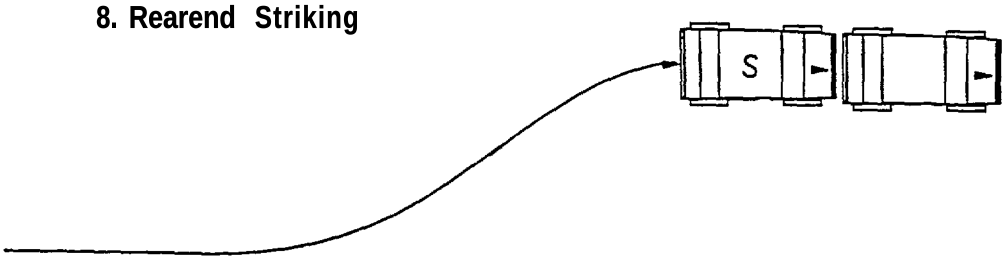
6. Both Changing Lanes



7. Sideswipe



8. Rearend Striking



4.4 Backing Crash Classifications

After studying the types of backing crashes, eight classifications are identified corresponding to backing maneuvers. A summary of the classifications and the populations follows in Table 4.4-l. Detailed diagrams of each classification of one-vehicle and two-vehicle backing crashes may be found in Figures 4.4-l and 4.4-2.

TABLE 4.4-1: Summary of Backing Crash Classifications

Number	Name	Description
3,177 (8 9 1)	BACK1 (STRIKING PEDESTRIAN)	the vehicle which is backing strikes a pedestrian
815 (444)	BACK2 (STRIKING PEDACY CLIST)	the vehicle which is backing strikes a pedacycle/pedacyclist
101,728 (9,389)	BACK3 (BACKING AND STRIKING)	the vehicle which is backing strikes another motor vehicle in transport ("parallel backing" is removed)
69,676 (6,973)	BACK4 (STRIKING A PARKED CAR)	the vehicle which is backing strikes a parked motor vehicle (or other motor vehicle not in transport)
25,920 (3,358)	BACK5 (STRIKING A PARALLEL PATH VEHICLE)	the backing vehicle strikes another vehicle stopped behind (at an intersection, railroad crossing, traffic control device or sign, etc.)
4,500 (1,087)	BACK6 (LEAVING A PARKING SPACE)	the backing vehicle is leaving a parking space and strikes a motor vehicle in transport
14,529 (2,259)	BACK7 (STRUCKBY A VEHICLE IN TRANSPORT)	backing vehicle is struck by motor vehicle in transport
12,499 (2,046)	BACK8 (STRIKING A FIXED OBJECT)	the vehicle which is backing strikes a fixed object

The total number of the backing crashes listed above is 232,844 (standard error 18,641), which is 3.9 % of the 5,982,606 crashes represented by the GES. A detailed discussion on the descriptive statistics of backing crashes as determined from the GES is found in Appendix A, sections A.2 and A.3.

Figure 4.4-1: Diagrams of the Classifications of One-Vehicle Backing Crashes

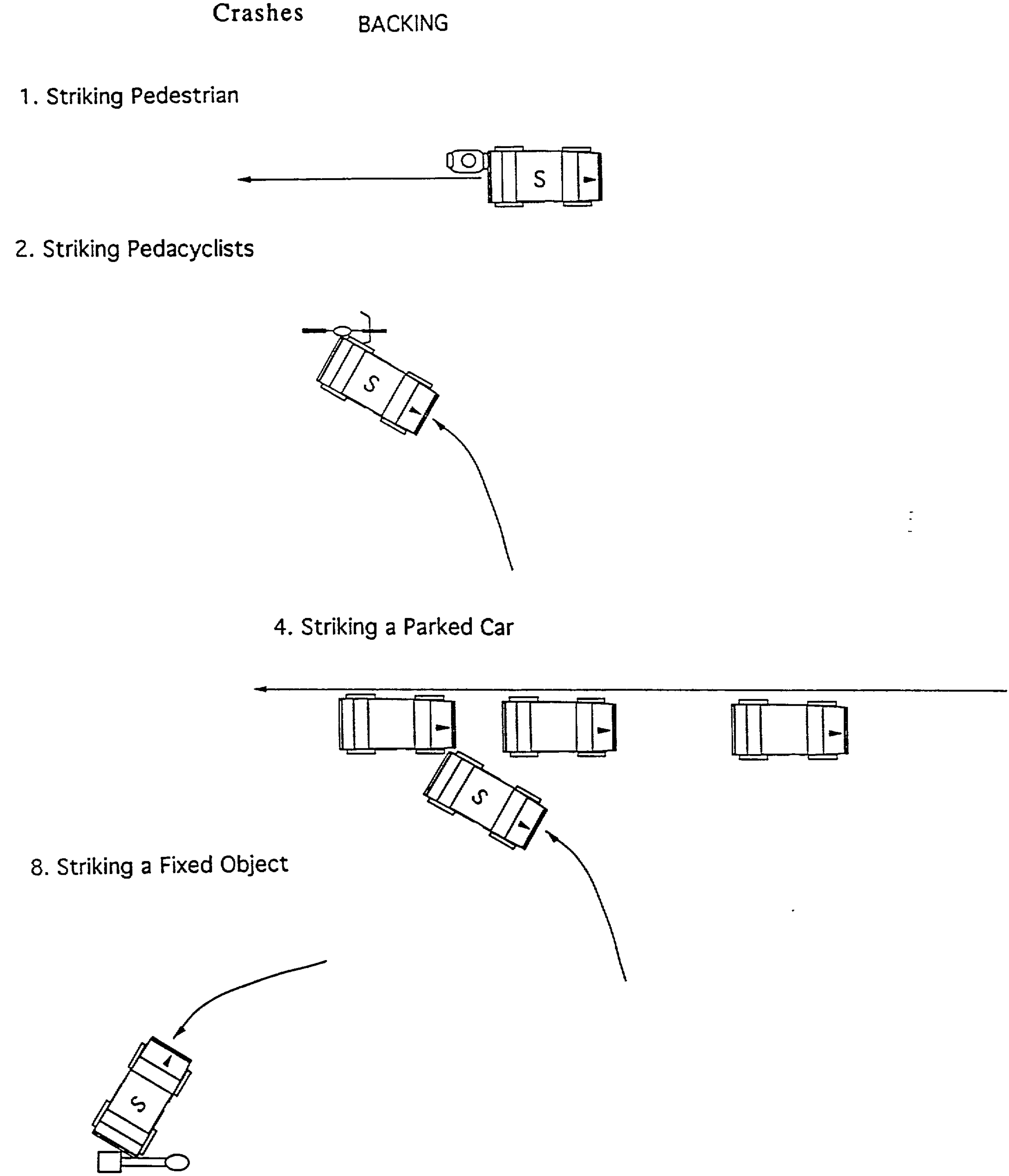
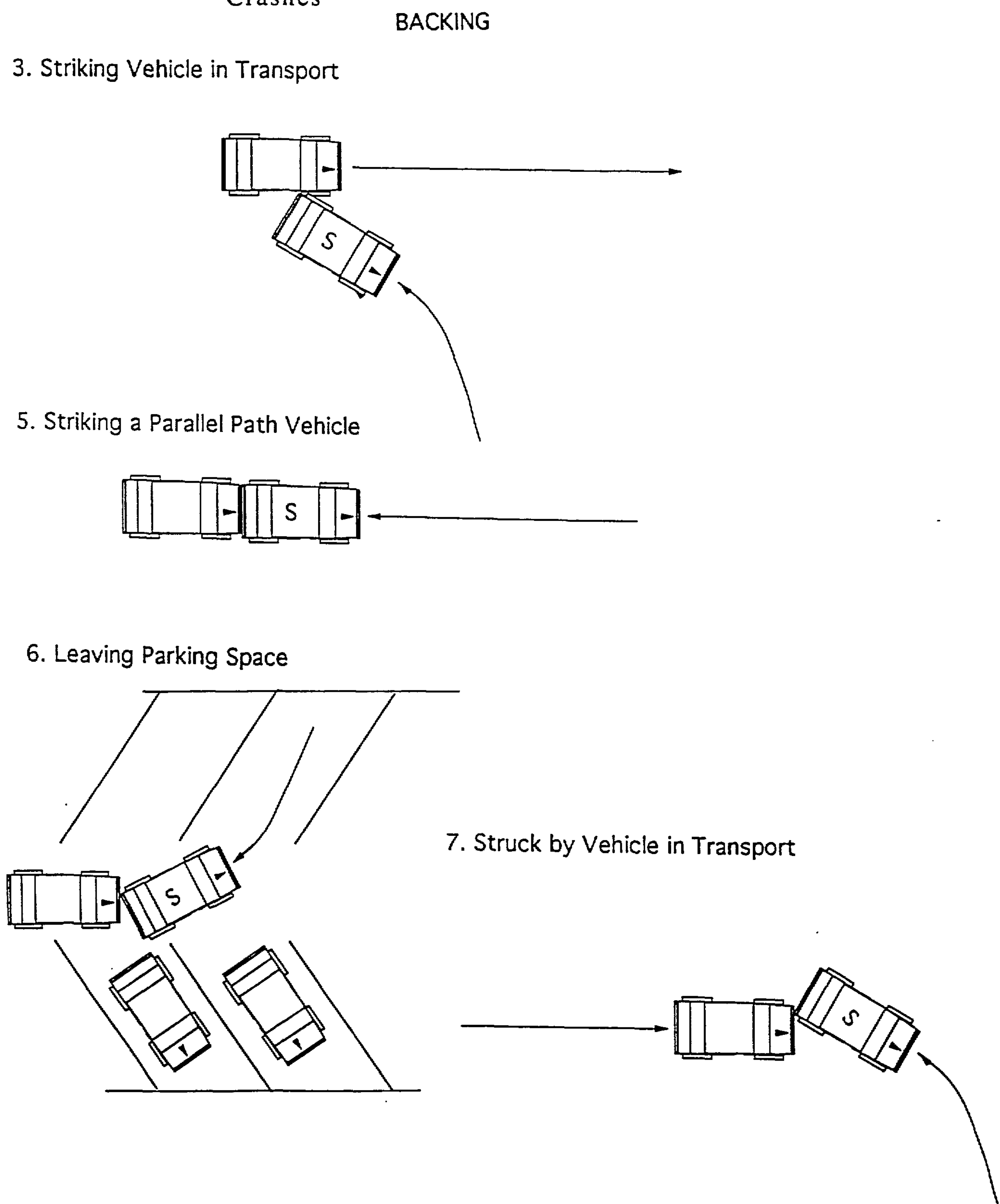


Figure 4.4-2: Diagrams of the Classifications of Two-Vehicle Backing Crashes



4.5 Loss due to Lane Change/Merge and Backing Crashes

Although it is important to compare the crashes in terms of numerical populations, it is not the only measure of the impact of vehicIe crashes on the economy or society. Different classifications of crashes are not equivalent in terms of frequency or severity. In order to quantify and compare the total damage or loss caused by different classifications of crashes, a suitable measure of severity applicable to all crashes and all levels of severity must be found.

One method consists of converting the accident-level variable MAXSEV given with respect to the KABCO rating scheme (Please see page 19 for further explanation) into Fatal Crash Equivalents (FCEs). Each injury level of the KABCO scheme is given a corresponding dollar value appropriate to the damage and loss inflicted (Reference 3). As shown in Table 4.5-l these dollar values are converted into FCE where the FCE for a fatal crash is 1.0. Then it is possible to find the most serious classification of accidents by comparing the total FCE sums, or alternatively, it is possible to find the most dangerous classification of accident by comparing the values of FCEs per crash. These quantities are shown in Tables 4.5-2 and 4.5-3 in which lane change/merge crashes are ranked according to the total FCE sums and the FCE rates respectively. The same categories of lane change/merge crashes were combined to study the major classifications of accidents. This is discussed more fully in section 5.1.1. Finally, it should be noted that one FCE (one fatality) is given a dollar equivalent of $ 2,722,548 in 1988 dollars which becomes $ 3,254,480 in 1993 dollars.

TABLE 4.5-l : “Fatal Equivalents” Crash Severity Scale

Crash Severity (Most severely-Injured Occupant)	Comprehensive $ Value Per Crash (1988 Dollars)	Fatal Crash Equivalent (FCE)
Fatality (K)	$ 2,722,548	1.0000
Incapacitating (A)	$ 228,568	0.0840
Non-incapacitating (B)	$ 48,333	0.0178
Possible Injury (C)	$ 25,228	0.0093
No Injury Reported (0)	$ 4,489	0.0016
Injury Unreported	$ 4,144	0.0015

Detailed breakdowns of the FCEs for each lane change/merge and backing category are found in Table 4.5-7 at the end of this section.

TABLE 4.5-2: Aggregated Categories of Lane Change/Merge Crashes Ranked by Total Sum of FCEs, Ranked from Highest Total of FCEs to Lowest Total of FCEs

	Fatal Equivalents (FCE)	FCE Per Crash	1993 Dollar Equivalent (Millions)
LCMSTRIKE: 170,014	711	4.3E-3	$2,314
LCM VEHICLE REAR END STRIKING: 16,351	329	2.0E-2	$1,071
LCMSTRUCK: 48,633	310	6.4E-3	$1,009
DRIFTING: 48,6 17	260	5.3E-3	$ 846
LEAVING PARKING STRIKING: 14,673	46	3.1E-3	$ 149
LEAVING PARKING STRUCK: 7,132	16	2.2E-3	$ 53

TABLE 4.5-3: Aggregated Categories of Lane Change/Merge Crashes Ranked by FCE per Crash Ranked from Most Hazardous to Least Hazardous

	Fatal Equivalents (FCE)	FCE Per Crash	1993 Dollar Equivalent (Millions)
LCM VEHICLE REAR END STRIKING: 16,351	329	2.0E-2	$1,071
LCMSTRUCK: 48,633	310	6.4E-3	$1,009
DRIFTING: 48,6 17	260	5.3E-3	$ 846
LCMSTRIKE: 170,014	711	4.3E-3	$2,314
LEAVING PARKING STRIKING: 14,673	46	3.1E-3	$ 149
LEAVING PARKING STRUCK: 7,132	16	2.2E-3	$ 53

Since backing crashes involving pedestrians and pedacyclists have the potential to produce serious injuries and death, the injuries caused by backing crashes are analyzed separately, not using the broad aggregated BACK1 ALL used in Section 5.2. Tables 4.5-4 and 4.5-5 show the one- and two-vehicle backing crash categories, each first ranked by total FCEs associated with that category and then by FCEs per crash associated with that category respectively.

TABLE 4.5-4: Backing Crash Categories Ranked by Total Sum of FCEs, Ranked from Highest Total of FCEs to Lowest Total of FCEs

	Fatal Equivalents (FCE)	FCE Per Crash	1993 Dollar Equivalent (Millions)
WE-VEHICLE BACKING CRASH CATEGORIES:			
Striking a Parked Vehicle:	122	1,8E-3	$ 397
Striking Pedestrian:	92	2.8E-2	$ 299
Striking Fixed Object:	38	3.0E-3	$ 123
Striking Pedacyclist:	10	1.2E-2	$ 32
TWO-VEHICLE BACKING CRASH CATEGORIES:			
Striking a Motor Vehicle in Transport:	227	2.2E-3	$ 739
Backing and Struck (BACK7):	112	7.6E-3	$ 365
Striking a Parallel Path Vehicle:	73	2.8E-3	$ 238
Backing from a Parking Place:	7	1.6E-3	$ 23

TABLE 4.5-5: Backing Crash Categories Ranked by FCE per Crash Ranked from Highest to Lowest

	Fatal Equivalents (FCE)	FCE Per Crash	1993 Dollar Equivalent (Millions)
ONE-VEHICLE BACKING CRASH CATEGORIES:			
Striking Pedestrian:	92	2.8E-2	$ 299
Striking Pedacyclist:	10	1.2E-2	$ 32
Striking Fixed Object:	38	3.0E-3	$ 123
Striking a Parked Vehicle:	122	1.8E-3	$ 397
TWO-VEHICLE BACKING CRASH CATEGORIES:			
Backing and Struck (BACK7):	112	7.6E-3	$ 365
Striking a Parallel Path Vehicle:	73	2.8E-3	$ 238
Striking a Motor Vehicle in Transport:	227	2.2E-3	$ 739
Backing from a Parking Place:	7	1.6E-3	$ 23

From the tables above, one can see the great costs associated with the various kinds of lane change/merge and backing crashes. Since the associated FCE levels place greater weight on the more serious injuries, one might conclude that most of total FCE sum is due to higher rates of incapacitating and/or fatal injuries. However, most crashes do not cause serious injury or death. Significant contributions to the total FCE sum are made by the very large numbers of low damage crashes. In Table 4.5-6 below, the categories or lane change/merge and backing crashes are ranked by the percent of FCE due to the combination of “no reported injuries” (0) and “possible injury” (C). In this case the rankings are from lowest to highest percent of C and 0 injuries. Also included are the projected numbers of fatalities associated with each classification based on the GES.

TABLE 4.5-6: Per Cents of Level C and 0 Injuries for Lane Change/Merge and Backing Crash Categories Ranked from Lowest to Highest

	Total Fatal Equivalents (FCE)	FCEs Due to Injury Levels C and 0	Number of Fatalities (GES)
LANE CHANGE/MERGE CATEGORIES:			
LCM VEHICLE REAR END STRIKING:	329	16 %	201
LCMSTRUCK:	310	40 %	95
DRIFTING:	260	45 %	8
LCMSTRIKE:	711	64 %	10
LEAVING PARKING STRIKING:	46	67 %	0
LEAVING PARKING STRUCK:	16	81 %	0
ONE-VEHICLE BACKING CRASH CATEGORIES:			
Striking Pedestrian (BACKl):	92	13 %	24
Striking Pedacyclist (BACK2):	10	50 %	0
Striking Fixed Object (BACK8):	38	66 %	0
Striking a Parked Vehicle (BACK4):	122	100 %	0
TWO-VEHICLE BACKING CRASH CATEGORIES:			
Backing and Struck (BACK7):	112	31 %	0
Striking a Parallel Path Vehicle (BACK5):	73	70 %	0
Striking a Motor Vehicle in Transport (BACK3):	227	84 %	0
Backing from a Parking Place and Striking (BACK6):	7	100 %	0

Based on the analysis of the 1992 GES database, the fatality rate is 0.0010 fatality/crash for all categories of lane change/ merge crashes and 0.00053 fatality/crash for the traditional set of lane change/merge crashes (LCM1, LCM2, LCM2A, LCM4, LCM6, and LCM7). The rates of FCE per crash associated with fatal and incapacitating injuries (K and A) are 1.8E-3 and 1.7E-3 FCE/crash respectively.

The category of backing and striking a pedestrian (BACKl) is the sole category of backing crashes associated with fatalities in the 1992 GES. The fatality rate for BACK1 is 0.0076 fatality/crash. For BACKl, the rate of FCE per crash associated with injury levels K and A is 0.016 FCE/crash. For all one-vehicle backing crashes taken together, the rate of FCE per crash associated with injury levels K and A is 7.3E-4 FCE/crash. For all two-vehicle backing crashes taken together, this rate is 4.8E-4 FCE/crash. For all backing crashes taken together, this rate is 5.8E-4 FCE/crash.

TABLE 4.5-7: Detailed Breakdown of FCEs Associated with each Category of Lane Change/Merge and Backing Classification

LANE CHANGE/MERGE CRASH CATEGORIES:	Number	Fatal Crash Equivalents (FCE)	Per Cent of Total FCE
LCM1 : 86,055			
Maximum Injury Severity:			
87 % None (0)	74,868	120	31
9 % Possible injury (C)	7,745	72	18
3 % Nonincapacitating evident injury (B)	2,582	46	12
2 % Incapacitating injury (A)	1,721	145	37
0 % Fatal injury (K) (0.012 % in this case)	10	10	3
		393	
LCM2 25,201			
Maximum Injury Severity:			
83 % None (0)	20,917	33	18
11 % Possible injury (C)	2,772	26	14
3 % Nonincapacitating evident injury (B)	756	13	7
1 % Incapacitating injury (A)	252	21	11
0 % Fatal injury (K) (0.36 % in this case)	91	91	49
1 % Unknown severity	252	0	0
		184	
LCM2A 7,986			
Maximum Injury Severity:			
95 % None (0)	7,587	12	55
4 % Possible injury (C)	319	3	14
1 % Incapacitating injury (A)	80	7	32
		22	
LCM3: 22,614			
Maximum Injury Severity			
85 % None (0)	19,222	31	46
10 % Possible injury (C)	2,261	21	31
4 % Nonincapacitating evident injury (B)	905	16	24
		68	

LCM3A: 26,003			
Maximum Injury Severity:			
75 % None (0)	19,502	31	16
14 % Possible injury (C)	3,640	34	18
7 % Nonincapacitating evident injury (B)	1,820	32	17
4 % Incapacitating injury (A)	1,040	87	45
0 % Fatal injury (K) (0.032 % in this case)	8	8	4
		192	
LCM4: 10,656			
Maximum Injury Severity:			
68 % None (0)	7,246	12	17
20 % Possible injury (C)	2,131	20	28
9 % Nonincapacitating evident injury (B)	959	17	24
2 % Incapacitating injury (A)	213	18	25
0 % Fatal injury (K) (0.038 % in this case)	4	4	6
1 % Unknown severity	107	0	0
		71	
LCM51: 14,673			
Maximum Injury Severity:			
89 % None (0)	13,059	21	46
7 % Possible injury (C)	1,027	10	22
1 % Nonincapacitating evident injury (B)	147	3	7
1 % Incapacitating injury (A)	147	12	26
2 % Unknown severity	293	0	0
		46	
LCM52: 6,444			
Maximum Injury Severity:			
94 % None (0)	6,057	10	71
4 % Possible injury (C)	258	2	14
2 % Nonincapacitating evident injury (B)	129	2	14
		14	
LCM53: 688			
Maximum Injury Severity:			
99 % None (0)	681	1	50
1 % Incapacitating injury (A)	2	1	50
		2	

LCM6: 4,790			
Maximum Injury Severity:			
80 % None (0)	3,832	6	40
19 % Possible injury (C)	910	8	53
1 % Nonincapacitating evident injury (B)	48	1	7
		15	
LCM7: 78,859			
Maximum Injury Severity:			
87 % None (0)	68,607	110	38
10 % Possible injury (C)	7,886	73	25
3 % Nonincapacitating evident injury (B)	2,366	42	14
1 % Incapacitating injury (A)	789	66	23
1 % Unknown severity	789	1	0
		291	
LCM8: 16,351			
Maximum Injury Severity:			
64 % None (0)	10,465	17	5
24 % Possible injury (C)	3,924	36	11
7 % Nonincapacitating evident injury (B)	1,145	20	6
4 % Incapacitating injury (A)	654	55	17
1 % Fatal injury (K) (1.23 % in this case)	201	201	61
		329	

ONE-VEHICLE BACKING CRASH CATEGORIES:

BACKl 3,177

Maximum Injury Severity (including pedestrian injuries):

40 % Possible injury (C)	1,271	12	13
49 % Nonincapacitating evident injury (B)	1,557	28	30
11 % Incapacitating injury (A)	349	28	30
1 % Fatal injury (K) (0.77 % in this case)	24	24	26
		92	

BACK2: 815

Maximum Injury Severity (including pedacyclist injuries):

70 % Possible injury (C)	571	5	50
31 % Nonincapacitating evident injury (B)	253	5	50
		10	

BACK4: 69,676

Maximum Injury Severity:

98 % None (0)	68,282	109	89
2 % Possible injury (C)	1,394	13	11
		122	

BACK8: 12,499

Maximum Injury Severity:

92 % None (0)	11,499	18	47
6 % Possible injury (C)	750	7	18
1 % Nonincapacitating evident injury (B)	125	2	5
1 % Incapacitating injury (A)	125	11	29
		38	

TWO-VEHICLE BACKING CRASH CATEGORIES:

BACK3: 101,728			
Maximum Injury Severity:			
94 % None (0)	95,624	153	67
4 % Possible injury (C)	4,069	38	17
2 % Nonincapacitating evident injury (B)	2,035	36	16
		227	
BACK5: 25,920			
Maximum Injury Severity:			
94 % None (0)	24,365	39	53
5 % Possible injury (C)	1,296	12	16
1 % Incapacitating injury (A)	259	22	30
		73	
BACK6: 4,500			
Maximum Injury Severity:			
100 % None (0)	4,500	7	100
BACK7: 14,529			
Maximum Injury Severity:			
73 % None (0)	10,606	17	15
13 % Possible injury (C)	1,889	18	16
11 % Nonincapacitating evident injury (B)	1,598	28	25
4 % Incapacitating injury (A)	581	49	44
		112	

4.6 Testing for Differences between Severe and Non-Severe Lane Change/Merge and Backing Crashes in the GES

The goal of this study is to test for significant differences for the severe lane change/merge and backing crashes versus those with less severe outcomes using the 1992 GES . (Reference - 11) A severe crash (SEVERE = 1) is one which produces incapacitating injury or fatalities (K or A on the KABCO scale), as measured by MAXSEV_I, the accident level variable which reports the worst injury sustained in a crash.

4.6.1 Introduction and Scope

During the course of the two-vehicle lane change/merge (LCM) and backing crash data analysis, many attributes of the LCM and backing crash modes were examined, including the injury severity. Another approach to the investigation of crash severity is to inquire whether the circumstances surrounding severe crashes are different from those surrounding less severe crashes. The following sections address this issue in a general fashion along with some suggestions for future areas of possible investigation.

The attributes to be compared include thirteen accident level variables and fifteen driver/vehicle level variables. The fifteen driver/vehicle level attributes are examined by vehicle role (the lane change/merge vehicle or the backing vehicle is the "SUBJECT" vehicle while the non-subject vehicle is referred to as the "OTHER"), so that there is a total of forty-three individual comparisons. Wherever possible, the variables were categorized into broad areas of dichotomous "risk" so that the issues may be explored in a relatively efficient and simple manner. This is to avoid allowing a potentially massive undertaking to overwhelm the original mission of this study.

The risk variables are explained in Table 4.6.1-1. The original variables may be correlated with those in Table 4.1-l beginning on page 13.

TABLE 4.6.1-1: Table of Risk Variables in which Accident-Level Variables are designated A and Driver/Vehicle-Level, DV

ORIGINAL VARIABLE	NEW VARIABLE	LEVELS	FILE	DEFINITION
MAXSEV_1	SEVERE	0,1	A	IF INCAPACITATING OR FATAL MAXIMUM SEVERITY ACCIDENTS THEN SEVERE =l
AGE-H	YOUTH	0,1	DV	IF AGE IS LESS THAN OR EQUAL TO 25 THEN YOUTH=1
AGE-H	OLDER	0,1	DV	IF AGE IS GREATER THAN OR EQUAL TO 75 THEN OLDER =l
	MANEUVER	0,1	DV	IF A DRIVER MANEUVER WAS ATTEMPTED THEN MANEUVER=1
ALIGN-I	CURVE	0,1	A	IF NOTED ON CURVE THEN CURVE =l
PROFIL-I	HILL	0.1	A	IF ON GRADE or HILLCREST THEN HILL = 1
SURCON-I	MESSYARD	0,l	A	IF THE ROAD HAS MUD, SLUSH, WATER, or OTHER THEN MESSYRD=l
TRFCON-I	CONTROL	0,l	A	IF THERE IS ANY TRAFFIC CONTROL DEVICE THEN CONTROL=1
LGTCON_I	DARKDUSK	0,l	A	IF DAWN, DUSK, NIGHT, LIGHTED NIGHT or OTHER THEN DARKDUSK =l
HOUR-1 AND WKDY-1	WEEKEND	0,1	A	IF AFTER SIX ON FRIDAY TO SIX AM SUNDAY THEN WEEKEND=1
NUM-LAN	NUMLAN	0,l	A	IF NUMBER OF LANES GREATER THAN 3 THEN NUMLAN =l
RELSPEED	CLOSE FAST	0,l	A	IFTHEABSOLUTEVALUEOF THE RELATIVE ESTIMATED SPEED IS GREATER THAN 35 MPH THEN CLOSE FAST =l
WEATHR-I	WEATHER	0,1	A	IF THE WEATHER IS OTHER THAN CLEAR AND DRY THEN WEATHER =l

ALCHL_I	DWI	0,1	A	IF ALCOHOL IS INVOLVED WITH CRASH THEN DWI =1
RELICT-1	INTER-CHANGE	0,1	A	IF INTERCHANGE AREA AS DEFINED BY GES THEN INTERCHANGE =l
RELJCT_I	NON-JUNCTION	0,1	A	IF CONTIGUOUS ROADWAY (NO DRIVEWAY&LY, ETC.) THEN NON-JUNCTION=1
VLTN-I	VIOLATION	0,l	DV	IF A CITATION WAS ISSUED THEN VIOLATION =l
SPEED	FAST	0,1	DV	IF SPEED GREATER THAN 55 MPH THEN FAST =l
SPEED	SLOW	0,1	DV	IF SPEED LESS THAN or EQUAL TO 20 MPH THEN SLOW =1
SEX-H	FEMALE	0,1	DV	IF DRIVER'S SEX = 1 THEN FEMALE=1
VEH-SEV	DAMAGE	0,1,2,3	DV	DAMAGE RANGES FROM NO DAMAGE (0) TO UNABLE TO. DRIVE (3)
REST-SYS	RESTRAINT	0,l	DV	IF RESTRAINTS ARE USED THEN RESTRAINT =l
P-CRASH4	SKID	0,1	DV	IF SKIDDING IS NOTED THEN SKID =l
STYLE	CAR	0,1	DV	IF VEHICLE IS PASSENGER CAR THEN CAR =l
VIS-OBSC	VISION	0,1	DV	IF VISION IS OBSCURED THEN VISION =l
DR-DSTRD	DISTRACT	0,l	DV	IF DRIVER IS DISTRACTED THEN DISTRACT=1
P-CRASH2	DEFECT	0,1	DV	IF A DEFECT IS NOTED THEN DEFECT=1
V_ALCH_I	VEHICLE ALCOHOL	0,1	DV	IF ALCOHOL IS NOTED IN VEHICLE THEN VEHICLE ALCOHOL =1

As stated previously, a severe crash (SEVERE = 1) is one which produces incapacitating injury or fatalities (K or A on the KABCO scale), as measured by MAXSEV-I, the accident level variable which reports the worst injury sustained in a crash. The percentage of the 1992 GES data with this designation ranges from zero (BACK2, striking a pedacyclist) to twenty-four percent (BACKl, striking a pedestrian). Due to the relatively small proportion of severe crashes in the majority of the files, the data were examined in eight combination aggregate files. Table 4.6.1-2 reports the file names and contents for the aggregate files examined. Note that the files do not include some categories, such as leaving a parking place (LCM5) or drifting (LCM3 and LCM3A).

TABLE 4.6.1-2: The Data Sets

DATA SET NAME	DATA IN BASE	NUMBER OF CRASHES	GES FILE NAME
LCM ALL	LCM STRIKE AND LCM STRUCK	1521*	LCMl LCM2 LCM2A LCM4 LCM7 LCM8
LCM STRI	LCM STRIKE	1368*	LCMl LCM7 LCM8
LCM STRU	LCM STRUCK	153*	LCM2 LCM2A LCM4
BACK ALL	BACKING, TWO VEHICLE, STRIKE AND STRUCK	677*	BACK3 BACK5 BACK6 BACK7
BACK STRI	BACK TWO VEHICLES STRIKE	571”	BACK3 BACK5 BACK6
BACK STRU	BACK TWO VEHICLES STRUCK	106*	BACK7
BACKPED	BACK SINGLE VEHICLE WITH ONLY PEDESTRIANS AND PEDACYCLISTS	61	BACK1 BACK2
BACKONE	BACKING, SINGLE VEHICLE STRIKING	393	BACK1 BACK2 BACK4 BACK8

* The number of individual observations is equal to twice the number of crashes, one observation being the SUBJECT vehicle and the other observation being the non-subject (OTHER) vehicle.

4.6.2 Methodology

First, the included variables were categorized into general “risk” variables (Table 4.6.1-1). Then, using SAS procedure for the General Linear Models, the means of these variables were statistically compared using Duncan’s multiple range test.

Duncan’s multiple range test is a widely used procedure for comparing pairs of means. It is performed by comparing the treatment averages

(SEVERE = 1 or SEVERE = 0) to the sample standard error times Duncan's significant range.

The sample standard error is the root of the mean square error to sample size ratio. As the sample sizes were uneven, the harmonic mean of n was used (equal to the number of samples divided by the sum of the inverse sample sizes).

Duncan's significant range is found in tables based on the degrees of freedom (number of observations less the number of treatments, in this case the number in the sample less two) and the significance level, alpha here chosen to be 0.05. This alpha is the probability of rejecting the null hypothesislgiven that it is true. The null hypothesis which this study tests is that the means are equal across the treatments (severities of crashes).

As the sample standard error is based on the number of observations, we chose to preserve the actual total number of observations (two for each crash in the two vehicle crash sets) in each sample so as not to seriously limit the power of the test. The GES weights were used to retain the relative proportion for each observation of each sample.

4.6.3 Results

There exist significant differences between the severe and less severe LCM and backing crash populations as exhibited by their differing means. These differences were found in the accident level variables and both sets of driver/vehicle level attributes as shown in Tables 4.6.3-1, 4.6.3-2 and 4.6.3-3. In the following tables, "N/A" is used for accident-level variables to indicate "not applicable".

TABLE 4.6.3-l: Results of Duncan's Multiple Range Test for LCM Crashes

DATABASE	VARIABLE	VEHICLE	MEAN (SEVERE)	MEAN (NOT SEVERE)
LCM ALL	DARKDUSK	N/A	0.41	0.24
LCM ALL	CLOSE FAST	N/A	0.10	0.01
LCM ALL	DWI	N/A	0.17	0.035
LCM ALL	INTERCHANGE	N/A	0.10	0.042
LCM ALL	WEEKEND	N/A	0.29	0.20
LCM ALL	FAST	SUBJECT	0.38	0.068
LCM ALL	DAMAGE	SUBJECT	2.335	1.4
LCM ALL	RESTRAINT	SUBJECT	0.68	0.91
LCM ALL	CAR	SUBJECT	0.8	0.88
LCM ALL	FAST	OTHER	0.148	0.041
LCM ALL	SLOW	OTHER	0.021	0.078
LCM STRI	DARKDUSK	N/A	0.42	0.24
LCM STRI	CLOSE FAST	N/A	0.11	0.01
LCM STRI	DWI	N/A	0.19	0.037
LCM STRI	INTERCHANGE	N/A	0.11	0.032
LCM STRI	WEEKEND	N/A	0.30	0.21
LCM STRI	FAST	SUBJECT	0.44	0.07
LCM STRI	DAMAGE	SUBJECT	2.28	1.40
LCM STRI	RESTRAINT	SUBJECT	0.69	0.90
LCM STRI	CAR	SUBJECT	0.77	0.88
LCM STRI	AGED	OTHER	0.039	0.011
LCM STRI	FAST	OTHER	0.17	0.035
LCM STRI	SLOW	OTHER	0.024	0.018
LCM STRU	CURVE	N/A	0.31	0.08
LCM STRU	DAMAGE	SUBJECT	2.74	1.37
LCM STRU	SKID	SUBJECT	0.26	0.05
LCM STRU	DAMAGE	OTHER	2.76	1.56
LCM STRU	RESTRAINT	OTHER	0.56	0.95

TABLE 4.6.3-Z: Results of Duncan's Multiple Range Test for Two-Vehicle Backing Crashes

DATABASE	VARIABLE	VEHICLE	MEAN (SEVERE)	MEAN (NOT SEVERE)
BACK ALL	DARKDUSK	N/A	0.65	0.17
BACK ALL	CLOSEFAST	N/A	0.12	0.009
BACK ALL	DWI	N/A	0.10	0.02
BACK ALL	HILL	N/A	0.41	0.23
BACK ALL	NUM LAN	N/A	0.24	0.21
BACK ALL	FEMALE	SUBJECT	0.33	0.33
BACK ALL	YOUTH	SUBJECT	0.53	0.28
BACK ALL	DAMAGE	SUBJECT	1.14	1.0
BACK ALL	RESTRAINT	SUBJECT	0.58	0.85
BACK ALL	SKID	SUBJECT	0.10	0.02
BACK ALL	DISTRACT	SUBJECT	0.30	0.07
BACK ALL	FAST	OTHER	0.04	0.001
BACK ALL	DAMAGE	OTHER	2.78	1.3
BACK ALL	RESTRAINT	OTHER	0.65	0.89
BACK ALL	VIOLATION	OTHER	0.21	0.05
BACK ALL	CAR	OTHER	0.90	0.97
BACK STRI	DARKDUSK	N/A	0.61	0.15
BACK STRI	CLOSEFAST	N/A	0.061	0.006
BACK STRI	HILL	N/A	0.60	0.22
BACK STRI	CONTROL	N/A	0.71	0.29
BACK STRI	YOUTH	SUBJECT	0.61	0.27
BACK STRI	DISTRACT	SUBJECT	0.56	0.08
BACK STRI	FAST	OTHER	0.06	0.0003
BACK STRI	DAMAGE	OTHER	2.21	1.36
BACK STRI	CAR	OTHER	0.89	0.97
BACK STRU	DARKDUSK	N/A	0.69	0.36
BACK STRU	CLOSEFAST	N/A	0.18	0.037
BACK STRU	DWI	N/A	0.19	0.02
BACK STRU	NUM LAN	N/A	0.48	0.13
BACK STRU	CONTROL	N/A	0.19	0.04
BACK STRU	DAMAGE	SUBJECT	2.6	1.6
BACK STRU	RESTRAINT	SUBJECT	0.5	0.84
BACK STRU	DISTRACT	SUBJECT	0.056	0.00
BACK STRU	CAR	SUBJECT	0.69	0.92
BACK STRU	FEMALE	OTHER	0.088	0.46

BACK STRU	DAMAGE	OTHER	3.0	1.6
BACKSTRU	RESTRAINT	OTHER	0.42	0.83
BACKSTRU	VIOLATION	OTHER	0.41	0.16

TABLE 4.6.3-3: Results of Duncan's Multiple Range Test for Single Vehicle Backing Crashes

DATABASE	VARIABLE	MEAN (SEVERE)	MEAN (NOT SEVERE)
BACKPED	NUMLAN	0.15	0.005
BACKPED	CONTROL	0.24	0.00
BACKPED	FEMALE	0.51	0.26
BACKPED	DISTRACT	0.056	0.37
BACK ONE	NUMLAN	0.20	0.016

Throughout the data files, the obvious "risk" related factors were generally associated with the more severe crashes that is to say, wherever a variable, say alcohol, was indicated as being significantly different, the higher mean was attached to the more serious crashes. Also, the crash artifact of mean vehicle damage severity is consistently shown to have significantly higher values wherever injury was more severe. Therefore, these data appear to respond to these tests in an appropriate fashion. Also it should be noted that the use of restraints is consistently lower in those crashes producing severe injuries, confirming the efficacy of restraint systems in protecting the users from injury.

However, it is important to note not only the categories in which there is a significant difference as shown by Duncan's multiple range tests but also the cases in which there was not a significant difference. Table 4.6.3-4 below is a matrix of all of the tests performed. The tests whose results indicate that significant differences exist are marked by X for accident-level variables, S for SUBJECT-vehicle variables and 0 for OTHER-vehicle variables.

TABLE 4.6.3-4: Matrix of Showing AllDuncan's Multiple Range Tests Performed on Accident-Level Variables, SUBJECT Vehicle Variables and OTHER Vehicle Variables in the Study of Differences between "Severe" and "Non-Severe Crashes

1 Vehicle

←------------------------ 2 Vehicles Crashes ------------------------→ ←--- Crashes →

VARIABLE	LCM ALL	LCM STRI	LCM STR	BACK ALL	BACK STRI	BACL STR	BACK PED	BACK ONE
CURVE			X					
HILL				X	X			
MESSYRD								
CONTROL					X	X	X	
DARKDUSK	X	X			X	X		
WEEKEND	X	X						
NUMLAN				X		X	X	X
CLOSEFAST	X	X		X	X	X		
WEATHER								
DWI	X	X		X		X		
INTERCHANGE	X	X						
NON-JUNCTION								
YOUTH				S	S			
OLDER		O						
VIOLATION				O		O		
FAST	S O	S O		O	O			
SLOW	S O	O						
FEMALE				S		O	S	
DAMAGE	S	S	S O	S O	O	S O		
RESTRAINT	S	S	O	S O		S O		
MANEUVER								
SKID			S	S				
CAR	S	S		O	O	S		
VISION								
DISTRACT				S	S	S	S	
DEFECT								
VEHICLE ALSOHOL								

Excluding the accident level variable SEVERE, there are 12 accident-level variable tests and I5 vehicle level variable tests, for a total of a maximum of 42 possibilities of finding significant differences between severe and non-severe crashes. A total of 320 tests were performed, but differences were found only in 71 tests. For DEFECT, VEHICLE ALCOHOL, MANEUVER, NON-JUNCTION and MESSYRD, no differences were found for any category.

4.6.3.1 Lane Change/Merge Crashes

The lane change and merge crashes with the "subject" vehicle striking dominated the aggregate file due to the greater number of observations in this file. In both the total LCM ALL and the LCM STRI files, the environmental factor which was most abundant in proportion and with significantly different means, is the DARKDUSK indicator. This indicator, of other than daylight conditions, may be useful for the evaluation of sensor effectiveness. These difficult light conditions should not diminish the effectiveness of any sensor as it affects the driver.

Also of possible importance to the evaluation of the design of the sensor is the mean increase of the closing speed (greater than thirty-five mph) associated with the higher severity crashes.

Interchange also has a significant mean difference. This variable does not affect a large proportion of the data and the interpretation of its meaning is not clear. Perhaps this is merely an attribute of increased exposure to more vehicles preparing to turn and changing their lanes. Two accident-level indicators, DWI and WEEKEND, showed differences.

In the lane change/merge and struck vehicle file, LCM STRU, curvature of roadway may indicate another risk factor of design interest.

FAST vehicles (both "subject" and "other") and lower seatbelt usage are associated with the higher injury crashes in the aggregate all LCM and the strike files. This is no surprise due to the higher injury producing speeds available. However, one aspect is intriguing: the slow "other" vehicles in these files show a small but significant difference. Perhaps this is merely another aspect of the fast closing speeds noted in the accident level.

For the struck vehicles, skidding was shown to be attached to the more serious crashes. This is usually indicative of an attempted avoidance maneuver and subsequent loss of control which may not be responsive to technology countermeasures. The lack the numbers of significant differences may only be a result of the smaller data files rather than true homogeneity across severity.

4.6.3.2 Two-Vehicle Backing Crashes

Two factors are of particular interest, DARKDUSK and HILL. Both factors affect a large proportion of these files and are two to over three times more prevalent in the serious crash sample than in that of the less severe crashes.

Number of lanes greater than three, NUMLAN, is also found to be different. It is not known if this could be an indication of a more confusing road configuration, or, similar to interchange in LCM crashes, merely the environment of increased exposure of the backing vehicles to the other vehicles.

Alcohol use is again shown to be associated with the more severe crashes. The proportion of youth, fast drivers and males increases with the more severe crashes.

Of particular interest is that these backing crash drivers have a much higher indicated distraction mean. This extends across all three aggregate files for two vehicle backing and may be important to the ability for a sensor to mitigate the seriousness, as well as the frequency, of these crashes.

In the backing/struck, BACK STRU, as well as the aggregate file with both strike and struck, BACK ALL, a large mean difference was found in the violation cited for the other vehicle. Depending on the type of violation, these crashes may not be amenable to sensor countermeasures. For example, speeding of ‘other’ vehicle may indicate that the usefulness of a warning to the subject driver would be small.

4.6.3.3 Single Vehicle Backing Crashes:

The single vehicle backing crashes files have only sixteen serious crash observations in the sample. Of these, thirteen are in the crashes with pedestrians. The pedestrian crashes have by far the highest level of serious injury reported (twenty-four percent) as would be expected by their lack of crash protection. The data were analyzed for the entire aggregate file (BACKl, BACK2, BACK4, BACK8) and then for only the pedestrian/pedacyclist files.

The only consistent accident level indicator was for the number of lanes. This may be considered due to the increased exposure to number and kinds of environmental obstacles, the increased distraction, and the severity attributes of faster traffic patterns found on larger roadways.

The pedestrian/bicyclist data produced an unusual result. The higher number of females present in the vehicle were associated with the higher severity crashes. This may be a finding or merely and artifact of using a small data set.

4.6.4 Conclusions

Serious injury lane change/merge and backing crash attributes differ from their less severe counterparts in numerous significant ways. The aggregate two-vehicle backing crashes, BACK ALL, has sixteen noted significant differences, and the aggregate lane change/merge file, LCM ALL, has eleven.

Several of these differences represent a large proportion of the sample data base. The most consistently important indicators throughout the files are the dark/dusk, the number of lanes, the environmental factor of a hill (backing), the notation of traffic control and also for backing, the high proportion of the drivers which have indication of distraction.

There are also several differences noted which may affect the level injury mitigation which the various sensor designs may achieve. These include the increased risk of alcohol use, violations cited for the non-subject drivers and higher than thirty-five mph closing speeds.

As this study has demonstrated, this is an area which could benefit from a further, more detailed exploration.

4.6.5 Further Work

This study was performed as a cursory examination of severity in lane change/merge and backing crashes. It entailed the aggregation of various files. Variables were also coarsely categorized.

There are three components of study which could clarify and refine the interpretation of the differences found for the severe lane change merge and backing crashes.

First, further work, similar to that which was performed here, should be done to more clearly define where the identified differences are centered. For example, the DARKDUSK variable should be broken out by the different lighting conditions to assess if there is an unequal contribution made by the lighted roads or the unlighted roads, etc.

Other variables, specifically manner of collision and damage severity, should be examined to further assess the appropriateness of file aggregation. Also, wherever possible, other files not included in this study may be brought into the appropriate aggregate files

Second, when part one is complete, logistic regression should be performed on selected files to model where the serious crashes for LCM and backing crashes differ from the general sample of serious two vehicle crash and, where appropriate, single vehicle sample populations. Several of the noted differences may be similar to that found for all serious crashes (lower restraint use and higher speeds are probable examples). Where they differ, for example the higher female population in the single vehicle backing crashes or increased traffic control, will help target where technology may be most useful for the LCM and backing crashes specifically.

Finally, with the results of the previous two parts, develop a model for the subset of lane change/merge and backing serious crashes versus those with lower severity. This should be performed using the largest aggregate files that were developed in the first part of this proposed study.

Though this research is ambitious, it could be of great importance due to the large number of differences found in this preliminary examination.

5.0 CAUSAL FACTORS AND CRASH AVOIDANCE OPPORTUNITIES

5.1 Crash Causal Factors and Crash Avoidance Opportunities Derived from the Descriptive Statistics

5.1.1 Lane Change/Merge Crashes

A standardized set of tables derived from weighted 1992 GES files for each lane change/merge accident category is found in Appendix A. It is clear that no significant causal factor emerges from this array of data. One would hope for such a factor or cluster of factors to find the best method for avoiding these collisions. Although no such result is evident, important information can be obtained from the data.

Similar categories of lane change/merge crashes were combined to study the major classifications of accidents as shown below:

LCMSTRIKE Crashes = LCMl + LCM7 + LCM6 (changing lanes/merging and striking)

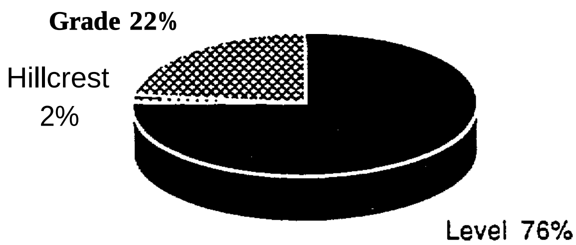
LCM STRUCK CRASHES = LCM2 + LCM2A + LCM4 + LCM6 (changing lanes/merging and subsequently struck)

DRIFTING CRASHES = LCM3 + LCM3A (drifting together where there was no intent to change lanes)

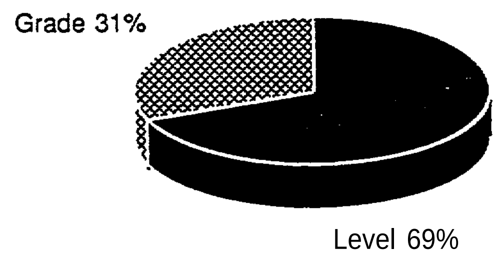
LEAVING PARKING STRUCK = LCM52 + LCM53 (pulling out of a parking space (not backing) and being struck)

Figures 5.1.2-l through 5.1.2-6 compare the environmental conditions - such as roadway profile, roadway alignment, weather, surface conditions, lighting conditions and the relation to junction - present for each of the major categories of lane change/merge accidents. It is easily seen that approximately two-thirds or more of these accidents occur under the benevolent environmental conditions of daylight, clear weather, dry road surface and level roadway. In addition, more than 60 % occur on areas of the roadway which are “non-junction”. In other words, the driver would seem to be under no external stresses due to driving conditions or the proximity of an intersection. It is possible to infer that crashes under these conditions may be due to driver inattention. The driver’s attention would be more focused if there were some outside condition the driver would perceive as dangerous, for example, an intersection. Without a determination of the “metric of exposure” or “exposure measure”, that is, the ambient conditions characterizing normal, non-crash driving experiences, one cannot compare these percentages to infer causal factors. The “metric of exposure” includes not only driver and vehicle characteristics, such as driver age and gender, vehicle body type, alcohol involvement, and so on, but also accident-level roadway characteristics and conditions , such as roadway alignment, profile, relation to junction, traffic control, lighting conditions, surface conditions, weather, and so forth.

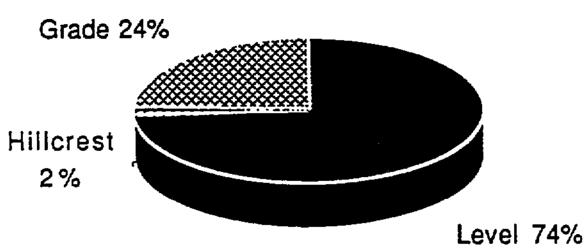
FIGURE 5.1.2-l: LCM Collisions by Road Profile



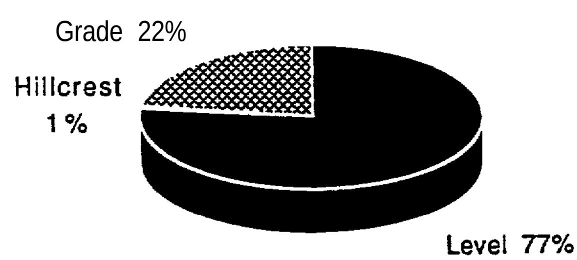
LCM Striking Collisions



Leaving a Parking Place Collisions

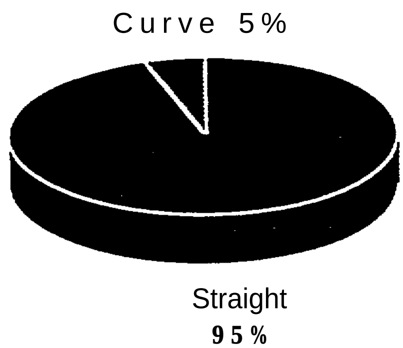


Drifting Collisions

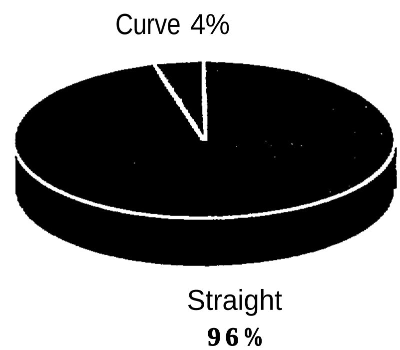


LCM Struck Collisions

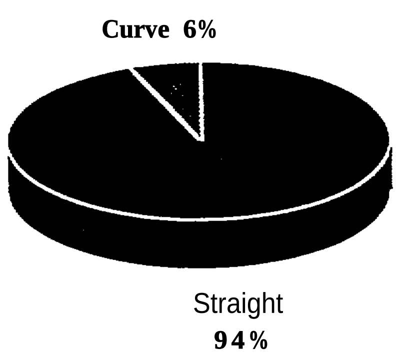
FIGURE 5.1.2-2: LCM Collisions by Road Alignment



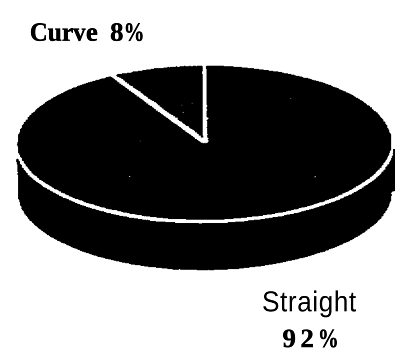
LCM Striking Collisions



Leaving a Parking Place Collisions

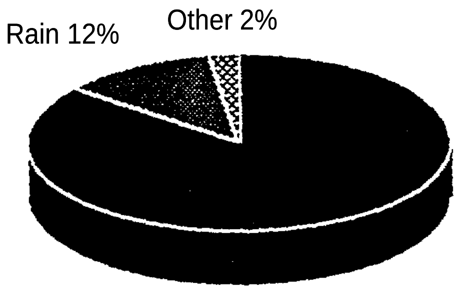


Drifiting Collisions

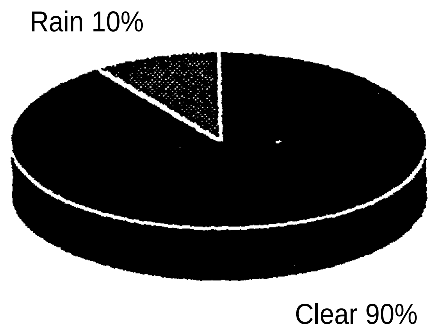


LCM Struck Collisions

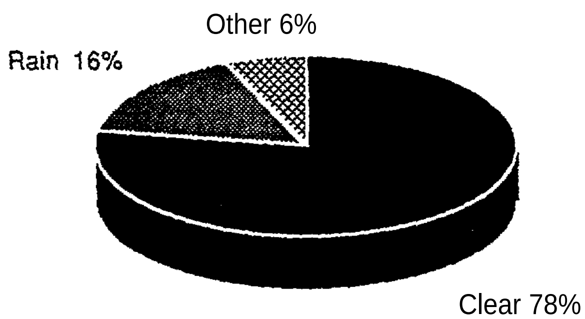
FIGURE 5,1,2-3: LCM Collisions by Weather Conditions



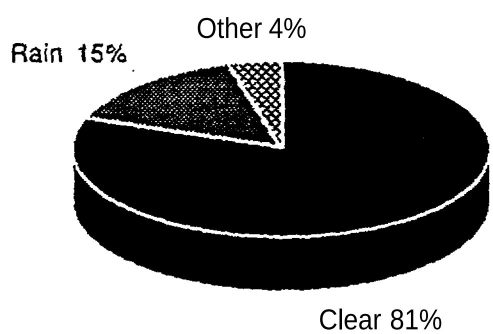
LCM Striking Collisions



Leaving a Parking Place Colisions

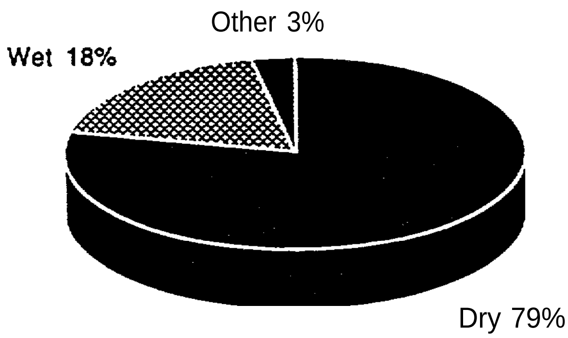


Drifiting Collisions

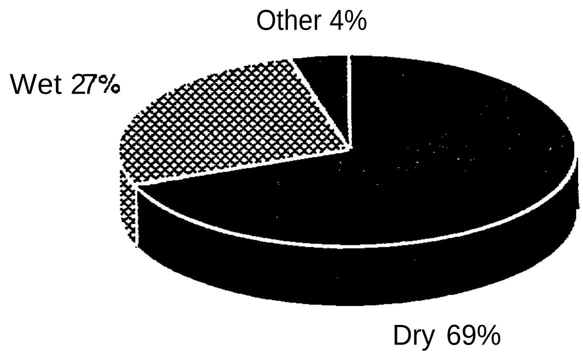


LCM Struck Collisions

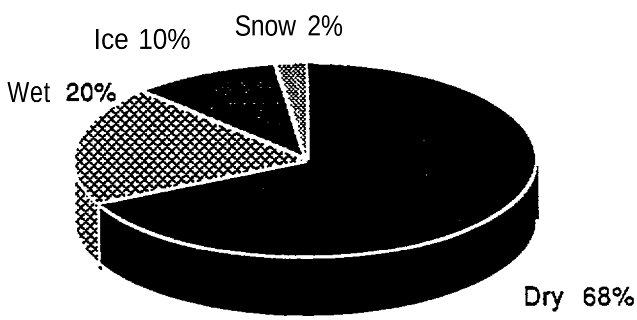
FIGURE 5.1.2-4: LCM Collisions by Surface Conditions



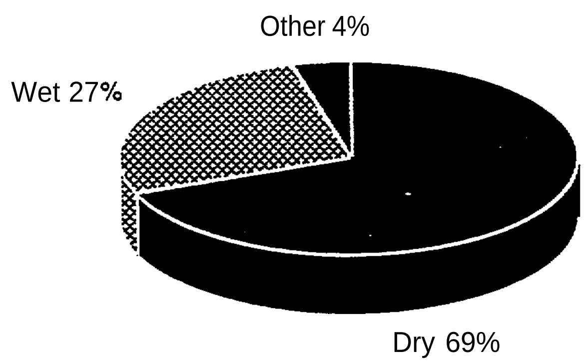
LCM Striking Collisions



Leaving a Parking Place Collisions

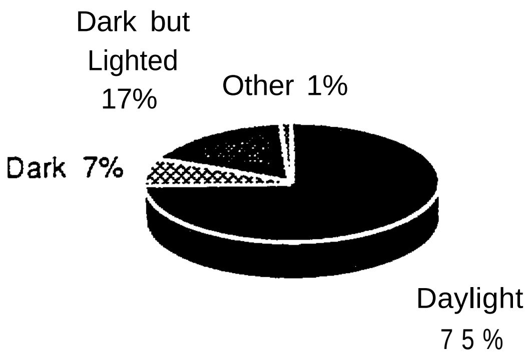


Drifiting Collisions

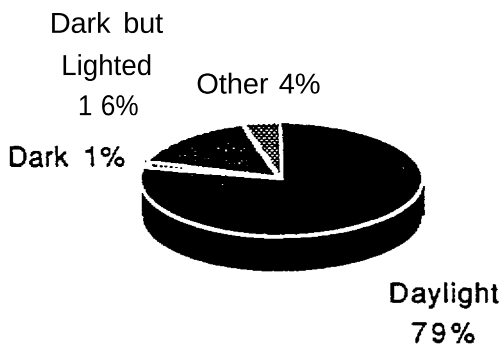


LCM Struck Collisions

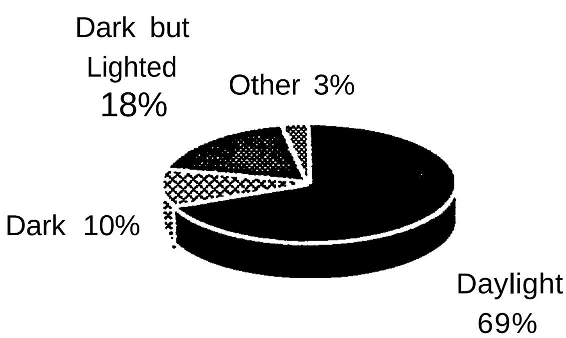
FIGURE 5.1.2-5: LCM Collisions by Lighting Conditions



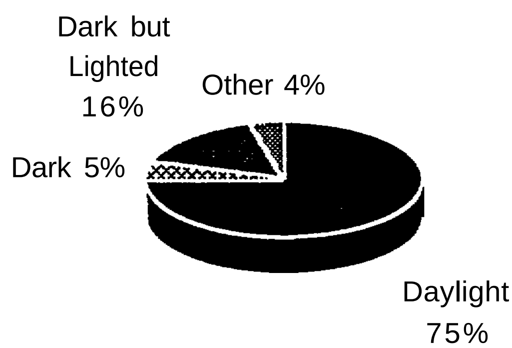
LCM Striking Collisions



Leaving a Parking Place Collisions

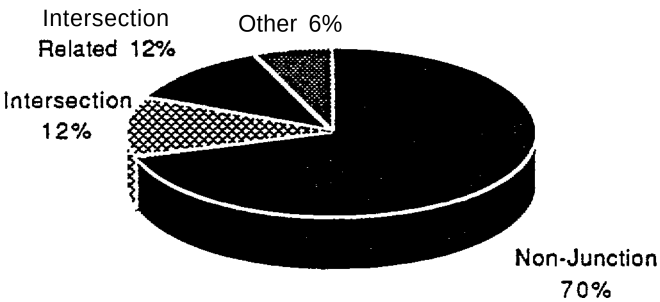


Drifiting Collisions

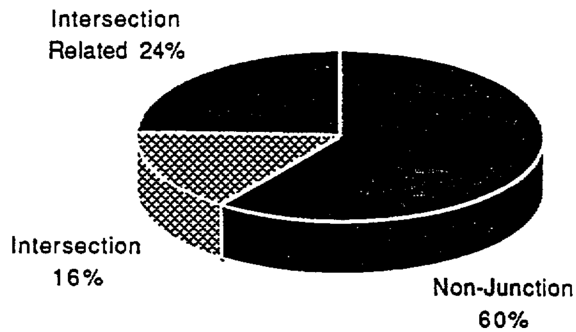


LCM Struck Collisions

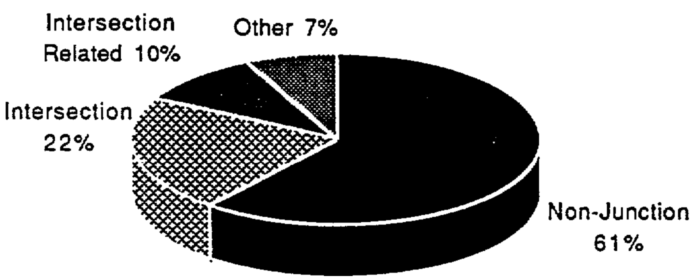
FIGURE 5.1.2-6: LCM Collisions by Relation to Junction



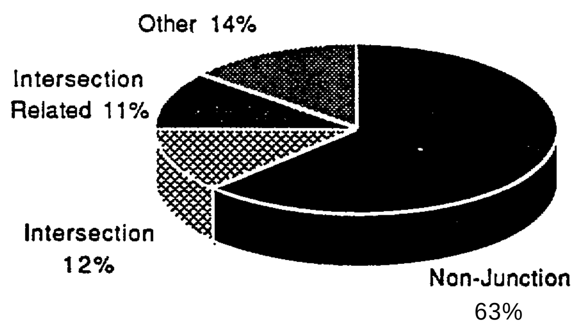
LCM Striking Collisions



Leaving a Parking Place Collisions



Drifiting Collisions



LCM Struck Collisions

However, to extract as much information as possible from the data at hand, statistical factors were calculated on two-way tables generated from the data sets. The most striking result was that there was a strong correlation between icy roads and nighttime as causal factors. That is, the proportion of accidents that occurred at night with icy roads was much higher than expected if one looks at theproportion that occur in the daylight.

To state that a causal factor is significant, one must compare that factor as observed in crash situations with the same factor as observed in the normal, non-crash experience. This measure of the fraction of time that this specific factor is encountered under normal driving conditions is termed the “exposure”. For example, if 22 % of accidents occur at night, is that significant? If 24% of all driving occurs at night, then the exposure is 24 %, and it is not important statistically. On the other hand, if only 12 % of driving occurs at night, then it is certainly statistically significant. However, the important point to the sensor designer is that the sensor must operate at night.

Lane change/merge accidents are complicated because they typically involve two moving vehicles that can impact from every possible direction, This factwhich emerges from the data, clearly indicates the difficulty in analyzing these accidents. Because of the complexity of moving from one lane to another, the driver must be aware of other vehicles in all directions. Many lane change/merge maneuvers are caused by a slower-moving lead vehicle. Care must be taken by the driver to not run into it from the rear while he is preparing to lane change/merge. Similarly, a surprising number (16,351 or 5.4 % of the 300,320 lane change/merge crashes) of these accidents occur when the lane changing/merging vehicle hits the rear of a vehicle already in the lane to be entered. At first thought, these accidents would not be mitigated by a lane change/merge CAS because it would most likely be side or rear looking. However, if some of the responsibility of thewide angle surveillance was removed from the driver, then it would be logical to assume that these accidents could also be reduced. It will be interesting to see if our driver-in-the-loop simulations bear this hypothesis out.

That no obvious causal factors emerge from the analysis is not necessarily bad. What becomes obvious is that many of these accidents occur under “normal” (daylight, clear weather, etc.) driving conditions when the driver is not distracted. In fact, many of the times the driver performs no maneuver to avoid the crash. This clearly indicates that the driver was not aware of the other vehicle when he performed the lane change/merge maneuver. An interpretation of the relative speed data (which is discussed later in this section) indicates that many of the vehicles engaged in the collision were in the blindspot of the driver, that is, they were next to or slightly behind the driver. Any sensor that monitored that volume and warned the driver appropriately when it was occupied would reduce the number of accidents significantly. That sensor might only have to detect the presence of another vehicle at ranges of at most about 20 feet, and not its relative speed. As mentioned before, even if the struck vehicle could not be directly observed by the CAS, it may well reduce those type of lane change/merge accidents because the driver's awareness of the forward zone could be increased.

Finally, a small number (10,656 or 3.5% of the 300,320 lane change/ merge crashes) of these accidents occur when the maneuvering vehicle is rearended by a faster moving vehicle in the entered lane. To help avoid these accidents, the CAS must be able to predict the future presence of that vehicle in the area to be occupied by the maneuvering vehicle. This requires a longer range sensor that also determines relative speed. The requirements to monitor the blindspot and to observe the adjacent lane out to long distances puts a strain on the design of the CAS for lane change/merge. This key design issue will be fully addressed later in the program.

Attempts to study distributions of relative speeds in two-vehicle crashes have been plagued by missing speed information. Most of the crashes have one or more speeds missing. When all records containing insufficient speed information are deleted, the studies of relative speeds depend on a very much diminished database. For example, there are 87,264 crashes in the LCMl data set, which includes records with missing speed information. However, since only crashes with complete speed data are used to study relative speeds, there are only 30,532 crashes in that data set corresponding to LCM 1.

The speeds of the lane change/merge vehicle were categorized as follows:

Slow	0 to 20 MPH
Medium	20 to 50 MPH
Fast	> 50 MPH

The relative speed RELSPEED was defined as

RELSPEED = SPEED(striking) - SPEED(struck).

Then the relative speed distributions were found for members of each classification. Since the lane change/merge vehicle may be either striking or struck depending on the classification, the sign of RELSPEED must be maintained.

In cases where the lane change/merge vehicle is striking, the condition

RELSPEED <= 0

represents cases in which the struck vehicle is overtaking or keeping pace with the striking vehicle. In these cases, a backward-looking crash avoidance system surveying the adjacent lane would benefit the driver of the lane change/merge vehicle. The limitations are that, if the speed of the struck vehicle is sufficiently great, the CAS may not warn the LCM driver with enough lead time to be effective.

In cases where the lane change/merge vehicle is struck, the condition

RELSPEED > = 0

represents cases in which the striking vehicle is overtaking or keeping pace with the struck vehicle. Here again, a backward-looking crash avoidance system surveying the adjacent lane would benefit the driver of the lane change/merge vehicle. The same limitations apply, that is, if the speed of the striking vehicle is sufficiently great, the CAS may not warn the LCM driver with enough lead time to be effective.

TABLE 5.1.2-1 Parts A and B present the per cent values obtained from the data sets containing complete speed information along with the per cent at RELSPEED=O and the maximum closing speed observed. The per cent values quoted in the table are defined as the percent of the crashes for which the speed of the LCM vehicle is designated (i.e., slow, medium or fast) in which the RELSPEED condition is satisfied. For a numerical example, if there were a total of 84 crashes in an LCMx-Medium, category and 63 satisfied the first condition on RELSPEED, then the per cent quoted would be "75". If RELSPEED=0 for 7 of those crashes, then the per cent entry for RELSPEED=0 would be "8" (rounded from 8.33).

TABLE 5.1.2-l: Relative Speed in Lane Change/Merge Crashes

Part A: LCM Vehicle is Striking

	LCM Speed	Per Cent RELSPEED #0	Per Cent RELSPEED =0	Maximum Closing speed
LCM1	Slow Medium Fast	75 72 43	27 45 35	40 MPH 20 MPH 10 MPH
LCM3	Slow Medium Fast	77 76 31	39 62 29	20 MPH 15 MPH 5 MPH
LCM3A	Slow Medium Fast	100 69 43	0 61 11	25 MPH 15 MPH 5 MPH
LCM51	Slow	100	0	52 MPH
LCM7	Slow Medium Fast	91 74 55	28 50 49	47 MPH 26 MPH 10 MPH

Part B: LCM Vehicle is Struck

	LCM Speed	Per Cent RELSPEED #0	Per Cent RELSPEED =0	Maximum Closing speed
LCM2	Slow Medium Fast	100 68 55	0 35 47	50 MPH 30 MPH 10 MPH
LCM2A	Slow Medium Fast	82 70 0	18 56 0	45 MPH 30 MPH Not Applicable*
LCM4	Slow Medium Fast	100 85 100	3 44 18	45 MPH 25 MPH 5 MPH
LCM52	Slow	100	0	17 MPH

* In this case, however, for 47 % of the crashes, the vehicles were moving with speeds within only 2 MPH of each other.

There were no observations with speed information for LCM53 and only one observation per category for LCM6. Not surprisingly, LCM51 and LCM52 only contained observations for the “slow” category. In addition, less than 10 observations were present for the following categories: LCM2A-Slow, LCM2A-Fast, LCM3A-Slow, LCM4-Fast and LCM52-Slow. Caution should be exercised in drawing conclusions from these sparse data. The category LCM8, lane change/merge followed by rearending the vehicle in front, was not considered here. However, it will be considered during the development of the preliminary specifications.

5.1.2 One-Vehicle Backing Crashes

In Appendix A, we have included a standardized set of tables for each one-vehicle backing accident category. This data was derived from weighted GES files for 1992. It is clear that no significant causal factor emerges from this array of data. One would hope for such a factor or cluster of factors to find the best method for avoiding these collisions, Although no such result is evident, important information can be obtained from that data, even though no direct causal factors emerged.

As opposed to many other kinds of accidents, backing into something other than a vehicle in transport is a slowly developing collision. Most backing speeds are well below 10 mph, and most struck objects are fixed, e.g., trees or poles, or slowly moving, e.g., pedestrians or pedacyclists. Again, many of the drivers who are in reverse make no avoidance maneuver of any kind. All this points to the driver not being aware of the impending accident during the backing maneuver.

The problem is that the driver’s vision of the rear of the vehicle can be somewhat obstructed by the structure of the vehicle. This is especially true in vans and small trucks. The value of the CAS for one-vehicle backing accidents is that it can readily monitor the obstructed area from its vantage point at the rear of the instrumented vehicle. During a backing maneuver, the region directly behind the vehicle must be monitored by the CAS. In addition, the region into which the vehicle is being steered must be watched, as well as the region from which a slow moving pedestrian/pedacyclist may emerge and enter the path of the vehicle. If the vehicle is backing along a curved path which causes the front to move to the right or left, the driver must watch these areas as well. This field of view may well be significantly larger than the area directly behind the vehicle, but its range will not extend beyond about twenty feet in any direction because of the slow speeds involved.

All one-vehicle backing crashes were aggregated into one data set and the weighted crash statistics for this set were analyzed. Although three-quarters of the vehicle speeds were missing, the recorded speeds indicate that 75 % were 5 MPH or less. Although the initial point of impact is overwhelmingly in the rear of the vehicle, in 14 % of the cases where data is present, the initial point of impact is cited as the front or the right or left side of the vehicle, indicating a need for the driver to remain alert to conditions near the front of the vehicle. There were no significant correlations with weather, surface conditions, lighting conditions, road alignment or profile. It is interesting to note that the 2-door coupe bodytype was involved more than the 4-door sedan bodytype, at least in cases where the specific bodytype data was noted.

5.1.3 Two-Vehicle Backing Crash Causal Factors

In Appendix A, we have included a standardized set of tables for two-vehicle backing accident categories. This data was derived from weighted GES files for 1992. It is clear that no significant causal factor emerges from this array of data. One would hope for such a factor or cluster of factors to find the best method for avoiding these collisions. Although no such result is evident, important information can be obtained from that data even though, based on the descriptive statistics studies, no direct causal factors are apparent.

The accidents in this category occur when a vehicle backs out into traffic and either strikes or is struck by a vehicle in transport. These accident types are problematical from the CAS viewpoint since many of them involve a vehicle approaching from other than the rear of the backing vehicle. Because of this, it is not clear what characteristics the backing CAS must have. If the field of view is expanded to see further out laterally, then many false alarms may be introduced. Also, if the range is greatly extended to anticipate the presence of rapidly approaching vehicles, then more stringent requirements have to be imposed on the CAS sensor in terms of radiated power, and again, the number of false alarms may greatly increase. To mitigate the false alarm occurrence, perhaps both the range and relative velocity of detected objects beyond a certain range must be measured, and only those objects with a non-zero ground speed need be reported. Careful analysis will determine if a backing CAS will be effective against these types of crashes. If not, then perhaps the forward looking sensor on the vehicle in transport may prove useful.

It is understood that for many of these accidents, the vehicle has been backing up long enough to achieve a constant velocity. This assumption will be utilized in any future simulations where the appropriate distribution of backing speeds will be sampled. On the other hand, the parallel path backing and the backing from a parking space categories are ones that occur when the target vehicle is close to the instrumented vehicle. In those cases, the simulations will assume a constant rearward acceleration, and the distribution for accelerations while in reverse will be sampled.

5.2 Statistics Calculated for Two-Way Crosstabulation Tables

The current study attempts to go beyond descriptive statistics, While it is reassuring, and indeed critical, that results from the descriptive statistical analysis presented here are in general agreement with past findings, it is our goal to discover significant causal factors, if any, from the 1992 GES data. In order to uncover possible causal factors, we shall look for association between independent variables as demonstrated in the accident frequency tables.

The primary statistical analysis tool used in the current study is the SAS frequency procedure, or PROC FREQ. (Reference 8 - SAS statistics manual) This procedure computes one-way to n-way frequency and crosstabulation tables. The crosstabulation tables show combined frequency distributions for two or more variables. For two-way tables, PROC FREQ computes a variety of statistics. For this report, as the most basic step in the statistical analysis of the GES data, only two-way crosstabulation tables have been analyzed. The strategy is to employ this most basic step to identify potential correlation in order to determine if more extensive analyses are warranted. More detailed possible analyses potentially involving hundreds of computer procedures are discussed in Section 8.

For two-way tables (which need not be square), when ALL is taken for the option in the frequency process, a number of tests are performed to test the null hypothesis of no association between the row variables and the column variables. These include the following: Pearson chi-square statistic, Phi coefficient, Cramer's V and the asymmetric lamda coefficients, lambda CIR and lambda RIC. Although other statistics are available, we have confined our usage to Cramer's V and the lambda coefficients. Cramer's V is based on the Pearson chi-square statistic but is scale invariant with an upper bound of 1.0. The lambda coefficient has a probabilistic interpretation which is discussed below.

The Pearson chi-square statistic involves the difference between the observed and expected frequencies. A common mistake is to use the value of chi-square itself as a measure of association. Even though chi-square is excellent as a measure of the significance of the association, it is not at all useful as a measure of the degree of association. For a given measure of association, the magnitude of chi-square strongly depends on the sample size. For example, it can be shown that when two sets of data indicating precisely the same amount of association are compared with one set containing exactly twice as many data points as the other, the chi-square of the larger set will be more than twice the chi-square of the smaller set. When dealing with the GES data sets which, when weighted, contain tens of thousands of samples, the chi-square statistic can become quite large. Furthermore, the chi-square test can also be compromised if the sample sizes are inadequate or the relative frequencies are extremely small. This occurs in many of the crosstabulation tables. The test is not scale invariant and must be used with caution.

To circumvent some of the difficulties associated with the chi-square statistic, the phi coefficient was chosen. The phi statistic is derived from Pearson's chi-square statistic and the total sample size N as follows:

$$phi = (n_{11}n_{22} - n_{12}n_{21})/(n_{1.}n_{2.}n_{.1}n_{.2})^{1/2} \text{ for 2 by 2 tables.}$$

$$phi = sqrt (chi\text{-}square/N) \text{ otherwise}$$

For a 2x2 contingency table, a value of phi less than 0.30 or 0.35 indicates no more than trivial association. (Reference 9 - Fleiss)

It can be shown that, if the frequency array under investigation is converted to a probability or rate array by dividing each element by the total number of samples, such that

$$p_{ij} = n_{ij} /N$$

$$p_{i.} = n_{i.} /N = (1/N) \Sigma_j n_{ij} = i^{th} \text{ row sum}$$

$$p_{.j} = n_{.j} /N = (1/N) \Sigma_i n_{ij} = i^{th} \text{ column sum,}$$

then phi corresponds to the square root of the chi-square associated with the probability array pij when the expected probabilities are found *subject to the hypothesis that the two classifications are independent of each other.* The tenability of the hypothesis that two characteristics are independent depends on the magnitudes of the differences (pij - pi. p.j) where i and j take on the indices of the table. The product pi. p.j is the expected probability of the (ij) component based on the hypothesis that the two classifications are independent of each other, and pij is the observed probability. Chi-square remains a viable indicator of association for large uniformly weighted samples because, as the sample size increases, the difference (pij - pi. p.j) approaches zero. In a weighted set of samples where the weight factor may vary by an order of magnitude or more, this difference will approach zero much more slowly, if at all. The probability array is independent of sample size.

The difficulty with the phi coefficient as a measure of association is that, the upper limit of phi becomes

sqrt[min(r-l, c-l)]

where r is the number of rows and c the number of columns in the table. This limit reduces to 1 for 2x2 tables or any case where r = 2 or c = 2.

Cramer’s V is defined as

V = sqrt[phi-square / min(r-l, c-l)]   or
V = phi/ [min(r-l,c-1)]1/2 .

Cramer’s V is designed so that -1 # V # 1. The attainable upper bound is always 1, and the magnitude of V lies between 0 and 1. Negative values of V are only possible for 2x2 tables. Cramer’s V is used in the following discussions of the *degree* of association.

(In passing, it should also be noted that the phi coefficient, and therefore Cramer’s V, have serious deficiencies when dealing with continuous distributions which have been cut into discrete segments for analysis. Then the value of phi depends strongly on where the cutting points are set. However, this is not the case here.)

Another statistic which is derived from a probabilistic model is the asymmetric lambda coefficient (Reference 10 - Goodman and Kruskal). If X and Y represent the variables in the crosstabulation table such that the rows are labeled by the values Xi and the columns by the values ‘Yj, then lambda CIR is interpreted as the probable improvement in predicting Y given that one has knowledge of X. The range of lambda is

0 # lambda # 1.

The model is the following: An individual observation is chosen at random from the population and the best possible prediction is made for the Yi value,

1. in the case that there is no further information, or
2. in the case that the row value Xi is given.

Clearly, case 1 represents the "worst case". Let the largest marginal proportion among the columns be represented by p.m and the largest cell proportion in the ath row by pam, that is,

$$P.m = \underset{b}{\mathrm{Max}}\ P.b \qquad \text{and} \qquad pam = \underset{b}{\mathrm{Max}}\ Pab\ .$$

Then in case 1, the best guess for Yi is that Yi for which p.i = p.m, that is, guessing the Y class which has the largest marginal proportion, and the probability of error is then (1 - P.m). In case 2, the best guess is that Yj for which paj = pam (letting the Xa be the given X class), and the probability of error in this case is then (1 - 3_a Pam). Then the measure of association lambda CIR is given by

$$l_{am}\ b\ d_a\ \mathrm{CIR} = \left[\frac{\text{(Prob. of error in case 1) - (Prob. of error in case 2)}}{\text{(Prob. of error in case 1)}} \right].$$

$$= [\ 3_a\ Pam - P.m\ 1 / (\ 1 - P.m\ )$$

which is the relative decrease in probability of error in guessing Yj as between Xa unknown and Xa known. To put this another way, lambda CIR gives the proportion of errors that can be eliminated by taking into account knowledge of the row (X) classifications of individuals. Lambda CIR is 0 if and only if knowledge of the row classification is of no help in predicting the column classification. Lambda CIR is 1 if and only if knowledge of an individual row class completely specifies the column class. In the case of statistical independence lambda CIR, when determinate, is zero. The converse need not hold: lambda CIR may be zero without statistical independence holding. Finally, lambda CIR is unchanged by permutation of rows or columns.A similar value of lambda RIC may also be derived by exchanging the row/column indices. As part of the standard SAS option on PROC FREQ, the asymtotic standard error (ASE) for each lambda is also calculated and tabulated for each 2-way table. A difficulty in interpreting these statistics arises when not all of the variables are truly independent. For example, in a 4x5 frequency table of surface conditions by weather, for a sample size of 46,869, the following statistics were calculated:

chi-square = 54,105
phi coefficient = 1.074
Cramer's V = 0.620 (upper bound = 1.0)

Lambda Asymmetric CIR = 0.385 ASE = 0.010
Lambda Asymmetric RIC = 0.602 ASE = 0.004

Looking at the expected values and the actual frequencies, one finds the following:

more crashes than predicted	clear and dry
more crashes than predicted	rain and wet
more crashes than predicted	snow and ice
fewer crashes than predicted	rain and dry (unlikely)
fewer crashes than predicted	snow and dry (unlikely)
fewer crashes than predicted	clear and wet (unlikely)
fewer crashes than predicted	clear and ice (unlikely)

It is a matter of the probability of encountering a given set of conditions. The top three are very likely combinations of weather and surface conditions which account for more than 80 % of the crash conditions. The final four are very unlikely combinations of rain and dry road surface and snow and dry road surface and the less unlikely combinations of clear and wet (possible but unlikely) and clear and ice (also possible but unlikely). The probability of the occurrence of rain and dry is not given by P(rain) * P(dry) as independent variables. Road surfaces are wet when it is raining. The road surface condition and the weather are not independent variables. High values of phi, Cramer's V and lambda asymmetric indicate the high degree of association between the road surface and weather, as expected.

Another 2-way table which logically is expected to show a high degree of association is the table of vehicle damage severities, that is, the vehicle damage severity of the striking vehicle versus that of the struck vehicle. Indeed this is the case.

In the following discussions, the final character in each variable name identifies the vehicle/driver represented by that character. For example, Vehicle Severity1 is the vehicle damage severity variable for vehicle 1 (striking) and Vehicle Severity2 is the vehicle damage severity variable for vehicle 2 (struck). Accident-level variables - for example, weather, surface conditions, lighting conditions, roadway profile, roadway alignment, etc. - are the same for both vehicle 1 and vehicle 2.

For the statistical analysis described above as well as other analyses, the lane change/merge and backing crashes were placed into five data sets which were aggregates of the more closely sorted data categories. The four lane change/merge aggregates - LCMSTRIKE, LCMSTRUCK, DRIFTING and LEAVING PARKING (STRUCK) - are described in sections 5.1 .l The various backing categories - BACKlALL, B2STRIKE, BACK7 and BACK7SLO - are described in section 5.2.2 and 5.2.3 below. In addition, the category LEAVING PARKING (STRIKING) has been added. LEAVING PARKING (STRIKING) is data set LCM51. The numbers of observations and weighted populations of each data set are shown in Table 5.2.0-l below.

TABLE 5.2.0-l: Aggregated Data Sets with Numbers of Observations and Weighted Populations

Category	Number Observations	Weighted Population
LCMSTRIKE	1,245	167,939
LCMSTRUCK	337	46,868
DRIFTING	397	48,6 17
LEAVING PARKING (STRIKING)	70	14,673
LEAVING PARKING (STRUCK)	40	7,131
BACKlALL	397	86,141
B2STRIKE	588	127,647
BACK7	106	14,529
BACK7SLO	16	1,829

As can be seen from the table above, BACK7SLO has significantly fewer observations than any other category, except perhaps LEAVING PARKING (STRUCK). For this reason, statistics associated with BACK7SLO are viewed with caution.

In order to estimate the expected values of Cramer's V and the lambda coefficients for situations in which a high degree of association is expected, the calculated statistics for the 2-way tables of road surface condition by weather and vehicle severity (striking) by vehicle severity (struck) are collected below in TABLES 5.2.0-2 and 5.2.0-3. Since the data set BACK7SLO has only 16 observations and the 2-way crosstabulation table statistics appear to be atypical in each case, the statistics for BACK7SLO are not included in the averages. Average values of Cramer's V for TABLES 5.2.0-2 and 5.2.0-3 are 0.603 and 0.553 respectively. Average values of lambda CIR are 0.366 and 0.579 respectively and for lambda RIC, 0.506 and 0.529 respectively. These numbers indicate the expected values of these statistics for tables of highly associated variables.

TABLE 5.2.0-2: Statistics for Highly Associated Tables: Roadway Surface by Weather

Category	Cramer's V	Lambda CIR	ASECIR	Lambda RIC	ASERIC
LCMSTRIKE	0.522	0.451	0.006	0.611	0.003
LCMSTRUCK	0.620	0.385	0.010	0.602	0.004
DRIFTING	0.559	0.415	0.007	0.533	0.004
PARKING (STRICKING)	0.736	0.492	0.019	0.498	0.013
PARKING (STRUCK)	0.537	0.000	0.000	0.311	0.010
BACK1ALL	0.647	0.347	0.009	0.581	0.004
B2STRICK	0.419	0.378	0.008	0.512	0.004
BACK7	0.781	0.459	0.024	0.403	0.008
BACK7SLO	0.359	0.000	0.000	0.044	0.010

Excluding BACK7SLO from the averages,the averages for Cramer's V, lambda CIR and lambda RIC are 0.603, 0.366 and 0.506 respectively.

TABLE 5.2.0-3: Statistics for Highly Associated Tables: Vehicle Severity (Striking) by Vehicle Severity (Struck)

Category	Cramer's V	Lambda CIR	ASECIR	Lambda RIC	ASE RIC
LCMSTRIKE	0.491	0.493	0.002	0.490	0.002
LCMSIRUCK	0.508	0.542	0.004	0.568	0.003
DRIFTING	0.460	0.476	0.004	0.45 1	0.004
PARKING (STRIKING)	0.660	0.691	0.005	0.647	0.007
PARKING (STRUCK)	0.710	0.837	0.007	0.589	0.009
B2STRIKE	0.440	0.394	0.002	0.319	0.002
BACK7	0.599	0.617	0.006	0.638	0.005
BACK7SLO	0.750	0.514	0.016	0.754	0.016

The 2x2 gender contingency table may be viewed as a control in which no association is expected between the gender of the driver of the striking vehicle and the gender of the driver of the struck vehicle. The statistics for the 2x2 gender contingency tables are collected in TABLE 5.2.0-4 below. When the magnitudes of Cramer's V are averaged, the average value is 0.058. When Cramer's V is averaged with the sign, the average is 0.041. The average of the statistic lambda CIR is 0.020 and that of lambda RIC is 0.012. The expected value for a perfectly non-associated system is zero. The largest contributions to these averages is due to LEAVING PARKING (STRUCK) which is the sum of LCM52 and LCM53, a data set for which 95 % of the striking drivers are female (based on the GES). Nevertheless, we see that these numbers are quite small compared to those obtained from TABLES 5.2.0-2 and 5.2.0-3..

TABLE 5.2.0-4: Statistics for Non-Associated Tables: Driver Gender (Striking Vehicle) by Driver Gender (Struck Vehicle)

Category	Cramer's V	Lambda CIR	ASECIR	Lambda RIC	ASE RIC
LCMSTRIKE	-0.006	0.000	0.000	0.000	0.000
LCMSTRUCK	+0.068	0.000	0.000	0.000	0.000
DRIFTING	+0.003	0.000	0.000	0.000	0.000
PARKING (STRIKING)	-0.056	0.000	0.000	0.000	0.000
PARKING (STRUCK)	+0.176	0.118	0.016	0.087	0.017
B2STRIKE	+0.032	0.021	0.003	0.000	0.000
BACK7	+0.067	0.000	0.000	0.000	0.000
BACK7SLO	-0.398	0.000	0.000	0.342	0.021

5.2.1 Lane Change/Merge Crash Statistical Analysis

In all, two-way tables were investigated and the statistics were calculated for the combinations of accident level variables of roadway profile, roadway alignment, surface conditions, lighting conditions, and weather. For vehicle level variables, the driver's alcohol involvement and gender were tabulated in contingency tables. The SAS frequency procedure with the options EXPECTED DEVIATION ALL was used with the five aggregated data sets and LEAVING PARKING (STRIKING).

The criteria for the lack of association is taken as V< 0.35, which is similar to Fleiss' suggestion that phi < 0.35 indicates no more than trivial association. In the cases cited below, the result of V < =.300 for the lane change/merge categories studied indicates that there is very little or no association. Tables indicating larger values of V indicate the greater possibility of association. For only eight crosstabulation tables were the statistics sufficiently large to consider the possibility or probability of association. Five of these tables were associated with LEAVING PARKING (STRUCK), two with LEAVING PARKING (STRIKING), and one with LCMSTRUCK. It is interesting to note that there were no tables for which

V $ 0.300 for the categories LCMSTRIKE and DRIFTING, which encompass216,556 crashes or 72% of the 300,320 lane change/merge crashes.

TABLE 5.2.1-2.A: List of Table Variables for the Category LCMSTRUCK for which 0.0 # V # 0.300 (Indicating Little or No Association).

Table Variables
Profile x Surface Conditions
Profile x Lighting Conditions
Profile x Weather
Alignment x Lighting Conditions
Alignment x Surface Conditions
Alignment x Weather
Surface Conditions x Lighting Conditions
Lighting Conditions x Weather
Driver Injury1 x Driver Injury2
Driver Alcohol1 x Driver Alcohol2
Driver Alcohol1 x Lighting Conditions
Driver Alcohol1 x Surface Conditions
Driver Alcohol1 x Weather
Driver Alcohol1 x Profile
Driver Alcohol1 x Alignment
Vehicle severity1 x Driver Injury1
Vehicle severity2 x Driver Injury2
Restraint Use1 x Driver Injury1
Restraint Use2 x Driver Injury2

With the exceptions of SurfaceConditions x Weather and Vehicle severity (striking) x Vehicle severity (struck) discussed above, all of the coefficients calculated for LCMSTRIKE indicate that there is little or no association.

TABLE 5.2.1-2.A: List of Table Variables for the Category LCMSTRUCK for which 0.0 # V # 0.300 (Indicating Little or No Association).

Table Variables
Profile x Surface Conditions
Profile x Lighting Conditions
Profile x Weather
Alignment x Lighting Conditions
Alignment x Surface Conditions
Alignment x Weather
Surface Conditions x Lighting Conditions
Lighting Conditions x Weather
Driver Injury1 x Driver Injury2
Driver Alcohol1 x Driver Alcohol2
Driver Alcohol1 x Lighting Conditions
Driver Alcohol1 x Surface Conditions
Driver Alcohol1 x Weather
Driver Alcohol1 x Profile
Driver Alcohol1 x Alignment
Vehicle severity1 x Driver Injury1
Vehicle severity2 x Driver Injury2
Restraint Use1 x Driver Injury1
Restraint Use2 x Driver Injury2

TABLE 5.2.1-2.B: List of Table Variables for the Category LCMSTRUCK for which 0.300 # V # 0.400 (Indicating Possible Association).

Table Variables	Cramer's V
Profile x Alignment	0.314

No tables for the category LCMSTRUCK had coefficients greater than those shown immediately above.

TABLE 5.2.1-3: List of Table Variables for the Category DRIFTING for which 0.0 # V # 0.300 (Indicating Little or No Association).

Table Variables
Profile x Surface Conditions
Profile x Lighting Conditions
Profile x Weather
Alignment x Lighting Conditions
Alignment x Surface Conditions
Alignment x Weather
Profile x Alignment
Surface Conditions x Lighting Conditions
Lighting Conditions x Weather
Driver Injury1 x Driver Injury2
Driver Alcohol1 x Driver Alcohol2
Driver Alcohol1 x Lighting Conditions
Driver Alcohol1 x Surface Conditions
Driver Alcohol1 x Weather
Driver Alcohol1 x Profile
Driver Alcohol1 x Alignment
Vehicle severity1 x Driver Injury1
Vehicle severity2 x Driver Injury2
Restraint Use1 x Driver Injury1
Restraint Use2 x Driver Injury2

With the exceptions of Surface Conditions x Weather and Vehicle severity (striking) x Vehicle severity (struck) discussed above, all of the coefficients calculated for DRIFTING indicate that there is little or no association.

TABLE 5.2.1-4.A: List of Table Variables for the Category LEAVING **PARKING (STRIKING)** for which 0.0 # V # 0.300 (Indicating Little or No Association).

Table Variables
Profile x Surface Conditions
Profile x Lighting Conditions
Profile x Weather
Alignment x Lighting Conditions
Alignment x Surface Conditions
Alignment x Weather
Profile x Alignment
Surface Conditions x Lighting Conditions
Lighting Conditions x Weather
Driver Alcohol1 x Driver Alcohol2
Driver Alcohol1 x Surface Conditions
Driver Alcohol1 x Weather
Driver Alcohol1 x Profile
Driver Alcohol1 x Alignment
Vehicle severity1 x Injury1
Vehicle severity2 x Injury2
Restraint Use1 x Injury1
Restraint Use2 x Injury2

With the exceptions of Surface Conditions x Weather and Vehicle severity (striking) x Vehicle severity (struck) discussed above and those table variables discussed below in TABLE 5.2.1-4B, the remaining coefficients calculated for LEAVING PARKING (STRIKING) indicate that there is little or no association.

TABLE 5.2.1-4.B: List of Table Variables for the Category LEAVING PARKING (STRIKING) for which 0.500 # V (Indicating Association Similar to TABLES 5.2.0-2 or 5.2.0-3).

Table Variables	**Cramer's V**	**Lambda CIR**	**Lambda RIC**
Driver Injury1 x Driver Injury2	0.5 12	0.203	0.000
Driver Alcohol1 x Lighting Conditions	0.501	0.001	0.034

TABLE 5.2.1-5.A: List of Table Variables for the Category LEAVING PARKING (STRUCK) for which 0.0 # V # 0.300 (Indicating Little or No Association).

Table Variables
Profile x Surface Conditions
Profile x Lighting Conditions
Profile x Weather
Alignment x Lighting Conditions
Alignment x Surface Conditions
Alignment x Weather
Profile x Alignment
Surface Conditions x Lighting Conditions
Lighting Conditions x Weather
Driver Injury1 x Driver Injury2
Driver Alcohol1 x Driver Alcohol2
Driver Alcohol1 x Lighting Conditions
Driver Alcohol1 x Surface Conditions
Driver Alcohol1 x Weather
Driver Alcohol1 x Profile
Driver Alcohol1 x Alignment
Vehicle severity1 x Driver Injury1
Vehicle severity2 x Driver Injury
Restraint Use1 x Driver Injury1
Restraint Use2 x Driver Injury2

With the exceptions of SurfaceConditions x Weather and Vehicle severity (striking) x Vehicle severity (struck) discussed above and the additional tables discussed in TABLES 5.2.1-5B and 5.2.1-5C below, the coefficients calculated for LEAVING PARKING (STRUCK) indicate that there is little or no association.

TABLE 5.2.1-5.B: List of Table Variables for the Category LEAVING PARKING (STRUCK) for which 0.300 # V # 0.400. (Indicating Possible Association)

Table Variables	Cramer's V
Profile x Surface Conditions	0.317
Surface Conditions x Lighting Conditions	0.331
Vehicle severity2 x Driver Injury2	0.332

TABLE 5.2.1-5.C: List of Table Variables for the Category LEAVING **PARKING (STRUCK)** for which 0.400 # V. (Indicating Probable Association)

Table Variables	Cramer's V	Lambda CIR	Lambda RIC
Driver Alcohol1 x Lighting Conditions	0.470	0.197	0.000
Restraint Use1 x Driver Injury	0.596	0.075	0.027

5.2.2 One-Vehicle Backing Crash Statistical Analysis

All of the one-vehicle backing crashes were aggregated into the data set BACK1 ALL. From the descriptive statistics studies, no direct causal factors are apparent. In addition, the same sets of statistics were calculated for one-vehicle backing crashes as were calculated for lane change/merge crashes. Except in those cases discussed above, the Cramer's V coefficient never exceeded (or even approached) 0.35, the minimum threshold for correlation.

TABLE 5.2.2-1: List of Table Variables for the Category BACKlALL for which 0.0 # V # 0.300 (Indicating Little or No Association).

Table Variables
Profile x Surface Conditions
Profile x Lighting Conditions
Profile x Weather
Alignment x Lighting Conditions
Alignment x Surface Conditions
Alignment x Weather
Profile x Alignment
Surface Conditions x Lighting Conditions
Lighting Conditions x Weather
Driver Alcohol1 x Lighting Conditions
Driver Alcohol1 x Surface Conditions
Driver Alcohol1 x Weather
Driver Alcohol1 x Profile
Driver Alcohol1 x Alignment

Since there is little vehicle damage severity or driver injury associated with one-vehicle backing crashes, these table variables were not computed. With the exceptions of Surface Conditions x Weather and Vehicle severity (striking) x Vehicle severity (struck) discussed above, all of the coefficients calculated for BACK1 ALL indicate that there is little or no association.

5.2.3 Two-Vehicle Backing Crash Statistical Analysis

The weighted crash statistics for the two-vehicle backing crashes were also analyzed as several data sets. These data sets were constructed as follows:

- B2STRIKE = BACK3 + BACK5 + BACK6 (backing on road or from parking place and striking)
- BACK7 (backing and struck by vehicle in transport)
- BACK7SLO (a subset of BACK7; backing and struck by vehicle in transport whose speed is less than or equal 30 MPH)

BACK7SLO contains only 16 observations. Due to the low number of observations and the variations in weights, some of the BACK7SLO statistics are not typical and are not considered highly reliable. Nevertheless, these are included for completeness. The backing CAS may prove effective in mitigating the crashes in BACK7SLO.

From the analysis of B2STRIKE, there were no significant correlations with weather, surface conditions, lighting conditions, road alignment or profile. However, in analyses similar to those described in section 5.1.2 for lane change/merge crashes, both BACK7 and BACK7SLO showed correlation of crash occurrence with lighting conditions and roadway profile, showing not only more crashes occurring on grades with degraded lighting conditions (dark, dark but lighted, or dawn) than expected but also more crashes on level areas in the daylight than expected.

TABLE 5.2.3-l: List of Table Variables for the Category B2STRIKE for which 0.0 # V # 0.300 (Indicating Little or No Association).

Table Variables
Profile x Surface Conditions
Profile x Lighting Conditions
Profile x Weather
Alignment x Lighting Conditions
Alignment x Surface Conditions
Alignment x Weather
Profile x Alignment
Surface Conditions x Lighting Conditions
Lighting Conditions x Weather
Driver Alcohol1 x Driver Alcohol2
Driver Alcohol1 x Lighting Conditions
Driver Alcohol1 x Surface Conditions
Driver Alcohol1 x Weather
Driver Alcohol1 x Profile
Driver Alcohol1 x Alignment
Vehicle Severityl x Driver Injury1
Vehicle Severity2 x Driver Injury2
Restraint Use1 x Driver Injury1
Restraint Use2 x Driver Injury2

With the exceptions of SurfaceConditions x Weather and Vehicle severity (striking) x Vehicle severity (struck) discussed above, all of the coefficients calculated for B2STRIKE indicate that there is little or no association.

TABLE 5.2.3-2.A: List of Table Variables for the Category BACK7 for which 0.0 # V # 0.300 (Indicating Little or no Association).

Table Variables
Profile x Surface Conditions
Profile x Lighting Conditions
Profile x Weather
Alignment x Lighting Conditions
Alignment x Surface Conditions
Alignment x Weather
Surface Conditions x Lighting Conditions
Lighting Conditions x Weather
Driver Injury1 x Driver Injury2
Driver Alcohol1 x Lighting Conditions
Driver Alcohol1 x Surface Conditions
Driver Alcohol1 x Weather
Driver Alcohol1 x Profile
Driver Alcohol1 x Alignment
Vehicle severity1 x Driver Injury1
Vehicle severity2 x Driver Injury2
Restraint Use1 x Driver Injury1
Restraint Use2 x Driver Injury2

TABLE 5.2.3-2.B: List of Table Variables for the Category BACK7 for which 0.300 # V # 0.400 (Indicating Possible Association).

Table Variables	Cramer's V
Profile x Alignment	0.349

TABLE 5.2.3-2.C: List of Table Variables for the Category BACK7 for which 0.400 # V (Indicating Probable Association).

Table Variables	Cramer's V	Lambda CIR	Lambda RIC
Driver Alcohol1 x Driver Alcohol2	0.409	0.000	0.000

The data set BACK7SLO is limited to those crashes in which the backing vehicle is struck by another vehicle whose travel speed is less than or equal 30 miles per hour. There are only 16 observations in the data set. The statistics for this data set have been excluded from the calculation of averages in the previous sections. However, crashes in the BACK7SLO data set may be prevented or mitigated by a CAS of sufficient range and coverage.

TABLE 5.2.3-3.A: List of Table Variables for the Category BACK7SLO for which 0 # V # 0.300 (Indicating Little or No Association).

Table Variables
Profile x Surface Conditions
Profile x Lighting Conditions
Profile x Weather
Alignment x Lighting Conditions
Alignment x Surface Conditions
Alignment x Weather
Profile x Alignment
Driver Alcohol1 x Driver Alcohol2
Driver Alcohol1 x Surface Conditions
Driver Alcohol1 x Weather
Driver Alcohol1 x Profile
Driver Alcohol1 x Alignment

TABLE 5.2.3-3.B: List of Table Variables for the Category BACK7SLO for which 0.300 # V # 0.400 (Indicating Possible Association).

Table Variables I	Cramer's V I
Driver Alcohol1 x Lighting Conditions	0.354
Restraint Use1 x Driver Injury1	0.380

TABLE 5.2.3-3.C: List of Table Variables for the Category **BACK7SLO** for which 0.400 # V (Indicating Probable Association).

Table Variables	Cramer's V	Lambda CIR	Lambda RIC
Surface Conditions x Lighting Conditions	0.700	0.888	0.683
Lighting Conditions x Weather	0.445	0.000	0.017
Vehicle severity1 x Driver Injury 1	0.515	0.108	0.095
Vehicle severity2 x Driver Injury2	0.499	0.197	0.255
Restraint Use2 x Driver Injury2	0.635	0.036	0.026

6.0 HARD COPIES ANALYSIS

The information gathered from the hard copy analyses of theCDS cases and the PARS is to be used to generate accident scenarios for the simulations.

6.1 Lane Change/Merge Analysis

6.1.1 CDS Hard Copy Selection

The CDS database was sorted for candidate lane change/merge crashes using either of the following criteria:

14 # PREMOVE # 15 (PREMOVE = changing lanes or merging)
44 # ACCTYPE # 47 (ACCTYPE = one of 4 types of adjacent lane encroachment, same direction crashes)

PREMOVE is the CDS variable equivalent to the GES Precrashl which describes what the driver/vehicle was doing just before recognition of the critical event. ACCTYPE is the same accident type variable found in the GES.

From this sorting, 299 records representing a total of 143 crashes emerged, including 4 crashes precipitated by a vehicle leaving a parked position (which could be considered a lane change situation in which a CAS would be of assistance). Hard copy reports of every case identified by the sorting procedure explained above were ordered.

6.1.2 CDS Hard Copy Analysis

In dealing with the CDS, categorizing by accident type is a better way to proceed. Two-vehicle lane change/merge crashes are categorized. By combinations of vehicle variables as follows:

1. Lane change to left and other vehicle straight ahead,
   (ACC-TYP = 47 and ACC-TYP = 44 or 45)

2. Lane change to right and other straight ahead.
   (ACC-TYP = 46 and ACC-TYP = 44 or 45)

3. Both straight ahead.
   (ACC-TYP = any combination of 44 and 45)

4. Leaving parking space as a lane change to left.
(PREMOVE = 7 and ACC-TYPE = 47)
5. Lane change or merge followed by rear-end crash.
(PREMOVE = 14 or 15 and MANCOLL = 1)
6. Others with one of the following requirements:
(PREMOVE = 14 or 15) or (44 # ACC-TYPE # 47)

Before the CDS hard copies arrived, it was possible to divide the cases into . six categories as shown below in Table 6.1.2-l. In the first four categories which were the best defined, the manner of collision was exclusively "sideswipe, same direction". The last two categories were more difficult to characterize, but the manner of collision was usually "rearend".

TABLE 6.1.2: Summary of InitialCDS Case Classifications

	Lane change to left; other straight ahead.
	Lane change to right; other straight ahead.
	Both straight ahead.
	Leaving parking space (seen as lane change).
	Singletons* and miscellaneous.
	Other

* When sorting through the CDS database for hard copy analysis candidates, usually two (or more) involved vehicles would appear on the list. "Singletons" were cases in which only one vehicle appeared per psu case number (the case identifiers).

Hard copies of the 143 LCM accident cases in the NASS CDS were analyzed. Of these, 61 cases were used to develop typical LCM crash scenarios involving an "at fault" passenger vehicle where an LCM CAS could have prevented the accident, another 32 cases were used to develop LCM crash scenarios where an LCM CAS on an "at fault" truck could have prevented the crash, and 50 cases were excluded from scenario development because an LCM CAS would not have prevented the crash.

6.1.3 Clinical Study

Analysis of each of the 143 hard copies proceeded as follows.

1. All information contained in the hard copy was reviewed thoroughly. Each hard copy included a variety of standard forms such as the CASE SUMMARY, an ACCIDENT COLLISION DIAGRAM, an ACCIDENT COLLISION MEASUREMENT TABLE, the ACCIDENT FORM, one or more GENERAL VEHICLE FORMS, EXTERIOR VEHICLE FORMS, INTERVIEW FORMS, INTERIOR VEHICLE FORMS, OCCUPANT ASSESEMENT FORMS, OCCUPANT INJURY FORMS, and UPDATE FORMS. Not all cases contained all forms, and the completeness of the information on each form varied significantly from case to case. However, each available form was reviewed so that a complete picture of the accident could be developed.

2. After reviewing each case, specific information was transferred to an analysis form entitled CDS INPUT VARIABLE FORM FOR LANE CHANGE/MERGE CRASHES (see Appendix B, Forml). This form consolidated pertinent information such as accident type, vehicle orientation, vehicle speed, etc. from various forms in the accident hard copy onto a single form.

3. Based on the information transferred to the CDS INPUT VARIABLE FORM FOR LANE CHANGE/MERGE CRASHES, each hard copy was then flagged and placed in one of the following three categories.

Green Flag -	an LCM CAS on a passenger vehicle could have prevented the crash
Red Flag -	an LCM CAS on a truck could have ‘prevented the crash
No Flag -	an LCM CAS would not have prevented the crash

Because an LCM CAS would not have prevented the accident, 50 of the 143 hard copies were not used in scenario development (No Flag cases). Generally, in these cases, the driver was not in control of the vehicle or was unable to initiate corrective actions which might have prevented the crash. Reasons for exclusion from scenario development were as follows.

DUI (driver rendered completely ineffective by alcohol or drugs).

Loss of vehicle control in which the driver is unable to control of the vehicle or affect its path.

Inappropriateness of case (that is, the case was miscategorized and there was no lane change).

Loss of control (due to medical problems such as seizure, heart attack, blackout, etc.)

Avoiding another critical event (such as hitting a motorcyclist, pedestrian, or other vehicle.)

Excessive speed (for example, one of the vehicles involved was traveling over 95 mph).

This completed the first level of hard copy analysis.

After the first level of hard copy analysis, 61 hard copies had green flags and were used to develop typical LCM crash scenarios of accidents involving an “at-fault” passenger vehicle. These 61 hard copies were sorted further into categories based on similar critical events. Each of these categories was then developed into an LCM passenger vehicle scenario. Thirteen scenarios resulted, each containing the information necessary to develop a computer model, as well as a sketch of the critical event. Those scenarios are summarized in TABLE 6.1.3-l.

TABLE 6.1.3-l : Table of Passenger Vehicle Scenarios Derived from the CDS Hard Copy Analysis

Scenario Number	Description
PVl.	Lane change/merge to the left, striking (6 cases)
PV2.	Lane change/merge to the left, struck (15 cases)
PV3.	Lane change/merge to the right, striking (10 cases)
PV4.	Lane change/merge to the right struck (10 cases)
PV5.	Both changing lanes, rearend (1 case)
PV6.	Drifting left, striking (1 case)
PV7.	Lane change/merge to the left, rearend struck (3 cases)
PV8.	Lane change/merge to the right, rearend struck (4 cases)
PV9.	Leaving a parking place, striking (3 cases)
PV10	Leaving a parking place, struck (1 case)
PVll.	Lane change/merge to the left across 2 lanes, striking (2 cases)
PV12.	Lane change/merge to the left across 2 lanes, struck (1 case)
PV13.	Lane change/merge, rearend striking (4 cases)

In categories where information differed significantly from hard copy to hard copy, ranges of data, such as velocity ranges, angle ranges, road condition variations, times of day, etc., were included in the scenario. In PV13, generally the lane change or merge was completed before the rearend crash occurred.

Another 32 of the 143 hard copies (red flagged cases) were used to develop crash scenarios where an "at fault" truck (semi, tractor-trailor, panel, straight, bus, garbage, etc.) would have benefitted greatly from some form of LCM CAS. Analysis of these 32 cases indicates that' most trucks have extensive blind spots and that most of these accidents are preventable.

After further sorting these 32 cases into categories based on similar critical events, 7 LCM truck scenarios were developed, each involving some kind of "at fault" truck. Those 7 scenarios are described in TABLE 6.1.3-2 below.

TABLE 6.1.3 -2: Table of Truck Scenarios Derived from theCDS Hard Copy Analysis

Scenario Number	Description
Tl.	Lane change/merge to the right, rearend striking (3 cases)
T2.	Lane change/merge to the left, rearend struck (1 case)
T3.	Lane change/merge to the right, striking (18 cases)
T4.	Lane change/merge to the right, struck (3 cases)
T5.	Lane change/merge to the left, striking (1 case)
T6.	Lane change/merge to the left, struck (5 cases)
T7.	Leaving a parking place, striking (1 case)

Since the CDS does not record data on heavy vehicles (gross vehicle weight $ 10,000 pounds), the hard copy reports do not provide information about the precrash circumstances, actions and conditions of many trucks, nor were any interviews obtained with the drivers of the trucks. Therefore, no consistent information is available (including estimates of speed and -distances).

It is easily seen that the CDS scenarios do not correspond exactly to the categories explored in the GES. This is not surprising since theCDS requirement for vehicle towing causes bias toward more severe crashes and crashes producing more severe injuries, and furthermore, theCDS is also biased toward crashes involving more recent vehicles (last 5 years). The GES populations contain both passenger cars and various trucks of all ages. Since the GES includes a wider spectrum of motor vehicles and crash severities and the CDS is biased, the GES data is used in treatments of injury severity, such as those found in section 4.5. Using percentages based on the accident type and total category populations from the GES found in the descriptive statistics in Appendix A, the above CDS ‘scenarios may be combined and then related to numbers derived from the GES populations. These derived numbers are shown in TABLE 6.1.3-3 below.

TABLE 6.1.3-3: Populations Derived from the GES which Correspond to the Various CDS Hard Copy Lane Change/Merge Scenarios

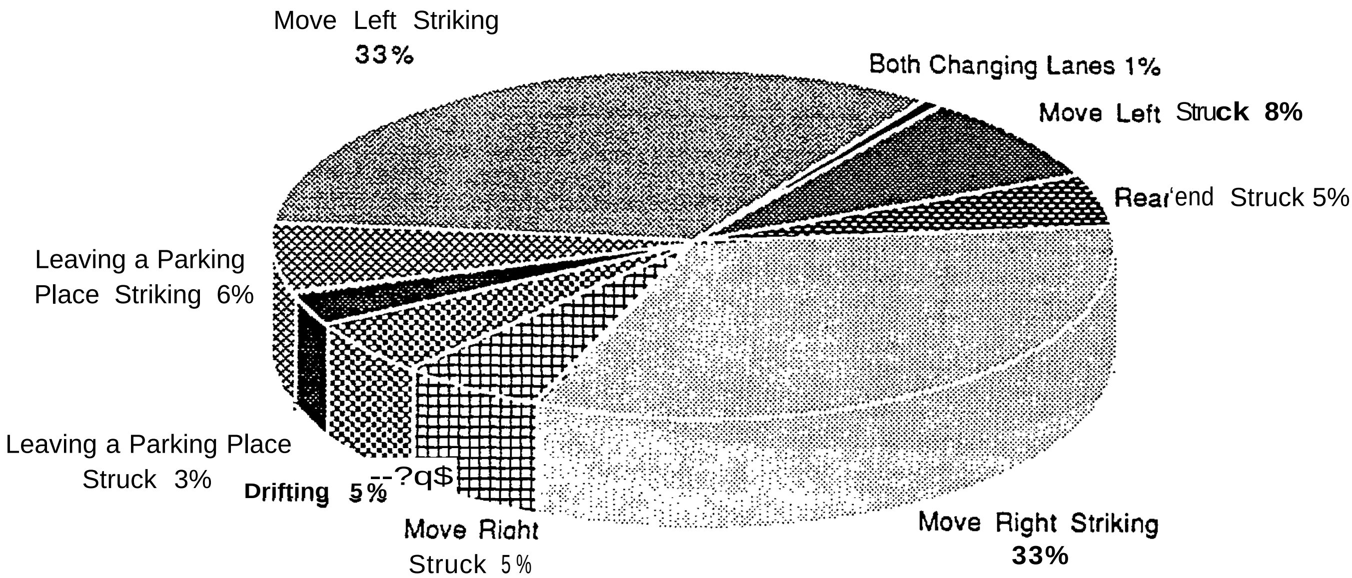
Scenario Combination	Description of Action	Corresponding GES Population
PVl, PVll, T5	Move to left, striking	72,850
PV2, PV12, T6:	Move to left, struck	18,321
PV3, T3:	Move to right, striking	74,212
PV4, T4:	Move to right, struck	11,892
PV5:	Both changing lanes	1,765
PV6:	Drifting (left, striking)	11,115
PV7, PV8, T2:	Move to left or right, rearend struck	10,656
PV9, T7:	Leaving a parking place, striking	14,673
PVl0:	Leaving a parking place, struck	7,132
PV13, Tl:	Lane change, rearend striking	16,351

The table above can be interpreted in the following way: in the GES there are 72,850 crashes (of all severities) corresponding to the combined categories of CDS scenarios PV 1, PVl 1 and T5. There are 18,321 crashes corresponding to the combined scenarios PV2, PV12 and T6, and so on. The total number of crashes contained in this GES population subset is 238,967 (Standard error 19,056). Therefore, scenarios PVl, PVl i and T5 together (move to left, striking) represent a 30 % part of the lane change/merge crashes in the GES population subset for which there are corresponding CDS scenarios. The CDS does not provide scenarios for all possible situations found in the GES. For example, there is no CDS scenario for drifting to the right, striking.

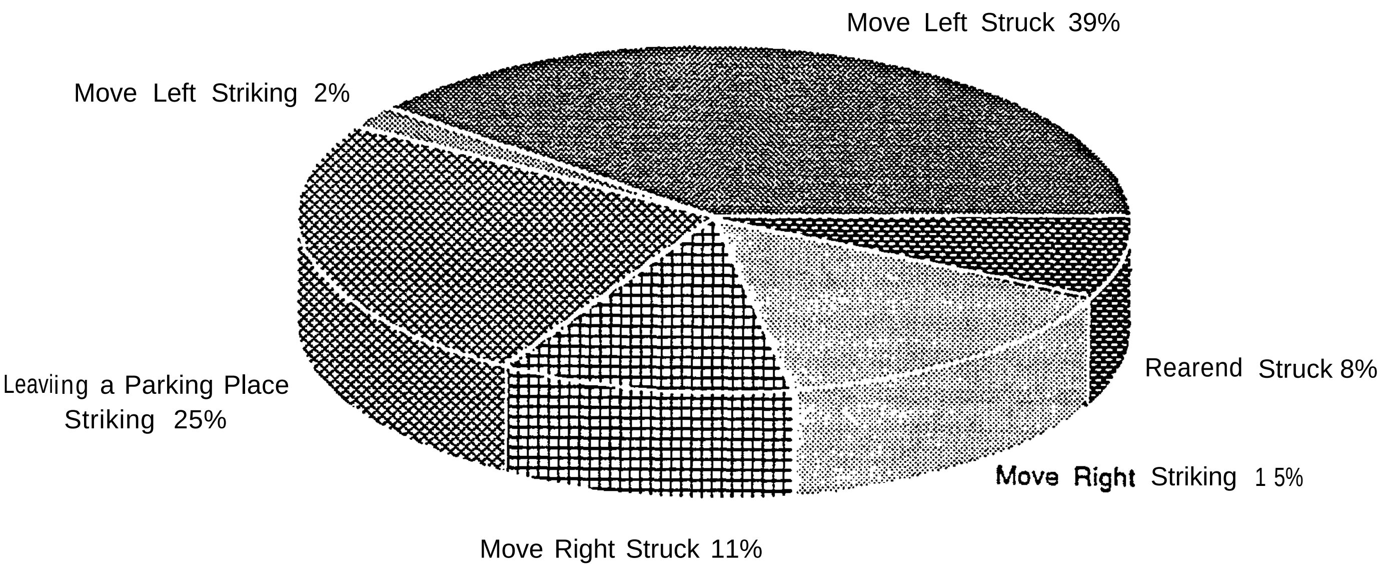
6.1.4 Comparison of hard copy and database analyses

The relative distributions of populations of the scenarios as derived from the CDS and GES are compared in Figure 6.1.4-1. For each scenario, the contributions due to the hard copy cases analyzed from the CDS were calculated by summing the case weights. The GES populations are those shown in TABLE 6.1.3-1. It is easily seen that there is not good correspondence between the two samples. Indeed, one would not expect the two populations to agree closely since the CDS is biased to more severe crashes involving later model vehicles, as previously discussed in section 4.2. However, it is possible to use the information gathered in the clinical study for each scenario and then to assign the proper weight to the scenario based on the numbers derived from the GES. The category lane change/merge rearend striking is not included in this comparison but will be considered in the development of the preliminary specifications.

FIGURE 6.1.4-l: Relative Distributions of Populations of Scenarios as Derived from the CDS and GES Databases



LCM Collision Scenarios Based on GES Populations



LCM Collision Scenarios Based on CDS Case Weights

6.2 Backing Crash Analysis

When the CDS was sorted for candidate backing crashes using the criteria PREMOVE = 12 (backing) or 92 # ACCTYPE # 93 (backing crash, striking or struck), only two possible candidate cases emerged. This was expected based on the CDS bias toward more serious accidents. Both cases appeared to be unusual. Since there were insufficient crashes in theCDS and those cases in the CDS appeared non-representative, it was necessary to review PARS corresponding to the GES entries.

6.2.1 GES PAR Selection

The lists of case numbers were generated by sorting the GES.GES92 data set in the usual ways described in sections 5.2 and 5.3 and then printing out the case numbers of each classification type along with the values of several other variables, such as case weight and speed. When there were large numbers of cases corresponding to a particular classification, those cases were sought in which vehicle speed(s) were available. When the number of cases was limited (for example, there were 11 backing crashes involvingpedacyclists, only 1 of which contained the vehicle speed), all available cases were examined, even those involving “hit and run”. Also all backing crashes involving pedestrians were examined.

The problem encountered in analyzing PARS was the small sample sizes (especially for samples containing vehicle speed information) available in some of the most important categories. All crashes in which a pedestrian (50 cases) or pedacyclist (11 cases) were struck were examined, even “hit and run” cases and those for which the vehicle speed information was unavailable. Also all crashes in which a vehicle backing from a parking place struck another motorvehicle in transport were examined (14 cases). In the remaining categories, there were sufficient numbers of cases with vehicle speed information. All PARS with vehicle speed information were examined for cases involving backing into a fixed object (15 cases) and cases in which the backing vehicle was struck (25 cases). One half of the PARS with vehicle speed information were sampled in the cases of backing and striking a parked car (23 cases resulted) and parallel path backing (32 cases resulted). One in five PARS with vehicle speed information was sampled in the case of general backing (33 cases resulted). It is assumed that the presence or absence of vehicle speed information is purelyrandom and not correlated with any other accident property. After this selection process, a total of 203 cases was chosen for analysis.

6.2.2 GES PAR Analysis

In February, 1994 a team from TRW and UTSA went to Arlington, VA to review PARS associated with backing crashes. A total of 203 reports were requested. The expected, actual and potentially useful counts of backing crashes studied are shown below in Table 6.2.2-l. Not all potentially useful cases yielded significant data.

TABLE 6.2.2-l : Numbers of Expected, Actual and Potentially Useful GES cases for backing crashes clinical study versus Classification.

	Expected*	Actual*	Potentially Useful	Usable
BACK1 (pedestrian)	50	50	38	30-31
BACK2 (pedacyclist)	11	11	11	9-10
BACK3 (general)	33	23	21	16
BACK4 (parked cars)	32	33	24	25-26
BACK5 (parallel path)	23	20	17	14-15
BACK6 (leaving parking space)	14	19	19	13
BACK7 (struck)	25	25	20	16-17
BACK8 (fixed object)	15	14	7	4
	203	195**	157	127-132

* Expected and actual counts vary due to some crashes being reclassified from one type to another after the PAR was studied. In other cases, the backing vehicle would not be a candidate for the backing crash avoidance system (e.g., a snowplow or a back hoe or a grass mower).

** There were 5 additional cases which were not relevant.

6.2.3 Clinical Study

Once the team arrived in Arlington, VA and the cases were pulled, it was necessary to systematize the method in which data was retrieved for each classification. Specialized forms were generated "on the fly". An example of one such form may be found in Appendix B, Form 2. The PARS contained much more detailed information than was available from the printout of the GES variables. The four days in Arlington, VA were devoted to preliminary scenario generation and gathering data for these scenarios. The results are presented in Section 7.2.

6.2.4 Comparison of PARS and Database Analyses

For the backing crashes as for the lane change/merge crashes, it is possible to use the information gathered in the clinical study for each scenario and then to assign the proper weight to the scenario based on the numbers derived from the GES. This approach is to be used in assessing the effectiveness of the CAS as determined by the simulations.

7.0 CRASH SCENARIO SUMMARIES

7.1 Lane Change/Merge Scenarios Based on CDS Hard Copy Analysis

In the CDS, the data is weighted to represent all police reported crashes involving light motor vehicles (gross vehicle weight **I** 10,000 pounds) occurring on a public trafficway in which at least one vehicle was towed due to damage. However, heavier vehicles may also be involved. "Special consideration" is given to late model vehicles (the 5 most recent years) and emphasizing more serious injury accidents. The pedestrian and non-motorist records are eliminated. The sum of the individual weights for all cases within a scenario represents the number of crashes meeting the restrictive CDS specifications.

The CDS scenarios do not precisely correspond to the categories explored in the GES. Please see Table 6.1.3-3 for the correspondence between the CDS scenarios and the number of GES cases. The CDS data is biased in the manner discussed above, while the GES populations contain both passenger cars and trucks of all ages and crashes of all severities. Since the GES includes a wider spectrum of motor vehicles and crash severities, the GES data is used in treatments of injury severity, such as those found in section 4.5 and 4.6.

In the following, the "Angle of Impact" is the angle between the velocity vectors of the vehicles at impact, based on numbers quoted in the CDS hard copy case report. Case numbers are unique case identifiers made up of the primary sampling unit number (PSU) and case number within that PSU. The case weights, which correspond to the number of police reported crashes represented by this sample crash, have been rounded to the nearest integer. In all cases, the data collected in the tables below are taken exactly as they appear in the CDS hard copy reports, without editing or interpretation. Data marked "99" or "unknown" in the hard copy reports are reported as "unknown" in the tables below.

The case weight specifies the number of police reported crashes satisfying the CDS specifications for which that case is considered representative. Within the 1992 CDS database, the CDS case weights are seen to vary from about 4 to over 3000. For each CDS hard copy report used in scenario development, the CDS case weight is included in order to assign a relative importance to those crash scenario characteristics derived from the analysis of that CDS hard copy report. As explained on page 96, these CDS case weights cannot be utilized to assign absolute probabilities to the occurrence of these types of accidents but must be correlated to the GES data as done in Table 6.1.3-3.

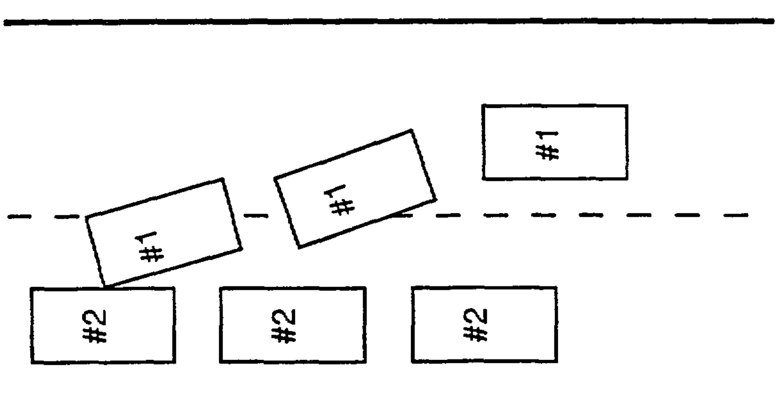
7.1.1 Passenger Vehicle Scenarios

The following thirteen lane change/merge scenarios were developed from the 61 cases which remained after hard copy analysis (see Section 6.0). Each of these 61 collisions involved an "at-fault" passenger vehicle whose critical event could have been prevented by an LCM CAS. These 61 hard copies were sorted further into categories based on similar critical events. Each of these categories was then developed into an LCM scenario. Thirteen scenarios resulted, each containing the information necessary to develop a computer model, as well as a sketch of the critical event. Those 13 scenarios are as follows.

SCENARIO PV1:	Lane Change Left Striking	
TIME OF DAY:	11:30 am - 10:00 pm	daylight (4) dark (2)
ROAD CONDITIONS:	dry, level, bituminous wet, level, bituminous	(5) (1)
GENERAL:	VEHICLE # 1 changing lanes left striking speed: 5-50 mph impact: left front bumper	VEHICLE # 2 going straight struck speed: 0-50 mph impact: right side
SPEED LIMIT:	30-55 mph	
ANGLE AT IMPACT:	5-10 degrees 80 degrees	

TOTAL CASES: 6
SUM OF CASE WEIGHTS: 394

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
72-230J (12)	unknown	30 mph	10 degrees
82-39F (92)	unknown	25-30 mph	9 degrees
41-102D (101)	50 mph	50 mph	10 degrees
4-17J (39)	unknown	unknown	4 degrees
73-12K (57)	unknown	unknown	80 degrees
2-159F (93)	5-10 mph	0 mph	10 degrees



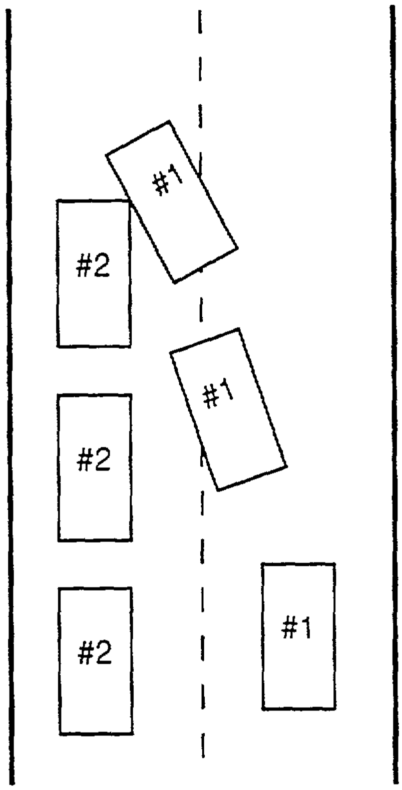
SCENARIO PV2: Lane Change Left Struck

TIME OF DAY:	9:00 am - 1:30 am	daylight (11) dark (4)
ROAD CONDITIONS:	dry, level, asphalt/concrete	(11)
	dry, incline, concrete	(1)
	dry, decline, asphalt/concrete	(2)
	wet, incline, bituminous	(1)
GENERAL:	VEHICLE # 1	VEHICLE # 2
	changing lanes left	going straight
	struck	striking
	speed: 5-55 mph	speed: 15-5.5 mph
	impact: left side	impact: rt ft corner
SPEED LIMIT:	25-55 mph	
ANGLE AT IMPACT:	0-50 degrees	

OBSERVATIONS: 15
NUMBER OF CRASHES: 7545

CASE NUMBER (WEIGHT):	SPEED VEHICLE #l	SPEED VEHICLE #2	ANGLE
9-20J (12)	45-50 mph	unknown	40 degrees
74-31E (122)	unknown	unknown	0 degrees
9-91J (30)	unknown	unknown	30 degrees
72-278C (5)	unknown	unknown	5 degrees
72-273 C (4)	unknown	unknown	5 degrees
78-l 16G (216)	20 mph	25 mph	15 degrees
74-111F (229)	unknown	unknown	15 degrees
79-43F (71)	unk	35 mph	10 degrees
41-81E (265)	55 mph	55 mph	0 degrees
13-135G (353)	30 mph	30 mph	20 degrees
6-16H (3725)	unknown	unknown	12 degrees
4-13G (177)	unknown	unknown	3 degrees
8 1-33H (2072)	5-10 mph	15-20 mph	25 degrees
6-165E (256)	unknown	unknown	5 degrees
82-65K (8)	30 mph	50 mph	52 degrees

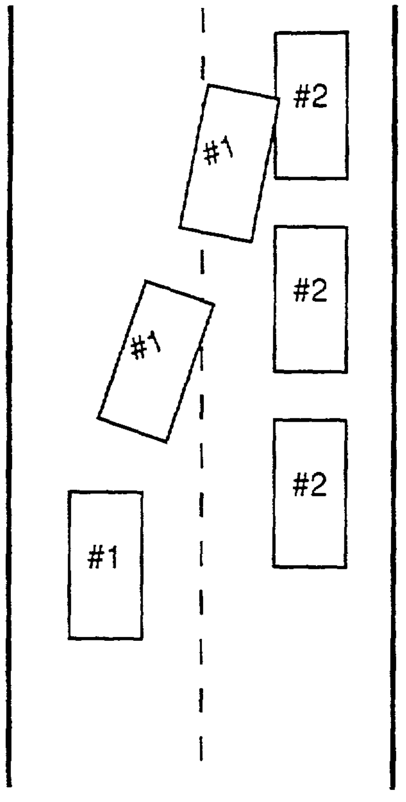
SCENARIO PV2: CRASH SCHEMATIC:



SCENARIO PV3:	Lane Change Right Striking	
TIME OF DAY:	9:45 am - 1:30 a m	daylight (5) dark (5)
ROAD CONDITIONS:	dry, level, bituminous dry, incline, bituminous foggy/wet, level, bituminous	(6) (2) (2)
GENERAL:	VEHICLE # 1 changing lanes right striking speed: 0-75 mph impact: right front bumper	VEHICLE # 2 going straight struck speed: 30-65 mph impact area: left side
SPEED LIMIT:	30-55 mph	
ANGLE AT IMPACT:	5-30 degrees	
OBSERVATIONS:	10	
NUMBER OF CRASHES:	3147	

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
78-190G (179)	30 mph	30 mph	12 degrees
82-15E (641)	unknown	unknown	7 degrees
12-88C (69)	75 mph	60-65 mph	unknown
72-144A (4)	unknown	50 mph	5 degrees
9-506A (0)**	unknown	30-40 mph	16 degrees
3-108F (485)	0 mph	35 mph	unknown
2- 156G (422)	unknown	unknown	30 degrees
75-1376 (1333)	40 mph	30 mph	11 degrees
49-133K (6)	55 mph	40-50 mph	20 degrees
82-71K (8)	unknown (>50)	50 mph	unknown

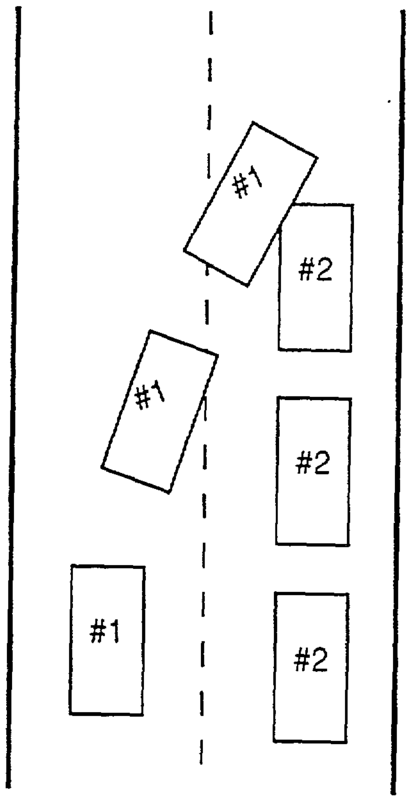
SCENARIO PV3: CRASH SCHEMATIC:



SCENARIO PV4:	Lane Change Right Struck	
TIME OF DAY:	11:15 am - 2:30 a m	daylight (3) dark (7)
ROAD CONDITIONS:	dry, level, bituminous dry, incline, bituminous wet, level, asphalt	(7) (2) (1)
GENERAL:	VEHICLE # 1 changing lanes right struck speed: 5-55 mph impact: right side	VEHICLE # 2 going straight striking speed: 20-80 mph impact: leftt front corner
SPEED LIMIT:	25-55 mph	
ANGLE AT IMPACT:	5 -30 degrees	
OBSERVATIONS:	10	
NUMBER OF CRASHES:	4441	

CASE NUMBER (WEIGHT):	SPEED VEHICLE #l	SPEED VEHICLE #2	ANGLE
76-l17J (153)	15 mph	45 mph	9 degrees
74-43F (152)	30 mph	35 mph	5 degrees
79-195A (8)	55 mph	80 mph	unknown
4-97H (670)	35 mph	20-25 mph	5 degrees
9-193F (1838)	unknown	unknown	20 degrees
48-35D (279)	5 mph	20 mph	27 degrees
72-84J (4)	unknown	55 mph	unknown
13-76F (153)	unknown	45 mph	20 degrees
13-225G (543)	20 mph	50 mph	22 degrees
76-147F (641)	20-30 mph	unknown	21 degrees

SCENARIO PV4: CRASH SCHEMATIC:

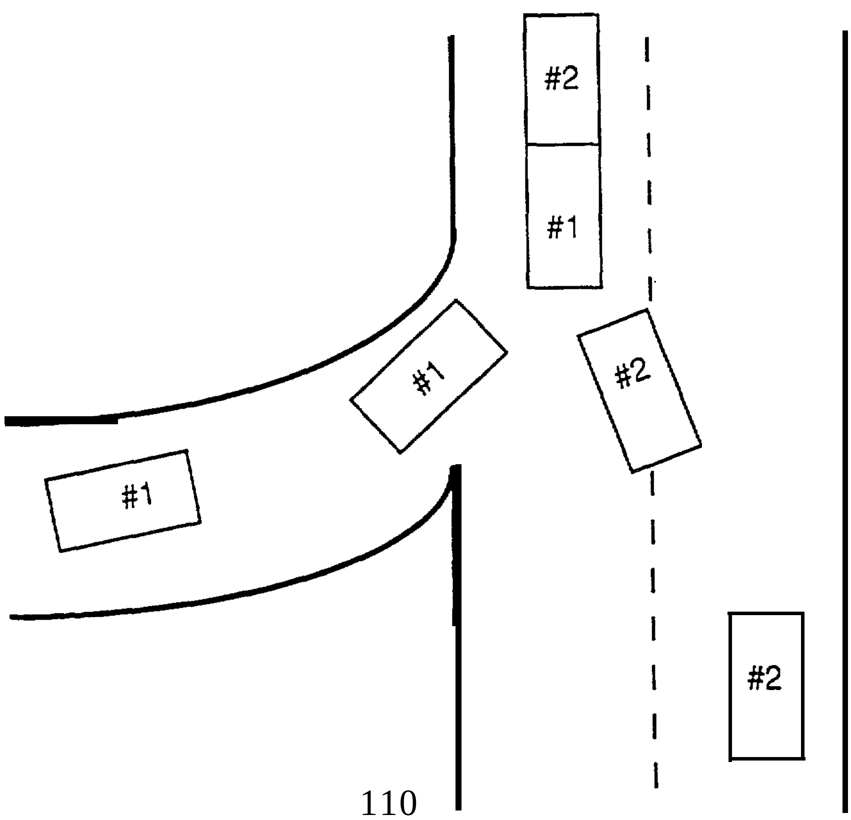


SCENARIO PV5: Both Changing Lanes

TIME OF DAY:	7:00 am	daylight
ROAD CONDITIONS:	dry, level, asphalt	
GENERAL:	VEHICLE # 1 changing lanes right merging onto highway striking speed: 30 mph impact: front bumper	VEHICLE # 2 changing lanes left struck speed: unknown impact: rear bumper
SPEED LIMIT:	45 mph	
ANGLE AT IMPACT:	0 degrees	

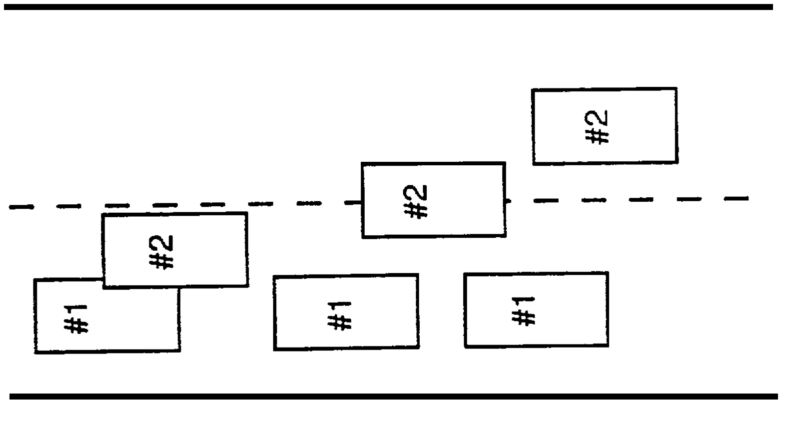
TOTAL CASES: 1
SUM OF CASE WEIGHTS:4

CASE NUMBER (WEIGHT):	SPEED VEHICLE # 1	SPEED VEHICLE #2	ANGLE
72-40C (4)	30 mph	unknown	0 degrees



SCENARIO PV6:	Drifting Left Striking	
TIME OF DAY:	C.10 pm	dusk
ROAD CONDITIONS:	wet/rainy/hazy, decline, bituminous	
GENERAL:	VEHICLE # 1 going straight struck speed: unknown impact: back right side	VEHICLE # 2 drifting left striking speed: 35-40 mph impact: left front bumper
SPEED LIMIT:	55 mph	
ANGLE AT IMPACT:	0 degrees	
TOTAL CASES:	1	
SUM OF CASE WEIGHTS:	161	

CASE NUMBER (WEIGHT):	SPEED VEHICLE #l	SPEED VEHICLE #2	ANGLE
2-14E (161)	unknown	35-40 mph	0 degrees



SCENARIO PV7: Rear-End Struck
Lane Change Left

TIME OF DAY: 12:30 pm - 12:00 am daylight (1)
dark (2)

ROAD CONDITIONS: dry, level,
concrete/asphalt

GENERAL:

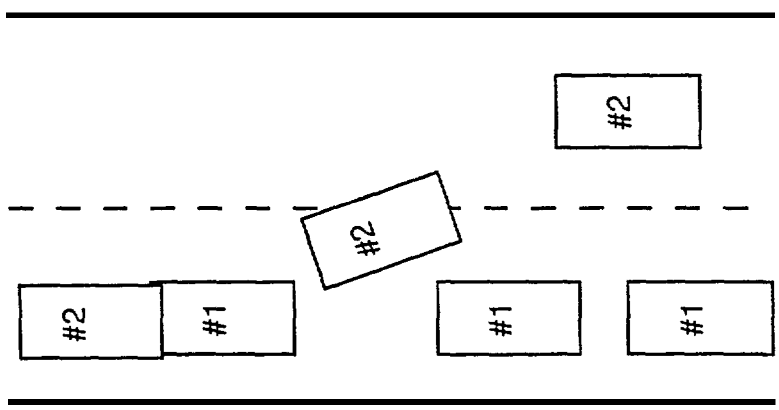
	VEHICLE # 1	VEHICLE # 2
	going straight	changing lanes left
	striking	struck
speed:	40 mph	45-50 mph
impact:	front bumper	rear bumper

SPEED LIMIT: 45-55 mph

ANGLE AT IMPACT: 0-5 degrees

TOTAL CASES: 3
SUM OF CASE WEIGHTS: 870

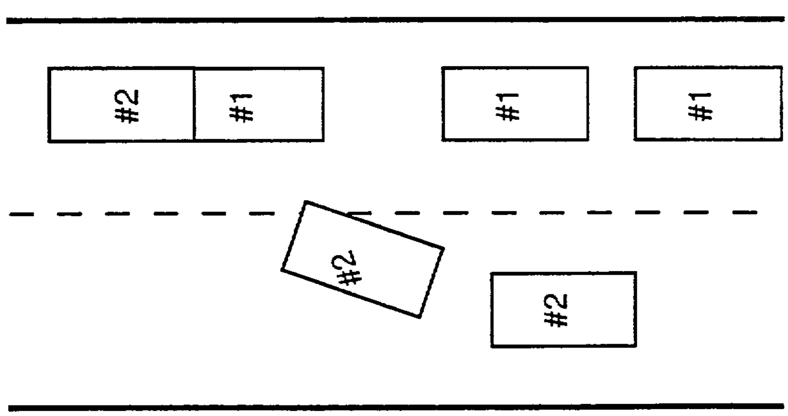
CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
49-78F (178)	40 mph	unknown	0 degrees
73-127F (673)	unknown	45-50 mph	5 degrees
72-79E (19)	unknown	unknown	0 degrees



SCENARIO PV8:	Rear-End Struck Lane Change Right	
TIME OF DAY:	12:30 pm - 11:30 pm	daylight (1) dark (3)
ROAD CONDITIONS:	dry, level, asphalt	
GENERAL:	VEHICLE # 1 going straight striking speed: 25-55 mph impact: front bumper	VEHICLE # 2 changing lanes right struck speed: 25-50 mph impact: rear bumper
SPEED LIMIT:	30-55 mph	
ANGLE AT IMPACT:	5-15 degrees	

TOTAL CASES: 4
SUM OF CASE WEIGHTS: 2344

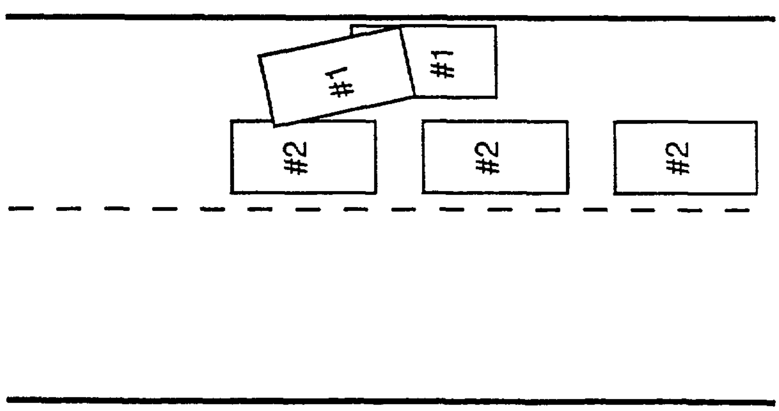
CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
79-77H (723)	45 mph	25 mph	5 degrees
6-161G (206)	unknnown	50 mph	10 degrees
48-215D (461)	55 mph	45 mph	11 degrees
81-105H (954)	25 mph	unknown	5 degrees



SCENARIO PV9:	Leaving a Parking Place Pulling into Traffic Striking	
TIME OF DAY:	2:00 - 4:30 pm	daylight
ROAD CONDITIONS:	dry, level, bituminous	
GENERAL:	VEHICLE # 1 pulling into traffic from stop striking speed: 3 mph impact: front left corner	VEHICLE # 2 going straight struck speed: 35 mph impact: right side
SPEED LIMIT:	20-30 mph	
ANGLE AT IMPACT:	10-30 degrees	

TOTAL CASES: 3
SUM OF CASE WEIGHTS:9501

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
73-23H (9321)	unknown	unknown	10 degrees
72-206F (40)	unknown	unknown	30 degrees
72-45H (140)	3 mph	35 mph	12 degrees



SCENARIO PV10: Leaving a Parking Place
Pulling into Traffic
Struck

TIME OF DAY: 8:50 pm dark

ROAD CONDITIONS: wet, level, bituminous

GENERAL:

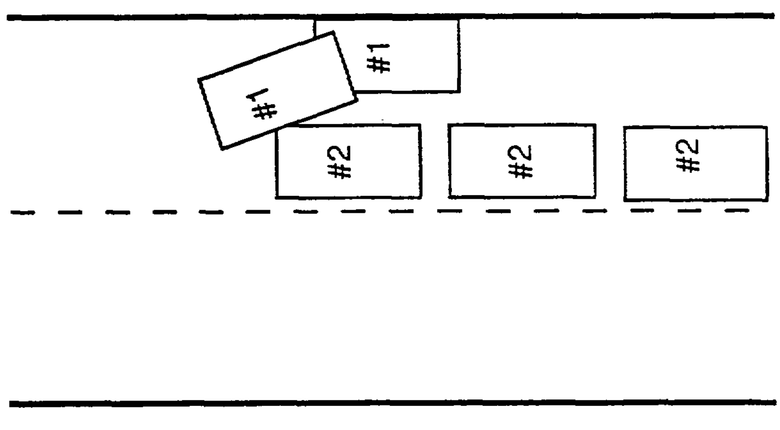
VEHICLE #1	VEHICLE #2
pulling into traffic from stop	going straight
struck	striking
speed: unknown	speed: 20-30 mph
impact: left side	impact: front right corner

SPEED LIMIT: 30 mph

ANGLE AT IMPACT: 25 degrees

TOTAL CASES: 1
SUM OF CASE WEIGHTS: 114

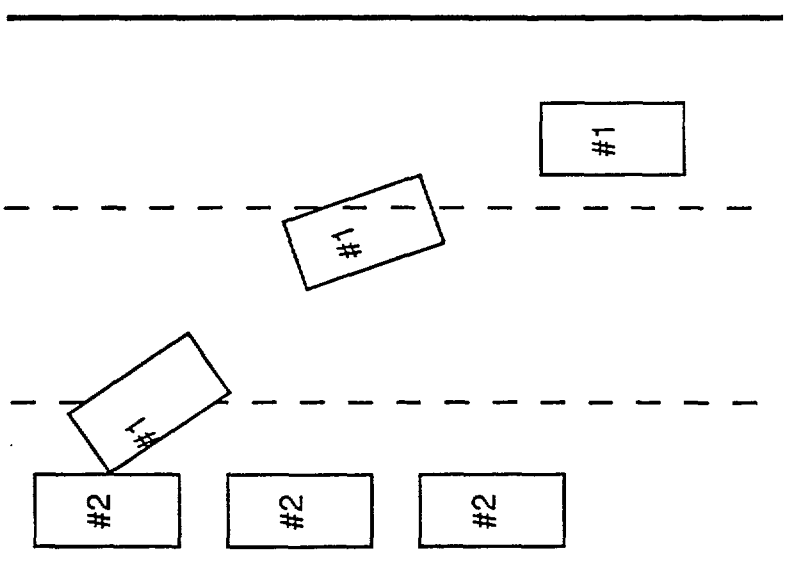
CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
72-258G (114)	unknown	20 - 30 mph	25 degrees



SCENARIO PV11:	Lane Change Left Across 2 Lanes Striking	
TIME OF DAY:	7:45 - 11:30 am	daylight
ROAD CONDITIONS:	dry, level, bituminous wet, level, bituminous	(1) (1)
GENERAL:	VEHICLE #1 . changing lanes left striking speed: 3-55 mph impact: front left bumper	VEHICLE # 2: going straight struck speed: 45-50 mph impact area: right side
SPEED LIMIT:	50-55 mph	
ANGLE AT IMPACT:	35-40 degrees	

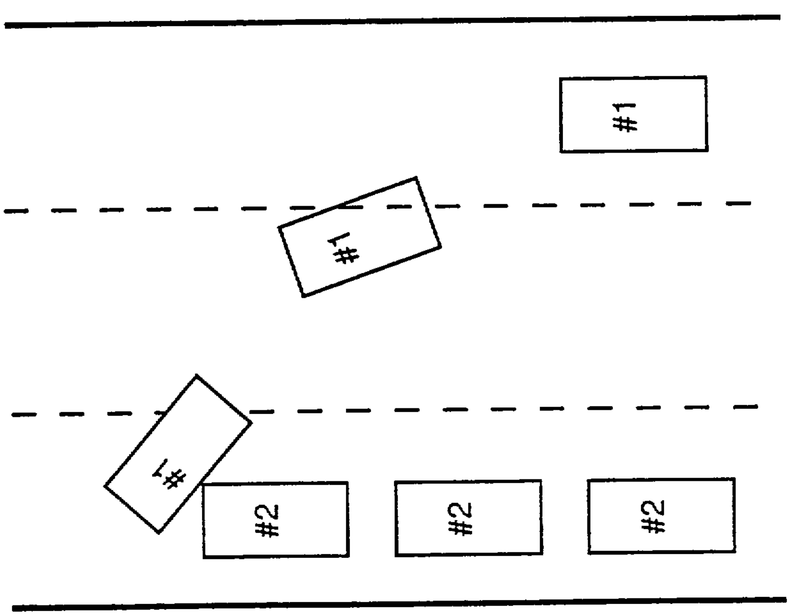
TOTAL CASES: 2
SUM OF CASE WEIGHTS: 196

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE#2	ANGLE
78-9C (73)	3 mph	45 mph	36 degrees
3-15G (123)	55 mph	50 mph	40 degrees



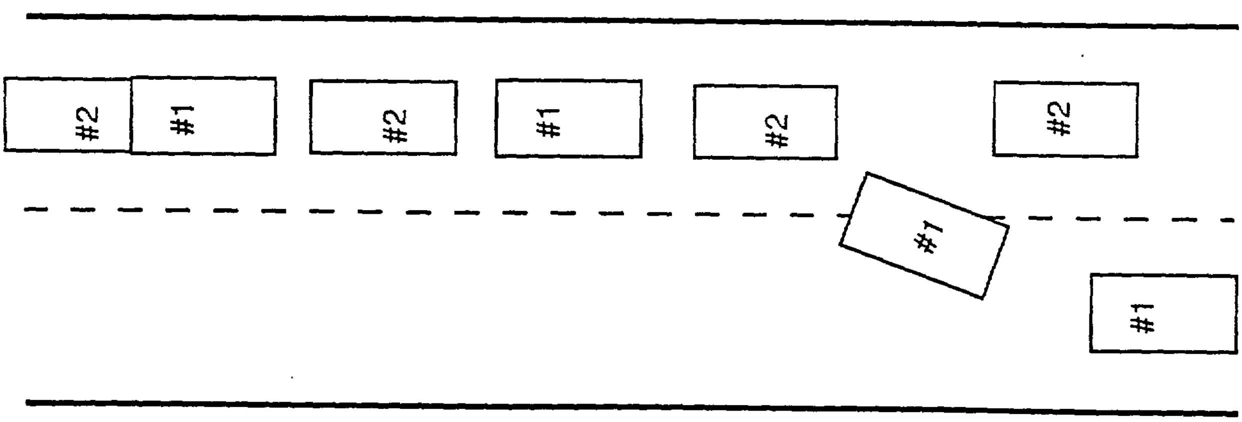
SCENARIO PV12:	Lane Change Left Across 2 Lanes Struck	
TIME OF DAY:	1:00 pm	daylight
ROAD CONDITIONS:	dry, level, bituminous	
GENERAL:	VEHICLE #1 changing lanes left struck speed: unknown impact: left side	VEHICLE # 2: going straight striking speed: 50-55 mph impact: front right bumper
SPEED LIMIT:	50 mph	
ANGLE AT IMPACT:	unk	
TOTAL CASES:	1	
SUM OF CASE WEIGHTS:	41	

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
4-42K (41)	unknown	50 - 55 mph	unknown



SCENARIO PV13:	Lane Change Rearend Striking	
TIME OF DAY:	11:30 am - 12:00 am	daylight (1) dark (3)
ROAD CONDITIONS:	dry, level, asphalt	(4)
GENERAL:	VEHICLE #1 changing lanes left (1) changing lanes right (3) striking speed: 20-50 mph impact: front bumper	VEHICLE # 2: going straight struck speed: 10-40 mph impact: rear bumper
SPEED LIMIT:	30-65 mph	
ANGLE AT IMPACT:	0-15 degrees	
OBSERVATIONS:	4	
NUMBER OF CRASHES:	1245	

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE#2	ANGLE
48-218D (836)	unknown	40 mph	2 degrees
9-184C (149)	20-30 mph	10-20 mph	2 degrees
82-94G (176)	40-50 mph	unknown	0 degrees
43-169G (84)	50 mph	40 mph	15 degrees

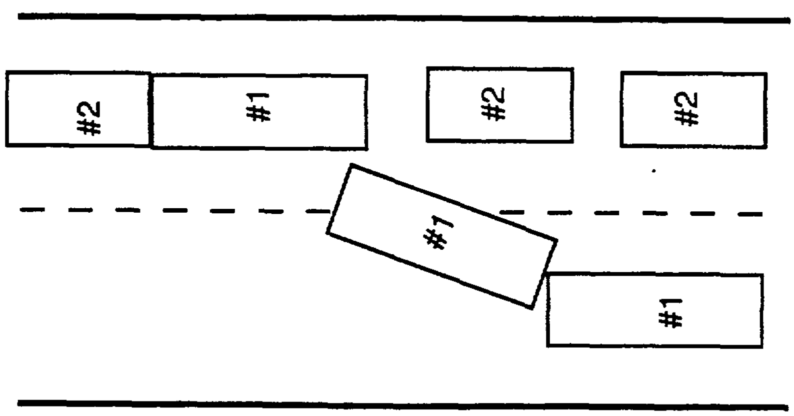


7.1.2 Truck Scenarios

The following 7 lane change/merge scenarios were developed from the 32 cases which involved an "at fault" truck as described above.

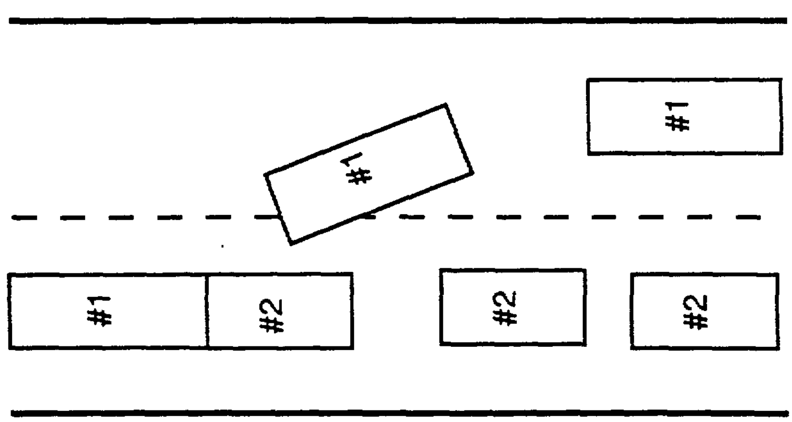
TRUCK SCENARIO T1:	Lane Change Right Rearend Striking	
TIME OF DAY:	8:00 am - 2:10 pm	daylight
ROAD CONDITIONS:	dry, level, bituminous (3)	
GENERAL SPECS:	VEHICLE #1 (TRUCK) changing lanes right rearend striking speed: 62 mph impact: front right bumper	VEHICLE # 2: going straight rearend struck speed: 30-55 mph impact: rear bumper
SPEED LIMIT:	40 - 55 mph	
ANGLE AT IMPACT:	0 - 15 degrees	
TOTAL CASES:	3	
SUM OF CASE WEIGHTS:	596	

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
72-299F (3)	unknown	unknown	10 degrees
72-297D (10)	unknown	30 - 40 mph	15 degrees
48-95D (583)	62 mph	55 mph	3 degrees



TRUCK SCENARIO T2:	Lane Change Left Rearend Struck	
TIME OF DAY:	1:59 pm	daylight
ROAD CONDITIONS:	wet, level, concrete	(1)
GENERAL SPECS:	VEHICLE #1 (TRUCK) changing lanes left rearend struck speed: unknown impact: rear bumper	VEHICLE # 2: going straight rearend striking speed: ~55 mph impact: front right bumper
SPEED LIMIT:	55 mph	
ANGLE AT IMPACT:	0 degrees	
TOTAL CASES:	1	
SUM OF CASE WEIGHTS:	442	

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
6-49F (442)	unknown	~55 mph	0 degrees



TRUCK SCENARIO T3: Lane Change Right Striking

TIME OF DAY: 5:30 am - 11:30 p m — daylight (14), dark (4)

ROAD CONDITIONS: dry, level, bituminous (18)

GENERAL SPECS:

VEHICLE #l (TRUCK)	VEHICLE # 2:
changing lanes right	going straight
striking	struck
speed: 25-62 mph	speed: 10-65 mph
impact: front right corner	impact: left side

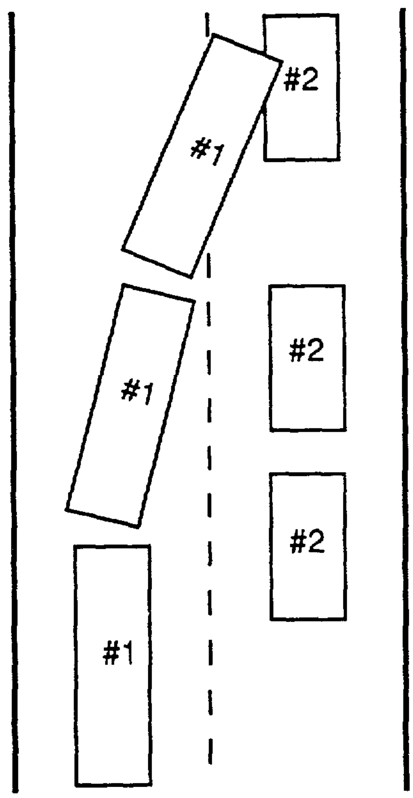
SPEED LIMIT: 25 - 55 mph

ANGLE AT IMPACT: 0-30, 90, 170 degrees

OBSERVATIONS: 18
NUMBER OF CRASHES: 3009

CASE NUMBER (WEIGHT):	SPEED VEHICLE 1	SPEED VEHICLE 2	ANGLE
78-156G (218)	62 mph	65 mph	5 degrees
5-140F (405)	unknown	45 mph	unknown
45-158D (209)	unknown	unknown	unknown
49-l 13H (600)	unknown	55 mph	90 degrees
72-147D (8)	unknown	unknown	10 degrees
72-67C (8)	43 mph	38 mph	13 degrees
72-19C (8)	unknown	unknown	15 degrees
72-107J (12)	unknown	unknown	10 degrees
72-167D (24)	unknown	55 mph	170 degrees
72-166C (18)	unknown	unknown	5 degrees
9-103K (69)	unknown	unknown	10 degrees
41-122D (54)	55 mph	55 mph	0 degrees
48-52C (304)	65 mph	65 mph	10 degrees
48-84D (296)	25 mph	45 mph	1 degree
72- 182G (29)	unknown	l0-15 mph	5 degrees
73-182F (590)	unknown	50-60 mph	10 degrees
72-274D (6)	unknown	60 mph	10 degrees
9-128C (151)	unknown	-15 mph	30 degrees

TRUCK SCENARIO T3: CRASH SCHEMATIC:



TRUCK SCENARIO T4: Lane Change Right Struck

TIME OF DAY: 5:50 am - 3:30 pm — daylight (2), dark (1)

ROAD CONDITIONS: dry, level, bituminous (3)

GENERAL SPECS:

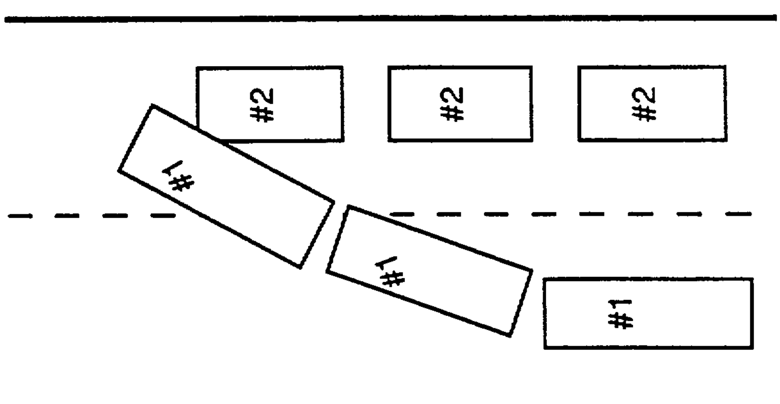
VEHICLE #1 (TRUCK)	VEHICLE # 2:
changing lanes right	going straight
struck	striking
speed: 40-55 mph	speed: 35-55 mph
impact: right side	impact: left side

SPEED LIMIT: 40 - 55 mph

ANGLE AT IMPACT: 0 - 10 degrees

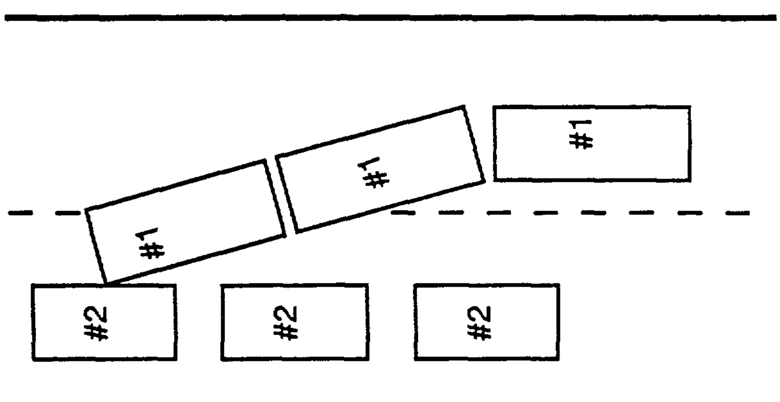
TOTAL CASES: 3
SUM OF CASE WEIGHTS: 170

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHI E #2	ANGLE
41-94C (10)	55 mph	55 mph	5 degrees
72-249D (5)	unknown	55 mph	10 degrees
76-88H (155)	40 mph	35 mph	0 degrees



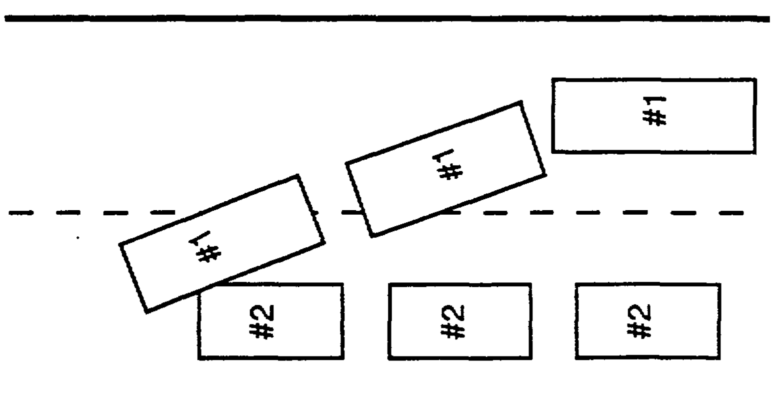
TRUCK SCENARIO T5:	Lane Change Left Striking	
TIME OF DAY:	6:55 pm	dusk (1)
ROAD CONDITIONS:	dry, level, concrete	(1)
GENERAL SPECS:	VEHICLE #1 (TRUCK) changing lanes left striking speed: unknown impact: front left corner	VEHICLE # 2: going straight struck speed: unknown impact: rear right corner
SPEED LIMIT:	55 mph	
ANGLE AT IMPACT:	5 degrees	
TOTAL CASES:	1	
SUM OF CASE WEIGHTS:	365	

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
72-298H (365)	unknown	unknown	5 degrees



TRUCK SCENARIO T6:	Lane Change Left Struck	
TIME OF DAY:	9:50 am -5:30 pm	daylight (5)
ROAD CONDITIONS:	dry, level, bituminous (5)	
GENERAL SPECS:	VEHICLE #1 (TRUCK) changing lanes left struck speed: unknown impact: left side	VEHICLE # 2: going straight striking speed: 40-65 mph impact: front right side
SPEED LIMIT:	40 - 55 mph	
ANGLE AT IMPACT:	0 - 10 degrees	
TOTAL CASES:	5	
SUM OF CASE WEIGHTS:	8383	

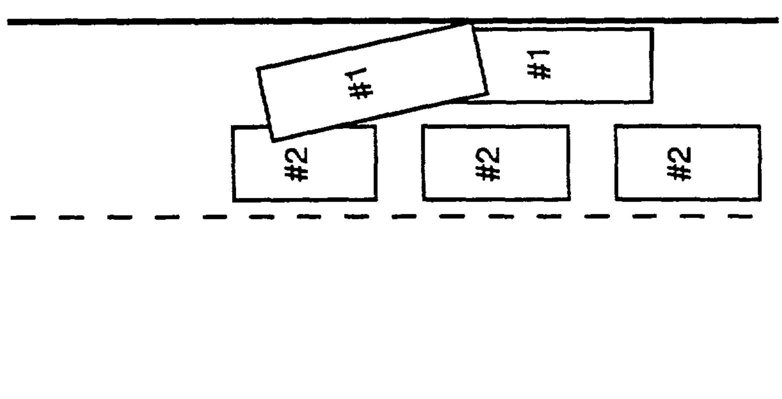
CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
11-168C (44)	unknown	40 mph	5 degrees
9-88F (1933)	unknown	unknown	10 degrees
45-83H (5187)	unknown	unknown	0 degrees
72-171E (16)	unknown	55 mph	5 degrees
48-2678C (1203)	unknown	65 mph	3 degrees



TRUCK SCENARIO T7:	Leaving a Parking Place Pulling into Traffic Striking

TIME OF DAY:	4:15 pm	daylight (1)
ROAD CONDITIONS:	dry, level, bituminous (1)	
GENERAL SPECS:	VEHICLE #1 (TRUCK) pulling into traffic from stop striking speed: 0-5 mph impact: left side	VEHICLE # 2: going straight struck speed: 25 mph impact: right side
SPEED LIMIT:	25 mph	
ANGLE AT IMPACT:	5 degrees	
TOTAL CASES:	1	
SUM OF CASE WEIGHTS:	785	

CASE NUMBER (WEIGHT):	SPEED VEHICLE #1	SPEED VEHICLE #2	ANGLE
11-151F (785)	0 - 5 mph	25 mph	5 degrees



7.2 Backing Crash Scenarios Based on PAR Analyses

From the analysis of the PARs, 32 backing scenarios were derived distributed among the 8 classifications as shown below in Table 7.2-l. Basically the scenarios were divided between straight path backing (43 %) and curved path backing (57 %). As much speed and orientation information as possible has been retained in the scenarios for use in the simulations.

The following table, TABLE 7.2-1, is a brief summary of the various backing scenarios derived from the PAR analysis.

TABLE 7.2-l: Classifications and Scenarios for Backing Crashes as Derived from PARs.

BACK1 : STRIKING PEDESTRIANS - 6 SCENARIOS

1. Backing from driveway - 12 cases
2. Backing on roadway - 9 cases
3. Backing from parking space - 9 cases
4. Backing into driveway - 2 cases
5. Backing into parking space - 3 cases
6. Backing across intersection - 2 cases

Results = 5 curved path + 25 straight paths with speed breakdowns

BACK2: STRIKING PEDACYCLISTS - 4 SCENARIOS

1. Pedacyclist on sidewalk; vehicle backing from driveway - 4 cases
2. Pedacyclist on road; vehicle backing from driveway - 3 cases
3. Pedacyclist and vehicle on road - 2 cases
4. backing into driveway on a curved path - 1 case

Results = 5 curved path + 5 straight paths with speed breakdowns and cyclist age spreads

BACK3: GENERAL 2-VEHICLE BACKING CRASHES - 2 SCENARIOS

1. Backing from driveway - 12 cases
2. Backing on roadway - 8 cases

Results = Backing from driveway: 4 curved + 7 straight
Backing on roadway: 3 curved + 2 straight
with speeds and angles of approach

BACK4: BACKING AND HITTING PARKED CAR - 4 SCENARIOS

1. Backing from driveway - 13 cases
2. Backing on shoulder or off-road or in parking lot - 10 cases
3. Backing from parking space - 5 cases
4. Backing on roadway - 4 cases

Results = 12 curved path + 10 straight path + 3 misc.
with speeds and angles of approach

BACKS: PARALLEL PATH BACKING AT CONTROLLED INTERSECTION - 3 SCENARIOS

1. Backing at signal or intersection - 14 cases
2. backing not in response to signal or intersection - 4 cases
3. Backing around corner or curve at intersection - 2 cases

Results = 2 curved path + 12 straight path the 2 curved path cases should probably be moved out of this category

BACK6: BACKING PROM PARKING AND HITTING MOTOR VEHICLE IN TRANSPORT- 3 SCENARIOS

1. Backing into a parallel parking place - 1 case
2. Backing from parallel parking or unknown parking - 4 cases
3. Backing from diagonal parking - 13 cases

Results = 13 curved path + 2(?) straight path case

BACK7: BACKING STRUCK - 4 SCENARIOS

1. Backing from driveway - I4 cases
   (These are all high relative speed, transverse crashes. Traditional rear obstacle detection system would not be helpful.)
2. Backing on roadway - 6 cases
3. Backing from diagonal parking - 2 cases
4. Backing into driveway - 3 cases (all non-standard vehicles)

Results = Combining 2 and 3: 4 probably curved + 1 probably straight path cases: all possibly have relatively high closing speeds

BACK8: BACKING AND HITTING FIXED OBJECT - 6 SCENARIOS

1. Backing around corner - 3 cases
2. Backing after miscellaneous event - 1 case
3. backing from driveway - 1 case
4. Backing on roadway - 1 case
5. backing into driveway - 1 case
6. Backing from parking - 1 case

Results = 2 cases curved path backing around a corner (1 large target-fence; 1 small target-stop sign) + 2 cases straight path backing (1 medium target-mailbox; 1 massive target-garage door) + 1 case which could be either (target-fence struck with right rear corner of auto at 45 degree angle)

8.0 DETAILED STATISTICAL ANALYSIS

8.1 Introduction

The statistical analyses presented in this report have been limited to an examination of the computed coefficients associated with two-way crosstabulation tables of accident variables. This in itself was a huge undertaking due to the many possible tables that could be constructed as well as the many categories of accident types that needed to be analyzed. From these tables and coefficients, attempts were made to discover causal factors associated with each accident type, but they were not be found.

The following sections discuss estimation, independence and correlation, and some additional specialized statistical analyses that could be undertaken to enhance the effort to isolate causal factors. These analyses necessarily are limited by the detail and accuracy of the data but they offer the opportunity to possibly unravel some of the complexities of the dataset. Also discussed are some issues related to the utility of the chosen methods and the choice of variables and accident subgroups to analyze.

8.2 Estimation

This section addresses the ability to estimate relative incidence rates of certain accident scenarios from information obtained in the GES data base. For the purposes of both sensor design and accident simulation, independence between accident type and the distribution of the relative vehicular velocities would greatly simplify both tasks.

Confidence intervals for population parameters, such as the proportions of occurrence, (e.g., the proportion of LCM accidents occurring at night) are often computed to quantify one's uncertainty in the estimate based on the sampling scheme used to obtain it. Standard charts can be found in most statistics books which tabulate standard errors for various confidence levels. These charts assume that the data are obtained from a single homogeneous but random sample. The GES data base is more intricate than a single sampling data scheme; these data are stratified and each stratum has a relative weight which is subject to possible variable inflation factors. Because the estimated proportion is best obtained from a mixture of weighted binomial distributions, the techniques used in single sample estimates taken from one homogeneous stratum are inadequate to handle the complexities found in the GES data base. In the GES data base, the problem is compounded by the weights themselves being treated as random variables, thus suggesting the possible use of Bayesian procedures.

Even well established large sample (asymptotic) theory via the Central Limit Theorem, which would allow us to treat the estimated proportion as a sample average having a normal distribution, is violated. The consequent percentiles obtained from the standard normal distribution and the estimated variance of the proportion used in random sampling from a homogeneous population are no longer adequate regardless of sample size.

The confidence intervals found in the standard statistical tables would infer that the errors associated with the values deduced from the weighted data would be relatively small because of the large numbers arising from weighting. Because these weighted data are based on only a much smaller sampling, the errors associated with them are much larger. For this reason, wherever errors are quoted in this document, the standard error tables generated for the 1992 GES data were utilized for the appropriate type of variable (i.e., vehicle, accident, or person). The errors quoted in those tables take into account the source of the data and the large weightings that have been applied.

8.3 Independence and Correlation

Two variables are said to be pairwise independent if fixing the value of one has no effect on the distribution of values of the other. As mentioned previously, the independence of the distributions of key variables such as relative velocity and accident sub-type would greatly simplify computer simulations and sensor design. Independence would imply that one could, given certain reasonable engineering constraints, combine the distributions for the accident sub-types and therefore have a more complete picture of the distribution of the variable under consideration. Since the sample sizes would be increased, one would anticipate better estimates for the relative proportions.

To evaluate the independence of two variables, one forms a contingency table in which the frequencies of the values of one variable are cross-tabulated against the values of the other variable. Independence between the two variables would imply that the relative frequencies with which values of the first variable occur with any specific value of the second variable are the same as they are in the global population. A test statistic is obtained by comparing the observed frequency of each cross-tabulation with its expected frequency under the assumption of independence. The chi-square test statistic is obtained by computing the term

$$X2 = \Sigma \Sigma (O_{ij} - E_{ij})^2 / E_{ij}$$

where Oij is the observed frequency of occurrence of the ith value of the first variable with jth value of the second variable and Eij is the corresponding expected frequency assuming independence. If one hypothesizes that no relation exists between various causal factors, say the time of day and the weather conditions, then one would anticipate good agreement between the observed and expected values. Good agreement between these values would lead to a small value of the chi-square test statistic, whereas large values of the test statistic would be indicative of dependence between the variables.

The chi-square test statistic has some inherent problems such as the denominator being an approximation to the variance of each cell count. This approximation is not appropriate for the weighted data found in the GES, and furthermore, it can be compromised if the sample size are inadequate or the relative frequencies are extremely small. The test lacks scale invariance and therefore must be used with caution whenever one is discretizing continuous distributions, such as relative velocities. On the other hand, the phi coefficient is a measure of the degree of association between variables which is based on the chi-squared test but is free of the influence of the total sample size. Since the phi coefficient is scale-invariant, it can be utilized with weighted data to produce a meaningful measure of correlation. Cramer's V statistic is based on the phi coefficient but has the further advantage that the upper limit is 1.0.

Likewise, if one is making multiple pairwise comparisons among the pairs of variables, he must consider the number of comparisons made if he wants to maintain an experiment-wide Type 1 error rate of 5%. This problem can often be accommodated by a Bonferroni adjustment to the pairwise Type 1 error rate. An additional problem surfaces among extremely large data sets such as those encountered in the census. The single conclusion is simply whether the variables are correlated but no quantification is give for the degree of correlation between the two variables. When data sets are extremely large, one can indeed detect that two variables are 5% or 10% correlated even if the Type 1 error rate is much less than 1%. These small association fall much below the level needed for causal factors that would be effective in sensor design. It is important therefore to quantify the correlation through an alternative procedure such as a log-linear or logistic regression model.

The problem associated with different variances from different strata within the GES data base, mentioned in Section 8.2, can also compromise the inferences about independence obtained from contingency tables. If one weights the respective contingency tables according to the weights given in the GES database as opposed to using the actual combined counts, one may not reject the hypothesis of independence with the weights assigned. Thus in the computation of the expected values, should one adjust for the weight in the GES data base?

A more dangerous problem with the interpretation of the chi-square test can occur whenever one considers three variables pairwise in three contingency tables. Mutual independence among the three variables is not a direct consequence of failing to reject the assumption of independence in the three pairwise tests. This higher order independence can be tested accurately via an alternative but more complicated procedure such as a log-linear or logistic regression model. Pairwise dependence between two variables does not necessarily imply causality. So the presence of many pairwise dependent variables such as speed, weather conditions, and type of roadway, does not imply that one must use all the variables in a predictive or simulation model.

Thus the statistical association found in statistical tests may not imply causality but rather directs the engineer or physicist to those variables which are most likely to be causal factors. This association can be converted into causality by examination of the individual accident reports.

8.4 Statistical Modeling For Causal Factors

8.4.1 Initial Modeling Considerations

Throughout this study it has been implied that a statistical analysis will be used to find the causal factors of the specified accident types. Statistical analysis will isolate associative factors but to determine if significant association implies causation would require more in-depth data than is provided in the GES. Nevertheless, there is high value in finding the associative factors as these provide insight into ways to determine the Crash Avoidance Systems. For this reason, we will continue to refer to these factors as causal ones.

Few correlations were found in the crosstabulation analyses, and there do not appear to be many dependencies among the measured variables. One problem may be that the situation is multivariate in nature and requires more detailed modeling than that provided by two-variable comparisons, Another problem may be that these types of accidents are related to variables that have not been recorded on a police report. For example, relative speed could be an important predictor as could lack of adequate vision of oncoming traffic. But neither of these variables are provided on police reports. Even surrogate variables are not available for most of these types of factors.

While it is not possible to increase the amount of information on a police report, it is possible to model the reported variables. Since we are examining probabilities, and since independence is an issue, we can transform the probabilities of an accident type to a log scale and express the probabilities as log odds. This implies we can model parts of the data using a log-linear model. Use of log odds ratios may be a helpful tool in further summarizing some of the results.

Before describing such an approach it is important to note that the GES files provide information only on conditions surrounding crashes but provide no information on the conditions surrounding non-crash situations. This is important from an associative viewpoint as it would aid in determining what specific variables distinguish these accidents from other types. Although no exposure measures (Please see pages 54 and 62.) are available, a comparison can be made by limiting our modeling to two-vehicle accidents where there is a striking and a struck vehicle. For example, if the striking vehicle is involved in a lane merging action and hits the other vehicle (the struck vehicle), we could compare the characteristics of the driver and vehicle of the two vehicles and see what distinguishes them from one another. This might provide clues as to the factors associated with a lane change/merge type of accident.

The developed models would demonstrate differences in distributions between the subject (lane changing/merging or backing) vehicle and the "other" vehicle involved in the crash. This matching of vehicles will provide the measure of exposure by which to statistically analyze the distribution of the variables associated with the subject vehicle. The idea is stimulated by a supposition that the "other" population of vehicle crash involvement is distinct from that of the subject vehicle. If this is indeed the case, the pairing would help identify variables associated with any differences between the crash experience of the two vehicles.

Since there is no universally accepted measure of exposure, it is suggested that the above exposure approach be utilized in the modeling effort. It could be used to search for causal significance relating to driving and vehicle variables. For example, the age and sex of the drivers in the non-accident-causing vehicle could be compared to those in the accident causing ones. Similarly, vehicle-related variables could be examined to uncover disproportionate numbers of a specific vehicle type for the accident-causing vehicles when compared to the non-violating vehicle types. The exposure metric would not be relevant for environmental causal factors since both the accident-causing and the non-violating vehicles were being driven under the identical external circumstances.

8.4.2 Modeling Approach

The proposed modeling effort involves the assessment of the correlation between multiple vehicle and driver variables associated with two-vehicle crashes (i.e., striking and struck). When these factors are discrete, this correlation is usually tested in a logistic regression model. The response variable of interest in the model would be a categorical variable having a value 1 or 0. A value of 1 would be used for those accidents where the vehicle is in a violating action, such as changing lanes, while a value 0 would be assigned to those accidents where no violating action occurs. The predictor variables in the model would consist of a set of about 20 variables selected from those listed in Table 4.1-l. By necessity, those variables that are not ordinal or numerical would be dichotomized so that they are binary in form. Some variables of interest might include the following:

Driver's vision obscured
Critical event (Precrash 2)
Corrective action attempted (Precrash 3)
Vehicle crash damage severity level
Driver's distraction
Alcohol use
Driver's maneuver to avoid
Travel speed
Driver's age
Driver's gender
Vehicle body type

Using the above set of predictor variables with the chosen response variable, it would be possible to model the outcome. Those variables found to be significant would be ones most useful in distinguishing between the two types of vehicles classified by the response variable. Thus it would be possible to determine what variables are significantly contributing to separating actions of the subject vehicle from actions of the other vehicle involved in a given crash.

Models could be run with and without interaction terms. Software, such as that available in PROC LOGISTIC in SAS, could be used to facilitate the analysis. Since data weights may be a concern due to their impact on the results, it may be useful to run the data with and without weights to determine what is significant.

Other SAS modeling software also could be utilized with this data such as that resulting from PROC PROBIT or PROC CATMOD. PROC PROBIT provides a different transformation to the data and PROC CATMOD allows for the construction of log-linear models for multiway tables. All of these approaches are dependent on the size and density of the database as well as the functional form of the chosen variables. Thus, some may be more useful than others.

It is not possible to extend this approach to single-vehicle crashes or to the conventional features surrounding these types of accidents. In the former case there is no comparison group while in the latter case both comparison groups experience the same environment. Thus, these types of accidents and variables will need to be studied using only the results of the crosstabulations.

It is recommended that a more detailed statistical analysis be made of the data associated with two-vehicle accidents (i.e., where there is a striking and a struck vehicle). This analysis would include the construction of a series of log-linear or logistic models where a response variable, reflecting the striking/struck nature of the vehicle, would be modelled as a linear function of several different vehicle and driver variables. Those variables identified as significant would become candidates for causal factors in the specified accident type.

9.0 CONCLUSIONS AND FURTHER WORK

The major conclusion from this work is that CAS are potentially very useful for both lane change/merging and backing accidents. This is based on the clear understanding of the circumstances surrounding the occurrence of these accident types which has arisen during the performance of this research. Tables 4.6.3-l to 4.6.3-3 in Section 4.6.3 imply that there are some factors or conditions (such as compromised lighting conditions for lane change/merge crashes) which may contribute to the occurrence of more severe accidents. This indicates specific conditions under which the CAS must operate to prevent or mitigate the more severe crashes. However, Table 4.5-7 in Section 4.5 shows that frequently more than half of the estimated harm (FCEs) is derived from non-severe crashes. These too must be prevented or mitigated by the CAS. The majority of these crashes occurs during normal driving circumstances, when no external causal factor is evident. Analysis of the reports and data base entries describing these accidents clearly points out that most of the drivers were unaware of the imminent crash and took no action to avoid it. The virtue of any CAS would be to signal to the driver the potential for danger if a specific maneuver is undertaken, warning the driver early enough to prevent the dangerous maneuver from occurring.

Because of the low speeds associated with many backing accidents and the low relative speeds that prevail for most lane change/merge accidents, there is adequate time to prevent many of these collisions. A class of sensors that could monitor the areas directly adjacent to the sides and the back of the instrumented vehicle would be effective a significant fraction of the time. In addition, accidents that do not occur with vehicles in these various blindspots could also be reduced if the burden of monitoring those areas was shared with the CAS.

The significance of various accident-level, vehicle-level and driver-level conditions associated with crashes can only be ascertained in contrast to those conditions characterizing normal, non-crash driving experiences.

Further statistical analysis would be useful to uncover underlying causal factors and their significance, and to determine the independence of various scenarios. If specific classifications were found to be dependent, then their scenarios could be merged for more efficient modeling. Also, the number of accidents falling into the combined category would increase, thus improving the statistics on the important variables that would need to be sampled during the simulations.

The next steps in this program will be twofold. The scenarios will be further refined and opportunities for crash avoidance will be identified. The key factors which determine this are the relative speeds and positions of the accident-causing vehicle and the object being struck. These factors determine the time to impact which in turn defines the window of opportunity for intervention. The knowledge we have gained from the crash analysis presented here has allowed for the creation of a test plan which will cover all the relevant scenarios for backing and lane change/merging accidents.

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APPENDIX A: DESCRIPTIVE STATISTICS DERIVED FROM THE GES

A.0 Introduction

The following sections provide summaries of the descriptive statistics. In general, the data is grouped into three sections: accident level variables, vehicle level variables and driver level variables. The accident level variables (which are the same for both vehicles) describe the physical circumstances surrounding the crash, such as lighting conditions, weather, road surfaces, etc. The vehicle level variables describe the individual circumstances of each vehicle in the two-vehicle crashes or the one vehicle in the one-car backing crashes. The vehicle precrash variables Precrashl, Precrash2, Precrash3, Precrash4 and Precrash5 are useful to describe the actions (and reactions) of each driver. Precrashl describes the actions of each vehicle immediately prior to the critical event which led to the crash. Precrash2 describes the location and nature of the critical event and assigns responsibility for initiating the critical event to one of the vehicle's drivers or an involved non-motorist. Precrash3 and Precrash4 describe the attempt of each driver to prevent the crash and the following control or loss of control over the motion of the vehicle. Precrash5 describes the vehicle's path after the corrective action described by Precrash3. Precrashl and Precrash2 are extremely useful due to their ability to describe the events leading up to the critical event and the critical event, as well as the location and responsibility for the critical event, as seen from the standpoint of each vehicle. At present, very few attempts are made by drivers to avoid the crashes, as can be seen throughout by examining Precrash3. If no corrective action is initiated, then Precrash4 and Precrash5 are coded as zero, for no corrective action.

The driver's injury severity and the vehicle damage severity may be seen as measures of the severity of the crash. Damage areas and initial point of impact describe in detail the impacts of the vehicles and subsequent damage. Other points of descriptive interest are the age and gender distributions of the drivers (although gender is an imputed attribute).

For several classifications of lane change/merge and backing crashes, the number of observations in the data set is quite small. The number of observations in each data set is noted for each classification as well as the weighted population corresponding to those observations. Caution is indicated in drawing conclusions for data sets containing only a few observations. Due to the small sample size and unequal weighting of the observations, artificial effects may be observed in evaluating even somewhat larger data sets. For example, it is reasonable to believe that a vehicle striking a pedacyclist sometimes produces serious injuries to the pedacyclist. Yet in the small number of observations of this category in the 1992 GES (only 11), no serious injuries were observed. (It should be noted that the Fatal Accident Reporting System would address only fatal injuries and would not provide any further information on serious injuries.) Similarly, it is reasonable to believe that at least some collisions between two motor vehicles in transport occurring when one is backing from a parked position occur at night or in adverse weather. It is also reasonable to assume that at least a few drivers would try some corrective action to avoid the crash. However, in the category of BACK6 which is based on 14 observations, all such crashes occur in daylight and clear weather, and there is no indication that either driver tried corrective action to avoid the crash.

A.1 Lane Change/Merge Crashes in the GES

A.l.l Segregating the Lane Change/Merge Crashes in the GES

From the data set GES.GES92, the large data set of two motor-vehicle-in-transport crashes with the driver present is constructed using the following steps:

> First, the observations to be examined are identified as those in which the first harmful event is a collision between two motor-vehicles-in-transport.
>
> Then, the accidents are limited to those involving two motor vehicles in transport.
>
> Finally, the records for which "person type = 1", implying that the driver is present, are chosen.

The resulting data set now contains two observations for each case number, one observation corresponding to each driver. This data set contains all kinds of two vehicle collisions where both drivers are present.

The data set LCMS is constructed from this larger data set by combining the information from both observations, so that now each case number is represented by only one entry into LCMS but the total information content is preserved. Each observation in set LCMS contains 185 variables. In addition, LCMS is constructed so that vehicle 1 is always the striking vehicle and vehicle 2 is always the struck vehicle. Cases in which a vehicle is identified as both striking and struck or in which both vehicles are identified as striking/struck are automatically deleted. This should not cause difficulties for cases involving only two vehicles. All the subsets LCMx discussed below (x is the scenario number) are derived directly from this set LCMS.

The final character in each variable name in data set LCMS identifies the vehicle represented by that character. For example, PCRASHll is the Precrashl variable for vehicle 1 (striking) and PCRASH12 is the Precrashl variable for vehicle 2 (struck). (Names may metamorphosize slightly at times but generally are preserved in spirit.)

Accident variables - for example, first harmful event, manner of collision, relation to junction, traffic control device, etc. - are the same for both vehicle 1 and vehicle 2.

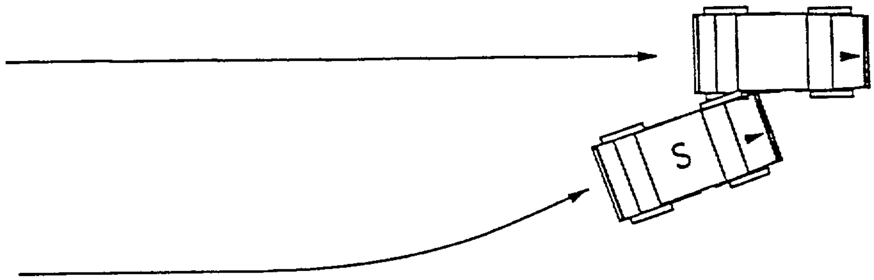
The data set LCMS is then subsequently sorted by the criteria set for each of the lane change/merge crash categories.

Lane Change/Merge data runs may be contaminated with various amounts of opposite direction crashes which are not pertinent. These crashes are characterized by accident types greater than 49. To eliminate these crashes, the accident types for both striking and struck vehicles were required to be less than 50. This was coded as the dual requirement that ACCTYPEl < 50 and ACCTYPE2 < 50.

Driver's drug involvement is only noted for LCM8, the only lane change/merge classification in which it is observed in the 1992 database.

A.1.2 Lane Change/Merge Crash Descriptive Statistics

1. <u>ANGLE STRIKING</u>: 86,055 GES Weighted (634 Observations)



LCM1: The vehicle which is changing lanes or merging strikes another vehicle going straight; the manner of collision is "angle"; this should be considered in conjunction with LCM7.

$16 \le \text{PCRASH11} \le 17$	$\text{PCRASH12} \ne 16$
MANCOL1 = 4 (angle)	$\text{PCRASH12} \ne 17$

ACCIDENT VARIABLES

<u>Relation to Junction</u>:
72 % Non-junction
13 % Intersection
12 % Intersection related
3 % Interchange related

<u>Traffic Control:</u>
83 % None
12 % Traffic control signal on colors
2 % Stop sign
1 % Yield sign

<u>Alcohol Involvement</u>:
3 % Yes
97 % No

<u>Interstate Highway</u>:
88 % No
12 % Yes

Maximum Injury Severity:
87 % None (0)
9 % Possible injury (C)
3 % Nonincapacitating evident injury (B)
2 % Incapacitating injury (A)
0 % Fatal injury (K) (0.012 % in this case)

Land Use:
6 % Area population 25,000 to 50,000
18 % Area population 50,000 to 100,000
39 % Area population 100,000 plus
32 % Other area
6 % Unknown

Roadway Alignment:
95 % Straight
5 % Curve

Roadway Surface Condition:
82 % Dry
16 % Wet
1 % Ice or snow/ice combined

Roadway Profile:
78 % Level
20 % Grade
2 % Hillcrest

Light Condition:
76 % Daylight
6 % Dark
17 % Dark but lighted
2 % Dusk

Atmospheric Conditions:
88 % No adverse atmospheric conditions
10 % Rain
1 % Snow

Number of Travel Lanes:
0% One
17 % Two
18 % Three
28 % Four
7 % Five
7 % Six
1% Seven
21 % Unknown

Trafficway Flow:

38 % Two-way trafficway (not physically divided)
38 % Divided highway
6 % One-way trafficway
18 % Unknown

Speed Limit:

12 % 25 MPH or less
36 % 30 or 35 MPH
25 % 40 or 45 MPH
24 % 50 of 55 MPH
3 % 65 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
11 % Hit and Run	<1% Hit and Run
84 % No avoidance maneuver	99 % No avoidance maneuver
4 % Vehicle in road	1 % Vehicle in road
1 % Unknown	0 % Unknown
Driver's Vision Obscured by:	
87 % Not obscured	99 % Not obscured
11 % Hit and Run	<1% Hit and Run
1 % Moving vehicle	
1 % Unknown	
Driver Distracted by:	
87 % Not distracted	99 % Not distracted
10 % Hit and Run	<1% Hit and Run
2 % Internal distractions	
Precrash 1:	
93 % Changing lanes	91 % Going straight
7 % Merging	6 % Stopped in traffic lane
	2 % Slowing/stopping in lane
Precrash2 (critical event):	
Critical event initiated by this vehicle encroaching into another vehicle's lane at non-junction from adjacent lane (same direction):	Critical event initiated by other vehicle encroaching into this vehicle's lane at non-junction from adjacent lane (same direction):
43 % over left lane line.	47 % over left lane line.
40 % over right lane line.	43 % over right lane line.

Precrash3 :	
86 % No corrective action	96 % No corrective action
1 % Braked/slowed	2 % Braked
2 % Steered to left	1 % Steered to left
4 % Steered to right	
6 % Unknown	1 % Unknown
Precrash4:	
86 % No corrective action	96 % No corrective action
3 % Control maintained	2 % Control maintained
1 % Longitudinal slide/skid	
1 % Other	
7 % Unknown	1 % Unknown
Precrash5:	
86 % No corrective action	96 % No corrective action
2 % Remained in same travel lane	3 % Remained in same travel lane
5 % Stayed on roadway but left travel lane	
1 % Stayed on roadway but unknown if left travel lane	
6 % Unknown vehicle path	1 % Unknown vehicle path
Speed:	
3 % 15MPH	6 % 0 MPH (stopped)
3% 20MPH	4 % 25 MPH
3% 25MPH	5 % 30 MPH
5% 30MPH	5 % 35 MPH
3% 35MPH	4 % 40 MPH
4% 40MPH	
65 % Unknown	60 % Unknown
Accident Type:	
45 % Changing lanes to right	95 % Going straight ahead
48 % Changing lanes to left	3 % Other
3 % Going straight	
Damage Severity:	
5 % None	2% None
36 % Minor	40 % Minor
14 % Functional	17 % Functional
5 % Disabling	4 % Disabling
40 % Unknown	37 % Unknown

Initial Point of Impact:

14 % Front	1 % Front
29 % Right side	45 % Right side
34 % Left side	38 % Left side
9 % Front right corner	2% Back
10 % Front left corner	3 % Front right corner
1 % Back right corner	4 % Front left corner
2 % Back left corner	3 % Back right corner
	3 % Back left corner

Vehicle STYLE:

90 % Cars, light trucks, vans	95 % Cars, light trucks, vans
7 % Trailering trucks	2 % Trailering trucks
3 % Straight trucks	1 % Straight trucks

Damage Area:

5 % No damage	2 % No damage
37 % Front and other	16 % Front and other
19 % Right side and other	41 % Right side and other
27 % Left side and other	37 % Left side and other
0 % Back and other	2 % Back and other
12 % Unknown	2 % Unknown

Body Type (5 maior types):

20 %	Unknown automobile type	19 %
19 %	4-door sedan, hardtop	25 %
22 %	2-door sedan, hardtop, coupe	20 %
	3-doer/2-door hatchback	4 %
7%	Unknown van type	
	Unknown type pickup truck	4 %
6%	Truck tractor (cab only)	
	Compact pickup truck	4 %
	Large pickup truck	4 %

Vehicle Defects:

88 %	None	98 %
12 %	Unknown	2 %

Driver's Sex:

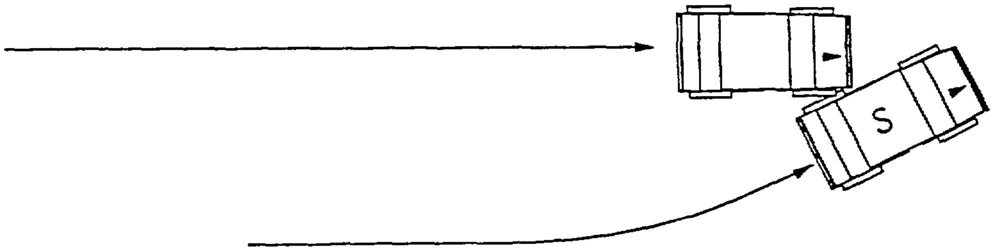
69 %	Male	63 %
31 %	Female	37 %

Driver's Age:

24 %	21 or less	18 %
22 %	22 to 30	27 %
21 %	31 to 40	26 %
11 %	41 to 50	15 %
10 %	51 to 65	10 %
11 %	over 65	4 %

Driver Impairment:		
88 %	None	99 %
12 %	Unknown	1%
Driver Injury Severity:		
95 %	None (0)	93%
3%	Possible injury (C)	5%
1%	Nonincapacitating evident injury (B)	0 %
1%	Incapacitating injury (A)	1%
Driver Restraint System Use:		
9%	None	8%
67 %	Restraint system used	79 %
24 %	Unknown	13 %
Driver Violations Charged:		
59 %	None	97 %
2%	Alcohol or drugs	
2%	Speeding	
2%	Failure to yield right-of-way	
10 %	Hit and run (no information)	
25 %	Other violations	2 %

2. ANGLE STRUCK: 25,201 GES Weighted (179 Observations)



LCM2: the vehicle which is changing lanes or merging is struck by anot:her vehicle going straight; the manner of collision is “angle”.

16 #PCRASH12 #17 PCRASHll | 16
MANCOL2 = 4 (angle) PCRASHll | 17

ACCIDENT VARIABLES

Relation to Junction:
62 % Non-junction
16 % Intersection
11 % Intersection related
3 % Driveway, alley access
2 % Entrance/exit ramp
6 % Interchange area

Traffic Control:
80 % None
16 % Traffic control signal on colors
1 % Yield sign

Alcohol involvement:
4 % Yes
96 % No

Interstate Highway:
94 % No
6 % Yes

Maximum Injury Security
83 % None (0)
11 % Possible injury (C)
3 % Nonincapacitating evident injury (B)
1 % Incapacitating injury (A)
0 % Fatal injury (K) (0.36 % in this case)
1 % Unknown severity

Land Use:
6 % Area population 25,000 to 50,000
19 % Area population 50,000 to 100,000
30 % Area population 100,000 plus
42 % Other area
2 % Unknown

Roadway Alignment:
89 % Straight
11 % Curve

Roadway Surface Condition:
62 % Dry
32 % Wet
1 % Snow or slush
4 % Ice or snow/ice combined

Roadway Profile:
75 % Level
23 % Grade
1 % Hillcrest

Light Condition:
73 % Daylight
6 % Dark
16 % Dark but lighted
2% Dawn
3 % Dusk

Atomspheric Conditions:
80 % No adverse atmospheric conditions
14 % Rain
1 % Sleet
4% Snow

Number of Travel Lanes:

2% One
16 % Two
20 % Three
32 % Four
8 % Five
3 % Six
19 % Unknown

Trafficway Flow:

41 % Two-way trafficway (not physically divided)
44 % Divided highway
4 % One-way trafficway
11 % Unknown

Speed Limit:

13 % 25 MPH or less
20 % 30 or 35 MPH
39 % 40 or 45 MPH
25 % 50 or 55 MPH
4 % 65 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
2 % Hit and Run	4 % Hit and Run
1 % Vehicle in road	2 % Vehicle in road
97 % No avoidance maneuver	93 % No avoidance maneuver
1 % Unknown	1 % Unknown
Driver's Vision Obscured by:	
97 % Not obscured	94 % Not obscured
2 % Hit and Run	4 % Hit and Run
1 % Unknown	2 % Unknown
Driver Distracted by:	
97 % Not distracted	94 % Not distracted
2 % Hit and Run	4 % Hit and Run
1 % Unknown	1 % Unknown
Precrash 1:	
94 % Going straight	93 % Changing lanes
5 % Passing/overtaking	7 % Merging

Precrash2 (critical event):l	
Critical event initiated by other vehicle encroaching into this vehicle's lane: at non-junction from adjacent lane (same direction):	Critical event initiated by this vehicle encroaching into other vehicle's lane: at non-junction from adjacent lane (same direction):
41 % over left lane line.	44 % over left lane line.
47 % over right lane line.	39 % over right lane line.
Precrash3:	
80 % No corrective action	90 % No corrective action
10 % Braked/slowed	1 % Braked/slowed
2 % Steered to left	1 % Steered to left
2 % Steered to right	2 % Steered to right
5 % Unknown	5 % Unknown
Precrash4:	
80 % No corrective action	90 % No corrective action
10 % Control maintained	3 % Control maintained
4 % Longitudinal slide/skid	1 % Longitudinal slide/skid
6 % Unknown	5 % Unknown
Precrash5:	
80 % No corrective action	90 % No corrective action
13 % Remained in same travel lane	1 % Remained in same travel lane
2 % Stayed on roadway but left travel lane	3 % Stayed on roadway but left travel lane
5 % Unknown vehicle path	5 % Unknown vehicle path
Speed:	
7 % 25 MPH	6% 5 MPH
5 % 30 MPH	3 % 20 MPH
6 % 35 MPH	7 % 25 MPH
5 % 45 MPH	5 % 35 MPH
	3 % 55 MPH
55 % Unknown	61 % Unknown
Accident Type:	
92 % Going straight ahead, same direction	38 % Changing lanes to right
3 % Straight ahead behind a slower vehicle	54 % Changing lanes to left
1 % Changing lanes to left	3 % Straight ahead in front of a faster vehicle

<u>Damage Severity</u>:

4 %	None	0 %	None
35 %	Minor	39 %	Minor
16 %	Functional	14 %	Functional
6 %	Disabling	8 %	Disabling
39 %	Unknown	40 %	Unknown

<u>Initial Point of Impact</u>:

41 %	Front	0 %	Front
20 %	Right side	36 %	Right side
13 %	Left side	41 %	Left side
14 %	Front right corner	13 %	Back
11 %	Front left corner	2 %	Front left corner
		4 %	Back right corner
		4 %	Back left corner

<u>Vehicle STYLE:</u>

90 %	Cars, light trucks, vans	98 %	Cars, light trucks, vans
7 %	Trailering trucks	1 %	Trailering trucks
3 %	Straight trucks	0 %	Straight trucks

<u>Damage Area:</u>

4 %	No damage	0 %	No damage
75 %	Front and other	8 %	Front and other
9 %	Right side and other	37 %	Right side and other
9 %	Left side and other	47 %	Left side and other
0 %	Back and other	5 %	Back and other
3 %	Unknown	3 %	Unknown

<u>Body Type (5 major types)</u>:

24 %	Unknown automobile type	23 %
17 %	4-door sedan, hardtop	26 %
24 %	2-door sedan, hardtop, coupe	15 %
	Unknown van type	7 %
	Unknown type pickup truck	8%
4 %	Station wagon	
6%	Truck tractor (cab only)	

<u>Vehicle Defects</u>:

94 %	None	94 %
1%	Brake failure	
5 %	Unknown	6 %

<u>Driver's Sex</u>:

63 %	Male	58 %
37 %	Female	42 %

Driver's Age:

21 %	21 or less	19 %
23 %	22 to 30	26 %
25 %	31 to 40	16 %
14 %	41 to 50	18 %
12 %	51 to 65	10 %
5%	over 65	11 %

Driver Impairment:

95 %	None	95 %
1%	Other	
4%	Unknown	5 %

Driver Iniury Severity:

95 %	None (0)	88 %
3%	Possible injury (C)	9 %
1%	Nonincapacitating evident injury (B)	2 %
1%	Incapacitating injury (A)	

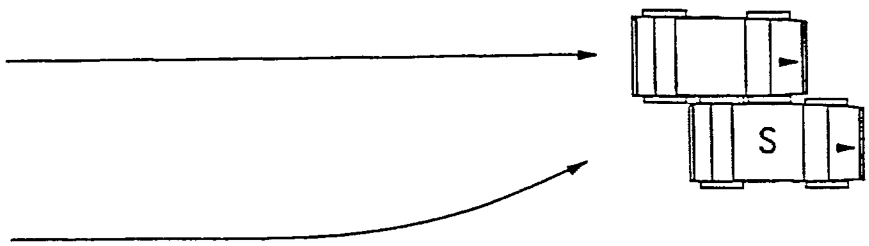
Driver Restraint Svstem Use:

7 %	None	12 %
77 %	Restraint system used	67 %
16 %	Unknown	21 %

Driver Violations Charged:

93 %	None	67 %
2%	Alcohol or drugs	
1%	Reckless driving	
	Failure to yield right-of-way	2%
2%	Hit and run (no information)	4 %
2%	Other violations	26 %

2A. <u>CHANGING LANES, STRUCK, SIDESWIPE</u>: 7,986 GES Weighted
(51 Observations)



LCM2A: the vehicle which is changing lanes or merging is struck by another vehicle going straight; the manner of collision is "sideswipe".

16 ≤ PCRASH12 ≤ 17	PCRASH11 ≠ 16
MANCOL2 = 5 (Sideswipe, same direction)	PCRASH11 ≠ 17

ACCIDENT VARIABLES

Relation to Junction:
58 % Non-junction
9 % Intersection
7 % Intersection related
5 % Driveway, alley access
21 % Interchange area

Traffic Control:
79 % None
7 % Traffic control signal on colors
4 % Stop sign
3 % Yield sign
7 % Other traffic control

Alcohol Involvement:
2 % Yes
98 % No

Interstate Highway:
69 % No
31 % Yes
Maximum Injury Severity:
95 % None (0)
4 % Possible injury (C)
1 % Incapacitating injury (A)
Land Use:
13 % Area population 25,000 to 50,000
17 % Area population 50,000 to 100,000
38 % Area population 100,000 plus
30 % Other area
1 % Unknown
Roadway Alignment:
96 % Straight
4 % Curve
Roadway Surface Condition:
75 % Dry
18 % Wet
4 % Snow or slush
3 % Ice or snow/ice combined
Roadway Profile:
59 % Level
38 % Grade
3 % Hillcrest
Light Condition:
70 % Daylight
8 % Dark
20 % Dark but lighted
2 % Dusk
Atmospheric Conditions:
82 % No adverse atmospheric conditions
14 % Rain
3 % Snow
Number of Travel Lanes:
3 % One
30 % Two
15 % Three
25 % Four
14 % Five
4 % Six
3 % Seven
6 % Unknown

Trafficway Flow:
34 % Two-way trafficway (not physically divided)
35 % Divided- highway
7 % One-way trafficway
24 % Unknown

Speed Limit:
10 % 25 MPH or less
27 % 30 or 35 MPH
22 % 40 or 45 MPH
36 % 50 or 55 MPH
4 % 65 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
2 % Hit and Run	4 % Hit and Run
3 % Vehicle in road	0 % Vehicle in road
89 % No avoidance maneuver	91 % No avoidance maneuver
5 % Unknown	5 % Unknown
Driver's Vision Obscured by:	
93 % Not obscured	88 % Not obscured
2 % Hit and Run	4 % Hit and Run
5 % Unknown	9 % Unknown
Driver Distracted by:	
93 % not distracted	91 % Not distracted
2 % Hit and Run	4 % Hit and Run
5 % Unknown	5 % Unknown
Precrash 1:	
95 % Going straight	92 % Changing lanes
1 % Passing/overtaking	8 % Merging
3 % Successful corrective to previous critical event	
Precrash2 (critical event):	
Critical event initiated by other vehicle encroaching into this vehicle's lane: at non-junction from adjacent lane (same direction):	Critical event initiated by this vehicle encroaching into other vehicle's lane: at non-junction from adjacent lane (same direction):
31 % over left lane line.	55 % over left lane line.
55 % over right lane line.	31 % over right lane line.

Precrash2 (continued): Critical event initiated by this vehicle encroaching into other vehicle's lane: at non-junction from adjacent lane (same direction):	Critical event initiated by other vehicle encroaching into this vehicle's lane: at non-junction from adjacent lane (same direction):
7 % over right lane line.	5 % over left lane line. 3 % over right lane line.
Precrash3:	
90 % No corrective action	91 % No corrective action
3 % Steered to right	4 % Braked/slowed
6 % Unknown	5 % Unknown
Precrash4:	
90 % No corrective action	91 % No corrective action
3 % Control maintained	3 % Control maintained
8 % Unknown	5 % Unknown
Precrash5:	
90 % No corrective action	91 % No corrective action
4 % Remained in same travel lane	4 % Remained in same travel lane
6 % Unknown vehicle path	5 % Unknown vehicle path
Speed:	
7 % 25 MPH	7 % 15 MPH
6 % 45 MPH	5 % 20 MPH
8 % 50 MPH	7 % 25 MPH
7 % 55 MPH	5 % 35 MPH
	6 % 45 MPH
51 % Unknown	50 % Unknown
Accident Type:	
92 % Straight ahead, center	5 % Straight ahead on left
8 % Other specifics	29 % Changing lanes to right
	59 % Changing lanes to left
	8 % Other specifics
Damage Severity:	
0 % None	0 % None
50 % Minor	64 % Minor
37 % Functional	21 % Functional
5 % Disabling	7 % Disabling
7 % Unknown	8 % Unknown

Initial Point of Impact

14 % Front	34 % Right side
32 % Right side	50 % Left side
23 % Left side	1 % Back right corner
21 % Front right corner	14 % Back left corner
5 % Front left corner	
4 % Back right corner	

Vehicle STYLE:

92 % Cars, light trucks, vans	86 % Cars, light trucks, vans
8 % Trailering trucks	11 % Trailering trucks
0 % Straight trucks	3 % Straight trucks

Damage Area:

44 % Front and other	3 % Front and other
33 % Right side and other	34 % Right side and other
21 % Left side and other	61 % Left side and other
1 % All	0 % All
1 % Unknown	1 % Unknown

Body Type (5 major types):

43 %	Unknown automobile type	32 %
29 %	4-door sedan, hardtop	14 %
7%	2-door sedan, hardtop, coupe	11 %
5%	Unknown van type	
	Unknown type pickup truck	15 %
8%	Truck tractor (cab only)	11 %

Vehicle Defects:

97 %	None	100%
3%	Unknown	

Driver's Sex:

87 %	Male	71%
13 %	Female	29 %

Driver's Age:

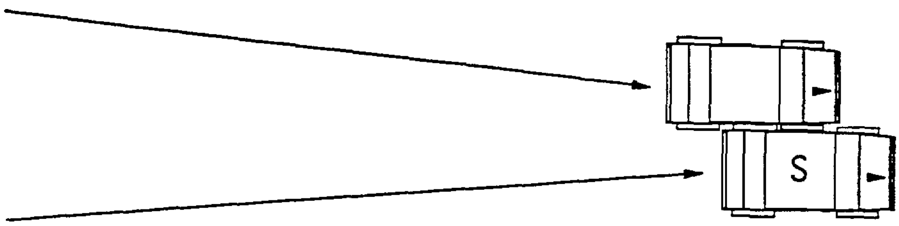
22 %	21 or less	20 %
33 %	22 to 30	23% .
15 %	31 to 40	22 %
17 %	41 to 50	22 %
10 %	51 to 65	8%
4%	over 65	5%

Driver Impairment:

95 %	None	96 %
5%	Unknown	4%

Driver Injury Severity:		
98 %	None (0)	98 %
	Possible injury (C)	2%
2 %	Nonincapacitating evident injury (B)	
Driver Restraint System Use:		
4 %	None	11 %
90 %	Restraint system used	79 %
6 %	Unknown	10 %
Driver Violations Charged:		
94 %	None	67 %
1%	Alcohol or drugs	
1%	Hit and run (no information)	4 %
4 %	Other violations	29 %

3. <u>DRIFTING</u>: 22,614 GES Weighted (166 Observations)



LCM3: neither vehicle intends to change lanes or merge; both vehicles are going straight but they drift together with a manner of collision which is "sideswipe, same direction".

PCRASHll = 1
PCRASH12 = 1
MANCOL1 = 5 (sideswipe, same direction)

ACCIDENT VARIABLES

Relation to Junction:
59 % Non-junction
22 % Intersection
7 % Intersection related
9 % Driveway, alley access
6 % Interchange related

Traffic Control:
73 % None
15 % Traffic control signal on colors
3 % Other traffic signal
4 % Stop sign
3 % Yield sign

Alcohol Involvement:
4 % Yes
96 % No

Interstate Highway:

86 % No
14 % Yes

Maximum Injury Severity:

85 % None (0)
10 % Possible injury (C)
4 % Nonincapacitating evident injury (B)

Land Use:

5 % Area population 25,000 to 50,000
11 % Area population 50,000 to 100,000
38 % Area population 100,000 plus
36 % Other area
11 % Unknown

Roadway Alignment:

97 % Straight
3 % Curve

Roadway Surface Condition:

74 % Dry
18 % Wet
1 % Snow or slush
6 % Ice or snow/ice combined

Roadway Profile:

76 % Level
21 % Grade
3 % Hillcrest

Light Condition:

67 % Daylight
13 % Dark
17 % Dark but lighted
3 % Dusk

Atmospheric Conditions:

87 % No adverse atmospheric conditions
10 % Rain
2% Snow
1 % Other

Number of Travel Lanes:

1 % One
30 % Two
16 % Three
18 % Four
9 % Five
1% Seven
25 % Unknown

Trafficway Flow:
56 % Two-way trafficway (not physically divided)
27 % Divided highway
16 % Unknown

Speed Limit:
14 % 25 MPH or less
37 % 30 or 35 MPH
21 % 40 or 45 MPH
22 % 50 or 55 MPH
6 % 65 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
19 % Hit and Run	2 % Hit and Run
75 % No avoidance maneuver	95 % No avoidance maneuver
1 % Vehicle in road	
5 % Unknown	3 % Unknown
Driver's Vision Obscured by:	
75 % Not obscured	94 % Not obscured
19 % Hit and Run	2 % Hit and Run
6 % Unknown	5 % Unknown
Driver Distracted by:	
76 % Not distracted	95 % Not distracted
19 % Hit and Run	2 % Hit and Run
5 % Unknown	3 % Unknown
Precrash 1:	
100% Going straight	100% Going straight
Precrash2 (critical event):	
Critical event initiated by this vehicle encroaching into another vehicle's lane: at non-junction from adjacent lane (same direction):	Critical event initiated by other vehicle encroaching into this vehicle's lane: at non-junction from adjacent lane (same direction):
31 % over left lane line.	40 % over left lane line.
36 % over right lane line.	29 % over right lane line.

<u>Precrash2 (continued):</u>	
Critical event initiated by this vehicle in other vehicle's lane (same direction):	Critical event initiated by this vehicle encroaching into other vehicle's lane at non-junction from adjacent lane (same direction):
7 % traveling with higher speed.	6 % over left lane line.
9 % Precrash2 unknown	7 % Precrash2 unknown
<u>Precrash3:</u>	
84 % No corrective action	95 % No corrective action
2 % Braked/slowed	1 % Braked/slowed
1 % Steered left	
2 % Steered right	
2 % Braked and steered left	
8 % Unknown	4 % Unknown
<u>Precrash4:</u>	
84 % No corrective action	95 % No corrective action
5 % Control maintained	1 % Control maintained
3 % Longitudinal slide/skid	
8 % Unknown	4 % Unknown
<u>Precrash5:</u>	
84 % No corrective action	95 % No corrective action
2 % Remained in same travel lane	1 % Remained in same travel lane
5 % Stayed on roadway but left travel lane	
8 % Unknown vehicle path	4 % Unknown vehicle path
<u>Speed:</u>	
5 % 10 MPH	6 % 20 MPH
4 % 20 MPH	6 % 30 MPH
5 % 35 MPH	5 % 35 MPH
	5 % 45 MPH
71 % Unknown	63 % Unknown
<u>Accident Type:</u>	
30 % Going straight ahead, same direction, left	9 % Going straight ahead, same direction, left
11 % Going straight ahead, same direction, right	65 % Going straight ahead, same direction, right
21 % Changing lanes to right	
14 % Changing lanes to left	
23 % Other specifics	23 % Other specifics

Damage Severity:

4 % None	0 % None
43 % Minor	51 % Minor
18 % Functional	25 % Functional
4 % Disabling	5 % Disabling
32 % Unknown	19 % Unknown

Initial Point of Impact:

3 % Front	2 % Front
38 % Right side	30 % Right side
32 % Left side	45 % Left side
13 % Front right corner	2 % Back
13 % Front left corner	4 % Front right corner
1 % Back left corner	8 % Front left corner
	3 % Back right corner
	6 % Back left corner

Vehicle STYLE:

86 % Cars, light trucks, vans	90 % Cars, light trucks, vans
6 % Trailering trucks	4 % Trailering trucks
2 % Straight trucks	2 % Straight trucks

Damage Area:

4 % No damage	0 % No damage
29 % Front and other	16 % Front and other
28 % Right side and other	32 % Right side and other
24 % Left side and other	48 % Left side and other
0 % Back and other	1 % Back and other
15 % Unknown	3 % Unknown

Body Type (5 major types):

39 %	Unknown automobile type	47 %
11 %	4-door sedan, hardtop	11 %
13 %	2-door sedan, hardtop, coupe	7 %
	Unknown van type	4%
5%	Unknown type pickup truck	
6%	Truck tractor (cab only)	4 %
	3-door/2-door hatchback	4 %

Vehicle Defects:

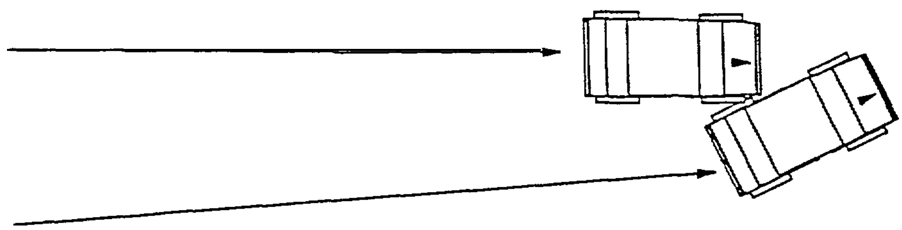
87 %	None	91 %
1%	Steering system failure	
0%	Other	1%
11 %	Unknown	8%

Driver's Sex:

71 %	Male	53 %
29 %	Female	47 %

Driver's Ape:		
25 %	21 or less	16 %
30 %	22 to 30	23 %
18 %	31 to 40	25 %
10 %	41 to 50	14 %
9%	51 to 65	12 %
8%	over 65	11 %
Driver Impairment:		
85 %	None	98 %
2%	Drowsy, sleepy, tired	
12 %	Unknown	2 %
Driver Injury Severity:		
93 %	None (0)	95 %
6%	Possible injury (C)	4 %
1%	Nonincapacitating evident injury (B)	1 %
Driver Restraint System Use:		
8%	None	7 %
59 %	Restraint system used	74 %
33 %	Unknown	19 %
Driver Violations Charged:		
57 %	None	92 %
2%	Alcohol or drugs	0%
1%	Speeding	
1%	Reckless driving	
	Failure to yield right-of-way	1%
19 %	Hit and run (no information)	1%
21 %	0 ther violations	5 %

3A. DRIFTING: 26,003 GES Weighted (231 Observations)



LCM3A: neither vehicle intends to change lanes or merge; both vehicles are going straight but they drift together with a manner of collision which is "angle".

PCRASHll = 1
PCRASH12 = 1
MANCOLl = 4 (angle)

ACCIDENT VARIABLES

Relation to Junction:
63 % Non-junction
21 % Intersection
13 % Intersection related
1 % Interchange related

Traffic Control:
79 % None
13 % Traffic control signal on colors
7 % Stop sign

Alcohol Involvement:
3 % Yes
97 % No

Interstate Highway:
89 % No
11 % Yes

Maximum Injury Severity:
75 % None (0)
14 % Possible injury (C)
7 % Nonincapacitating evident injury (B)
4 % Incapacitating injury (A)
0 % Fatal injury (K) (0.032 % in this case)

Land Use:
3 % Area population 25,000 to 50,000
8 % Area population 50,000 to 100,000
45 % Area population 100,000 plus
36 % Other area
8 % Unknown

Roadway Alignment:
90 % Straight
10 % Curve

Roadway Surface Condition:
62 % Dry
22 % Wet
3 % Snow or slush
13 % Ice or snow/ice combined

Roadway Profile:
71 % Level
27 % Grade
2 % Hillcrest

Light Condition:
72 % Daylight
8 % Dark
18 % Dark but lighted
2 % Dusk

Atomospheric Conditions:
70 % No adverse atmospheric conditions
21 % Rain
1 % Sleet
6% Snow
2 % Other

Number of Travel Lanes:

1% One
23 % Two
11 % Three
18 % Four
2 % Five
1 % Six
1 % Seven
43 % Unknown

Trafficway Flow:

33 % Two-way trafficway (not physically divided)
27 % Divided highway
1 % One-way trafficway
39 % Unknown

Speed Limit:

19 % 25 MPH or less
32 % 30 or 35 MPH
19 % 40 or 45 MPH
26 % 50 or 55 MPH
5 % 65 MPH

VEHICLE VARIABLES

	Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:		
	13 % Hit and Run	1 % Hit and Run
	78 % No avoidance maneuver	93 % No avoidance maneuver
	4 % Vehicle in road	3 % Vehicle in road
	1 % Poor road conditions	
	4 % Unknown	3 % Unknown
Driver's Vision Obscured by:		
	83 % Not obscured	94 % Not obscured
	13 % Hit and Run	1 % Hit and Run
	1 % Curve or hill	1 % Curve or hill
	4 % Unknown	4 % Unknown
Driver Distracted by:		
	85 % Not distracted	96 % Not distracted
	13 % Hit and Run	1 % Hit and Run
	3 % Unknown	3 % Unknown
Precrash 1:		
	100% Going straight	100% Going straight

Precrash2 (critical event):

Critical event initiated by this vehicle encroaching into another vehicle's lane: at non-junction from adjacent lane (same direction):

11 % over left lane line.

13 % over right lane line.

Critical event initiated by this vehicle in other vehicle's lane (same direction):

11 % traveling with higher speed.

11 % Loss of control due to poor road conditions.

7 % Critical event initiated by other vehicle encroaching into this vehicle's lane at non-junction over right lane line.

11 % Precrash2 unknown

Precrash3:

76 % No corrective action
7 % Braked/slowed
1 % Steered left
2 % Braked and steered left
2 % Other
12 % Unknown

Precrash4:

76 % No corrective action
2 % Control maintained
4 % Longitudinal slide/skid
2 % Vehicle rotated
3 % Other
13 % Unknown

Critical event initiated by other vehicle encroaching into this vehicle's lane: at non-junction from adjacent lane (same direction):

22 % over left lane line.

18 % over right lane line.

5 % Critical event initiated by this vehicle encroaching into other vehicle's lane at non-junction from adjacent lane (same direction) over right lane line.

6 % Loss of control due to poor road conditions.

11 % Precrash2 unknown

89 % No corrective action
2 % Braked/slowed
4 % Steered left
2 % Braked and steered left
3 % Unknown

89 % No corrective action
3 % Control maintained
3 % Vehicle rotated
1 % Other
3 % Unknown

Precrash5:			
76 %	No corrective action	89 %	No corrective action
5%	Remained in same travel lane	3%	Remained in same travel lane
4%	Stayed on roadway but left travel lane	2%	Stayed on roadway but left travel lane
3%	Stayed on roadway but unknown if left travel lane	1%	Stayed on roadway but unknown if left travel lane
1%	Vehicle departed roadway	1%	Vehicle departed roadway
12 %	Unknown vehicle path	3%	Unknown vehicle path
Speed:			
3%	25 MPH	2%	10 MPH
3%	30 MPH	5%	35 MPH
4%	35 MPH	7%	40 MPH
6%	40 MPH	2%	45 MPH
3%	45 MPH		
3%	55 MPH		
76%	Unknown	73 %	Unknown
Accident type:			
19 %	Going straight ahead, same direction, left	10 %	Going straight ahead, same direction, left
14 %	Going straight ahead, same direction, right	33 %	Going straight ahead, same direction, right
7 %	Changing lanes to right		
7 %	Changing lanes to left		
45 %	Other specifics	45 %	Other specifics
Damage Severity:			
8 %	None	4%	None
20 %	Minor	28 %	Minor
18 %	Functional	15 %	Functional
10 %	Disabling	7%	Disabling
44 %	Unknown	46 %	Unknown
Initial Point of Impact:			
28 %	Front	1%	Front
27 %	Right side	35%	Right side
23 %	Left side	39%	Left side
12 %	Front right corner	10%	Back
10 %	Front left corner	2%	Front right corner
		3%	Front left corner
		4%	Back right corner
		7%	Back left corner

Vehicle STYLE:

89 %	Cars, light trucks, vans	85 %
5 %	Trailering trucks	4 %
6 %	Straight trucks	9 %

Damage Area:

9 %	No damage	4 %
53 %	Front and other	10 %
13 %	Right side and other	36 %
16 %	Left side and other	43 %
1 %	Back	5 %
8 %	Unknown	1 %

Body Type (5 major types):

25 %	Unknown automobile type	15 %
24 %	4-door sedan, hardtop	29 %
14 %	2-door sedan, hardtop, coupe	14 %
6%	Unknown van type	
6%	Unknown type pickup truck	
7%	Unknown medium/heavy truck	9%
	Compact pickup truck	6%

Vehicle Defects:

87 %	None	97 %
1%	Tires	
1%	Brake failure	
11 %	Unknown	3%

Driver's Sex:

73 %	Male	64 %
27 %	Female	36 %

Driver's Age:

17 %	21 or less	17 %
21 %	22 to 30	23 %
37 %	31 to 40	21 %
16 %	41 to 50	25 %
6%	51 to 65	11%
4%	over 65	3%

Driver Impairment:

86 %	None	97 %
1%	Drowsy, sleepy, tired	
13 %	Unknown	3%

Driver Injury Severity:

88 %	None (0)	87 %
6%	Possible injury (C)	8%
4%	Nonincapacitating evident injury (B)	3%
2%	Incapacitating injury (A)	2%

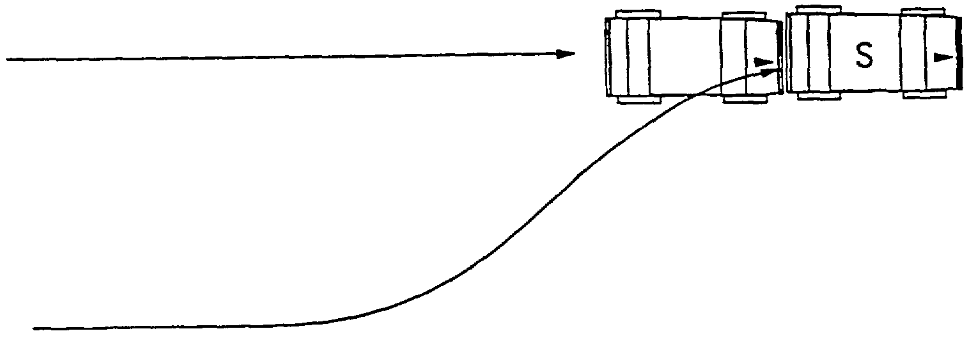
Driver Restraint System Use:

16 %	None	13 %
52 %	Restraint system used	62 %
32 %	Unknown	25 %

Driver Violations Charged:

68 %	None	87 %
1%	Alcohol or drugs	
3%	Speeding	2%
2%	Reckless driving	
	Driving, suspended/revoked license	1%
13 %	Hit and run (no information)	1%
15 %	Other violations	8%

4. REAREND STRUCK: 10,656 GES Weighted (81 Observations)



LCM4: the vehicle changing lanes or merging is struck in the rear by the car going straight; the striking vehicle is not changing lanes or merging

$16 \leq PCRASH12 \leq 17$
MANCOL2 = 1 (rearend)
$PCRASH11 \neq 16$ and $PCRASH11 \neq 17$

ACCIDENT VARIABLES
Relation to Junction:
73 % Non-junction
8 % Intersection
10 % Intersection related
3 % Entrance/exit ramp
7 % Interchange related
Traffic Control:
87 % None
8 % Traffic control signal on colors
3 % Yield sign
Alcohol Involvement:
4 % Yes
96 % No
Interstate Highway:
81 % No
19 % Yes

Maximum Injury Severity:
68 % None (0)
20 % Possible injury (C)
9 % Nonincapacitating evident injury (B)
2 % Incapacitating injury (A)
0 % Fatal injury (K) (0.038 % in this case)
1 % Unknown severity

Land Use:
3 % Area population 25,000 to 50,000
13 % Area population 50,000 to 100,000
47 % Area population 100,000 plus
34 % Other area
4 % Unknown

Roadway Alignment:
96 % Straight
4 % Curve

Roadway Surface Condition:
76 % Dry
24 % Wet

Roadway Profile:
84 % Level
16 % Grade

Light Condition:
79 % Daylight
4 % Dark
13 % Dark but lighted
3 % Dawn
1 % Dusk

Atmospheric Conditions:
80 % No adverse atmospheric conditions
20 % Rain

Number of Travel Lanes:
3 % One
12 % Two
29 % Three
35 % Four
8 % Five
3 % Six
12 % Unknown

Trafficway Flow:
31 % Two-way trafficway (not physically divided)
51 % Divided- highway
5 % One-way trafficway
12 % Unknown

Speed Limit:
7 % 25 MPH or less
24 % 30 or 35 MPH
34 % 40 or 45 MPH
32 % 50 or 55 MPH
2 % 65 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
3 % Hit and Run	12 % Hit and Run
94 % No avoidance maneuver	85 % No avoidance maneuver
Driver's Vision Obscured by:	
95 % Not obscured	88 % Not obscured
3 % Hit and Run	12 % Hit and Run
3 % Unknown	
Driver Distracted by:	
92 % Not distracted	88 % Not distracted
3 % Hit and Run	12 % Hit and Run
3 % Other internal events	
3 % Unknown	
Precrash 1:	
96 % Going straight	94 % Changing lanes
3 % Passing/overtaking	6 % Merging
1 % Negotiating a curve	
Precrash2 (critical event):	
Critical event initiated by this vehicle traveling in another vehicle‘s lane (same direction):	Critical event initiated by this vehicle encroaching into another vehicle's lane at non-junction(same direction):
41 % with higher speed.	29 % over left lane line.
4 % with lower speed.	11 % over right lane line.

Precrash2 - continued: Critical event initiated by other vehicle encroaching into this vehicle's lane at non-junction (same direction): 15 % over left lane line. 27 % over right lane line.	Critical event initiated by this vehicle, vehicle already in other vehicle's lane (same direction) traveling: 11 % with lower speed. 5 % with higher speed. Critical event initiated by other vehicle already in this vehicle's lane (same direction) traveling: 3 % with lower speed. 31 % with higher speed. 5 % Other specifics
Precrash3: 90 % No corrective action 9 % Braked	91 % No corrective action 1 % Braked/slowed 2 % Steered left 3 % Steered right 4 % Unknown
Precrash4: 90 % No corrective action 6 % Control maintained 4 % Longitudinal slide/skid	91 % No corrective action 4 % Control maintained 1 % Longitudinal slide/skid 4 % Unknown
Precrash5: 90 % No corrective action 10 % Remained in same travel lane 0 % Stayed on roadway but unknown if left travel lane 0 % Unknown vehicle path	91 % No corrective action 3 % Remained in same travel lane 3 % Stayed on roadway but left travel lane 4 % Unknown vehicle path
Speed: 6 % 30 MPH 5 % 35 MPH 7 % 40 MPH 64 % Unknown	4 % 25 MPH 6 % 40 MPH 5 % 45 MPH 66 % Unknown

Accident Type:

71 % Going straight ahead, rearended vehicle going more slowly or decelerating	71 % Going straight ahead, rearended
13 % Other specifics	13 % Other specifics
16 % Going straight, in lane change accident	4 % Changing lanes to right
	13 % Changing lanes to left

Damage Severity:

3 % None	0 % None
32 % Minor	45 % Minor
23 % Functional	12 % Functional
10 % Disabling	8 % Disabling
32 % Unknown	35 % Unknown

Initial Point of Impact:

100 % Front	100 % Back

Vehicle STYLE:

89 % cars, light trucks, vans	95 % cars, light trucks, vans
4 % trailering trucks	0 % trailering trucks
4 % straight trucks	3 % straight trucks

Damage Area:

3 % No damage	0 % No damage
92 % Front and other	1 % Front and other
0 % Right side and other	11 % Right side and other
0 % Left side and other	22 % Left side and other
0 % Back and other	57 % Back and other
5 % Unknown	9 % Unknown

Body Type (5 major types):

22 %	Unknown automobile type	20 %
18 %	4-door sedan, hardtop	31 %
8 %	2-door sedan, hardtop, coupe	9 %
9%	Unknown van type	5%
8 %	Unknown type pickup truck	
	Station wagon	5%

Vehicle Defects:

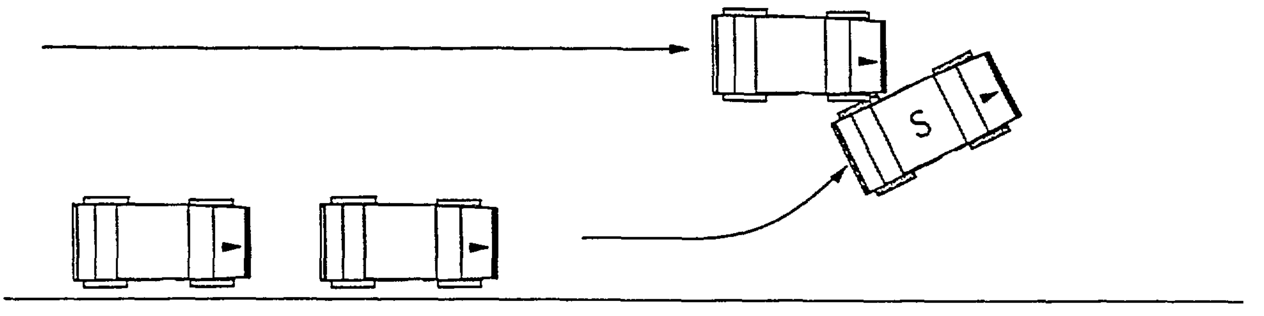
95 %	None	88 %
5 %	Unknown	12 %

Driver's Sex:

73 %	Male	67 %
27 %	Female	33 %

Driver's Aee:		
18 %	21 or less	22 %
22 %	22 to 30	27 %
24 %	31 to 40	19 %
21 %	41 to 50	16 %
12 %	51 to 65	7%
3%	over 65	8%
Driver Impairment:		
95 %	None	88 %
5 %	Unknown	12 %
Driver Injury Severity:		
91 %	None (0)	87 %
6%	Possible injury (C)	8%
3 %	Nonincapacitating evident injury (B)	2%
0 %	Incapacitating injury (A)	2%
0 %	Injured, severity unknown	1%
Driver Restraint Svstem Use:		
4 %	None	8%
84 %	Restraint system used	75 %
12 %	Unknown	17 %
Driver Violations Charged:		
83 %	None	52 %
	Alcohol or drugs	1%
5 %	Speeding	
	Reckless driving	3%
	Driving, suspended/revoked license	1%
	Failure to yield right-of-way	1%
3 %	Hit and run (no information)	11 %
8%	Other violations	31 %

5. LEAVING A PARKING PLACE: 21,805 GES Weighted



LCM5: a vehicle leaves a parking place (not backing) and strikes or is struck by another vehicle

5.1 LEAVING A PARKING PLACE AND STRIKING: 14,673 GES Weighted (70 Observations)

LCM51: a vehicle leaves a parking place (not backing) and strikes another vehicle

PCRASH11 = 7
ACCTYPE ≠ 92
4 ≤ MANCOL1 ≤ 5 (angle or sideswipe, same direction)

ACCIDENT VARIABLES

Relation to Junction:
89 % Non-junction
6 % Intersection
5 % Intersection related

Traffic Control:
87 % None
8 % Traffic control signal on colors
2 % Stop sign
3 % Other

Alcohol Involvement:
4 % Yes
96 % No

Manner of Collision:
61 % Angle
39 % Sideswipe, same direction

Interstate Highway:
98 % No
2 % Yes

Maximum Injury Severity:
89 % None (0)
7 % Possible injury (C)
1 % Nonincapacitating evident injury (B)
1 % Incapacitating injury (A)
2 % Unknown severity

Land Use:
4 % Area population 25,000 to 50,000
19 % Area population 50,000 to 100,000
48 % Area population 100,000 plus
25 % Other area
4 % Unknown

Roadway Alignment:
94 % Straight
6 % Curve

Roadway Surface Condition:
85 % Dry
13 % Wet
2 % Ice or snow/ice combined

Roadway Profile:
83 % Level
17 % Grade

Light Condition:
82 % Daylight
4 % Dark
11 % Dark but lighted
3 % Dusk

Atmospheric Conditions:
89 % No adverse atmospheric conditions
11 % Rain

Number of Travel Lanes:
25 % Two
8 % Three
8 % Four
59 % Unknown

Trafficway Flow:
50 % Two-way trafficway (not physically divided)
2 % Divided highway
2 % One-way trafficway
46 % Unknown

Speed Limit:
52 % 25 MPH or less
37 % 30 or 35 MPH
4 % 40 or 45 MPH
7 % 50 or 55 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
6 % Hit and Run	0 % Hit and Run
92 % No avoidance maneuver	98 % No avoidance maneuver
2 % Unknown	2 % Unknown
Driver's Vision Obscured by:	
77 % Not obscured	90 % Not obscured
6 % Hit and Run	0 % Hit and Run
2 % Running a "stop"	1 % Running a "stop"
2 % Violation of some kind	
13 % Unknown	10 % Unknown
Driver Distracted by:	
90 % Not distracted	98 % Not distracted
6 % Hit and Run	2 % Unknown
2 % Internal distractions	
2 % Unknown	
Precrash 1:	
100% Leaving a parked position	97 % Going straight 1 % Passing/overtaking 2 % Entering a parked position
Precrash2 (critical event):	
Critical event initiated by this vehicle's encroach on another vehicle's lane (same direction) non-junction:	Critical event initiated by other vehicle encroaching into this vehicle's lane at non-junction (same direction):
38 % over left lane line.	44 % over right lane line.
2 % over right lane line.	44 % from parallel/diagonal parking lane.
57 % from parallel/diagonal parking lane.	3 % over left lane line.

Precrash3:	
90 % No corrective action	90 % No corrective action
2 % Steered to right	1% Braked/slowed
	2% Steered to left
	2% Steered to right
	2% Braked and steered left
8 % Unknown	4% Unknown
Precrash4:	
90 % No corrective action	90 % No corrective action
2 % Control maintained	6% Control maintained
	1% Longitudinal slide/skid
8 % Unknown	4% Unknown
Precrash5:	
90 % No corrective action	90 % No corrective action
2 % Remained in same travel lane	6% Remained in same travel lane
8 % Unknown vehicle path	4% Unknown vehicle path
Speed:	
4% 0MPH	7% 25 MPH
5% 2MPH	4% 30 MPH
4% 4MPH	
81 % Unknown	82 % Unknown
Accident Type:	
15 % Going straight ahead	98 % Going straight ahead
77 % Changing lanes to the left	2% Changing lanes, to the right
8 % Changing lanes to the right	
Damage Severity:	
4 % None	4% None
21 % Minor	20 % Minor
19 % Functional	25 % Functional
3 % Disabling	5% Disabling
53 % Unknown	46 % Unknown
Initial Point of Impact:	
20 % Front	0% Front
2 % Right side	84 % Right side
48 % Left side	6 % Left side
6 % Front right corner	1 % Top
24 % Front left corner	6 % Front right corner
	4 % Back left corner
Vehicle STYLE	
91 % Cars, light trucks, vans	96 % Cars, light trucks, vans
0 % Trailering trucks	2 % Trailering trucks
8 % Straight trucks	0 % Straight trucks

Damage Area

4 % No damage	4 % No damage
54 % Front and other	7 % Front and other
1 % Right side and other	79 % Right side and other
32 % Left side and other	10 % Left side and other
0 % Back	0 % Back
10 % Unknown	0 % Unknown

Body Type (5 major types):		
21 %	Unknown automobile type	23 %
24 %	4-door sedan, hardtop	27 %
16 %	2-door sedan, hardtop, coupe	17 %
7%	Unknown van type	8%
6%	Station wagon	
6%	Unknown medium/heavy truck	
	3-door/2-door hatchback	6%
Vehicle Defects:		
92 %	None	96 %
8%	Unknown	3%
Driver's Sex:		
61 %	Male	57 %
39 %	Female	43 %
Driver's Age:		
29 %	21 or less	15 %
27 %	22 to 30	38 %
19 %	31 to 40	18 %
5%	41 to 50	10 %
14 %	51 to 65	15 %
6%	over 65	4%
Driver Impairment:		
89 %	None	99 %
2%	Physical impairment - no details	
9%	Unknown	2%
Driver Injury Severity:		
96 %	None (0)	95 %
1%	Possible injury (C)	3%
	Nonincapacitating evident injury (B)	2 %
1%	Incapacitating injury (A)	
2%	Injured, severity unknown	
Driver Restraint System Use:		
7%	None	5%
54 %	Restraint system used	65 %
39 %	Unknown	30 %

Driver Violations Charged:

60 %	None	88 %
2%	Alcohol or drugs	
2%	Driving, suspended/revoked license	2%
7%	Failure to yield right-of-way	
6%	Hit and run (no information)	
23 %	0 ther violations	10 %

5.2 LEAVING A PARKING PLACE: 6,444 GES Weighted (35 Observations)

LCM52: a vehicle leaves a parking place (not backing) and is struck by another vehicle

PCRASH12 = 7.
ACCTYPE1 ≠ 92
4 # MANCOLl # 5 (angle or sideswipe, same direction)

ACCIDENT VARIABLES
Relation to Junction:
65 % Non-junction
9 % Intersection
26 % Intersection related
Traffic Control
78 % None
4 % Traffic control signal on colors
13 % Stop sign
Alcohol Involvement:
5 % Yes
95 % No
Manner of Collision
60 % Angle
40 % Sideswipe, same direction
Interstate Highway:
100% No
Maximum Injury Severity:
94 % None (0)
4 % Possible injury (C)
2 % Nonincapacitating evident injury (B)
Land Use:
10 % Area population 50,000 to 100,000
56 % Area population 100,000 plus
32 % Other area
2 % Unknown
Roadway Alignment:
95 % Straight
5 % Curve
Roadway Surface Condition:
70 % Dry
25 % Wet
4 % Other

Roadway Profile:

70 % Level
30 % Grade

Light Condition:

79 % Daylight
16 % Dark but lighted
5 % Dusk

Atmospheric Conditions:

94 % No adverse atmospheric conditions
6 % Rain

Number of Travel Lanes:

26 % Two
4 % Three
6 % Four
4 % Seven
59 % Unknown

Trafficway Flow:

52 % Two-way trafficway (not physically divided)
47 % Unknown

Speed Limit:

42 % 25 MPH or less
43 % 30 or 35 MPH
15 % 40 or 45 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
4 % Hit and Run	0 % Hit and Run
78 % No avoidance maneuver	87 % No avoidance maneuver
17 % Unknown	13 % Unknown
Driver's Vision Obscured by	
74 % Not obscured	83 % Not obscured
4 % Hit and Run	0 % Hit and Run
22 % Unknown	18 % Unknown
Driver Distracted by	
78 % Not distracted	87 % Not distracted
4 % Hit and Run	13 % Unknown
17 % Unknown	
Precrashl:	
91 % Going straight	100% Leaving a parked position
4 % Entering a parked position	
5 % Changing lanes	

Precrash2 (critical event):	
Critical event initiated by this vehicle encroaching into other vehicle's lane at non-junction (same direction):	Critical event initiated by this vehicle encroaching into other vehicle's lane at non-junction (same direction):
9 % over left lane line.	26 % over left lane line.
9 % over right lane line.	52 % from parallel/diagonal parking lane.
critical event initiated by other vehicle encroaching into this vehicle's lane at non-junction (same direction):	9 % critical event initiated by other vehicle already in this vehicle's lane traveling in same direction with higher speed.
16 % over right lane line.	
56 % from parallel/diagonal parking lane.	
Precrash3:	
83 % No corrective action	87 % No corrective action
17 % Unknown	13 % Unknown
Precrash4:	
83 % No corrective action	87 % No corrective action
17 % Unknown	13 % Unknown
Precrash5:	
83 % No corrective action	87 % No corrective action
17 % Unknown vehicle path	13 % Unknown vehicle path
Speed:	
11 % 15 MPH	8 % 0 MPH (stopped)
5 % 17 MPH	5 % 1MPH
4 % 20 MPH	4% 3MPH
1 % 25 MPH	11% 5MPH
4 % 89 MPH	1% 10 MPH
74 % Unknown	70 % Unknown
Accident Type	
72 % Going straight ahead	19 % Going straight ahead
9 % Changing lanes to the left	66 % Changing lanes, to the left
9 % Changing lanes to the right	4 % Changing lanes to the right
10 % Other	10 % Other
Damage Severity:	
9 % None	0 % None
12 % Minor	14 % Minor
16 % Functional	19 % Functional
6 % Disabling	0 % Disabling
57 % unknown	66 % Unknown

Initial Point of Impact:

24 % Front	6 % Front
28 % Right side	9 % Right side
13 % Left side	58 % Left side
31 % Front right corner	6 % Back
4 % Front left corner	4 % Front right corner
	18 % Front left corner

Vehicle STYLE

100% Cars, light trucks, vans	95 % Cars, light trucks, vans
	4 % Straight trucks

Damage Area

9 % No damage	0 % No damage
60 % Front and other	31 % Front and other
13 % Right side and other	13 % Right side and other
9 % Left side and other	52 % Left side and other
0 % Back	4 % Back
9 % Unknown	0 % Unknown

Body Type (5 major types):

12 %	Unknown automobile type	27 %
26 %	4-door sedan, hardtop	38 %
37 %	2-door sedan, hardtop, coupe	17 %
10 %	Unknown type pickup truck	
6%	Large pickup truck	
	Hatchback, number doors unknown	4%
	Other automobile type	4%
	Unknown medium/heavy truck	4%

Vehicle Defects:

87 %	None	83 %
	Other	4%
13 %	Unknown	13 %

Driver's Sex:

61 %	Male	57 %
39 %	Female	43%

Driver's Age:

10 %	21 or less	22 %
29 %	22 to 30	12 %
14 %	31 to 40	25 %
18 %	41 to 50	14 %
23 %	51 to 65	17 %
5%	over 65	11 %

Driver Impairment:

91 %	None	96 %
9%	Unknown	4 %

Driver Injury Severity:		
96 %	None (0)	99 %
3%	Possible injury (C)	1%
Driver Restraint System Use:		
18 %	None	17 %
42 %	Restraint system used	50 %
40 %	Unknown	33 %
Driver Violations Charged:		
94 %	None	68 %
	Failure to yield right-of-way	9%
4%	Hit and run (no information)	
2%	Other violations	23 %

5.3 LEAVING A PARKING PLACE: 688 GES Weighted (CAUTION! 5 Observations)

LCM53: a vehicle leaves a parking place (not backing) and is rearended by another vehicle

PCRASH12 = 7
ACCTYPE2 | 92
MANCOL2 = 1 (rearend)

ACCIDENT VARIABLES
Relation to Junction:
14 % Non-junction
81 % Intersection
4 % Interchange related
Traffic Control
59 % None
41 % Traffic control signal on colors
Alcohol Involvement:
100% No
Manner of Collision
100% Rearend
Interstate highway:
95 % No
5 % Yes
Maximum Iniury Severity:
99 % None (0)
1 % Incapacitating injury (A)
Land Use:
40 % Area population 50,000 to 100,000
18 % Other area
42 % Unknown
Roadway Alignment:
100 % Straight
Roadway Surface Condition:
59 % Dry
41 % Wet
Roadway Profile:
60 % Level
40 % Grade
Light Condition:
82 % Daylight
4 % Dark
14 % Dark but lighted

Atmospheric Conditions:
59 % No adverse atmospheric conditions
41 % Rain

Number of Travel Lanes:
46 % Two
41 % Four
14 % Unknown

Trafficway Flow:
81 % Two-way trafficway (not physically divided)
5 % Divided highway
14 % Unknown

Speed Limit:
14 % 25 MPH or less
41 % 40 MPH
41 % 50 or 55 MPH
4 % 65 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
0 % Hit and Run	4 % Hit and Run
100% No avoidance maneuver	96 % No avoidance maneuver
Driver's Vision Obscured by	
100% Not obscured	96 % Not obscured
0 % Hit and Run	4 % Hit and Run
Driver Distracted by	
100% Not distracted	96 % Not distracted
0 % Hit and Run	4 % Hit and run
Precrash 1:	
59 % Going straight	100% leaving a parked position
41 % Slowing/stopping in traffic lane	
Precrash2 (critical event):	
81 % Critical event initiated by this vehicle in another vehicle's lane traveling in same direction with higher speed.	81 % Critical event initiated by this vehicle in another vehicle's lane traveling in same direction with lower speed.

Precrash2 (continued):

Critical event initiated by other vehicle encroaching into this vehicle's lane at non-junction (same direction):	Critical event initiated by this vehicle encroaching into another vehicle's lane (same direction) at non-junction:
1 % over right lane line.	1 % over left lane line.
18 % from parallel/diagonal parking lane.	18 % from parallel/diagonal parking lane.
Precrash3:	
18 % No corrective action	54 % No corrective action
1 % Braked and steered left	
81 % Unknown	46 % Unknown
Precrash4:	
18 % No corrective action	54 % No corrective action
1 % Longitudinal slide/skid	
81 % Unknown	46 % Unknown
Precrash5:	
18 % No corrective action	54 % No corrective action
1 % Remained in same travel	
81 % Unknown vehicle path	46 % Unknown vehicle path
Speed:	
ALL SPEEDS MISSING !	
Accident Type	
4 % Going straight ahead behind slower vehicle	4 % Going straight ahead more slowly
81 % Going straight ahead behind decelerating vehicle	81 % Going straight ahead, decelerating
14 % Going straight ahead	14 % Lane change to the left
Damage Severity:	
81 % Minor	81 % Minor
1 % Functional	0 % Functional
4 % Disabling	1% Disabling
14 % Unknown	18 % Unknown
Initial Point of Impact:	
100 % Front	100 % Back
Vehicle STYLE	
99 % Cars, light trucks, vans	96 % Cars, light trucks, vans
1 % Straight trucks	4 % Trailering trucks

Damage Area

0 %	No damage	0 %	No damage
100%	Front and other	0 %	Front and other
0 %	Right side and other	1 %	Right side and other
0 %	Left side and other	14 %	Left side and other
0%	Back	81 %	Back
0 %	Unknown	4 %	Unknown

Body Type (major types):

81 %	Unknown automobile type	81%
18 %	2-door sedan, hardtop, coupe	14 %
	Unknown medium/heavy truck	1%
	Station wagon	1%
	Truck tractor (cab only)	4%

Vehicle Defects:

100 %	None	96 %
	Unknown	4%

Driver's Sex:

5%	Male	19 %
95 %	Female	81 %

Driver's Age:

4%	21 or less	1%
0%	22 to 30	81 %
54 %	31 to 40	18 %
0%	41 to 50	0%
1%	51 to 65	0%
41 %	over 65	0%

Driver Impairment:

100 %	None	96 %
	Unknown	4%

Driver Injury Severity:

100 %	None (0)	99 %
	Incapacitating injury (A)	1%

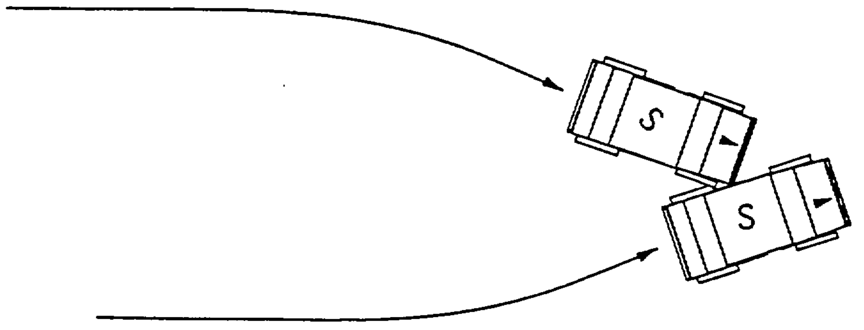
Driver Restraint System Use:

100 %	Restraint system used	82 %
	Unknown	18 %

Driver Violations Charged:

55 %	None	95 %
	Failure to yield right-of-way	1%
	Hit and run (no information)	4%
45 %	Other violations	

6. BOTH CHANGING LANES 4,790 GES Weighted (35 Observations)



LCM6: Both vehicles are changing lanes or merging

$16 \leq PCRASH12 \leq 17$
$16 \leq PCRASH11 \leq 17$

ACCIDENT VARIABLES

Relation to Junction:
47 % Non-junction
12 % Intersection
23 % Intersection related
6 % Driveway, alley access, etc.
6 % Entrance/exit ramp
6 % Interchange related

Traffic Control:
70 % None
12 % Traffic control on colors
6 % Other traffic signal
12 % Yield sign

Manner of Collision:
37 % Rearend
25 % Angle
38 % Sideswipe, same direction

Alcohol Involvement:
100% No

Interstate Highway:
79 % No
21 % Yes

Maximum Iniury Severity:
80 % None (0)
19 % Possible injury (C)
1 % Nonincapacitating evident injury (B)
Land Use:
6 % Area population 25,000 to 50,000
12 % Area population 50,000 to 100,000
55 % Area population 100,000 plus
27 % Other area
Roadway Alignment:
70 % Straight
30 % Curve
Roadway Surface Condition:
82 % Dry
12 % Wet
6 % Ice or snow/ice combined
Roadwav Profile:
68 % Level
32 % Grade
Light Condition:
90 % Daylight
8 % Dark but lighted
1% Dawn
Atmospheric Conditions:
82 % No adverse atmospheric conditions
12 % Rain
6% Snow
Number of Travel Lanes:
15 % Two
6 % Three
18 % Four
1 % Five
6 % Six
54 % Unknown
Trafficway Flow:
37 % Two-way trafficway (not physically divided)
27 % Divided highway
12 % One-way trafficway
24 % Unknown

Speed Limit:
42 % Less than 25 MPH
17 % 30 or 35 MPH
7 % 40 of 45 MPH
34 % 50 or 55 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
6 % Hit and Run	6 % Hit and Run
87 % No avoidance maneuver	88 % No avoidance maneuver
1 % Vehicle in road	
6 % Unknown	6 % Unknown
Driver's Vision Obscured by	
82 % Not obscured	82 % Not obscured
6 % Hit and Run	6 % Hit and Run
12 % Unknown	12 % Unknown
Driver Distracted bv	
88 % Not distracted	82 % Not distracted
6 % Hit and Run	6 % Hit and Run
6 % Unknown	6 % Unknown
Precrash 1:	
64 % Changing lanes	64 % Changing lanes
36 % Merging	36 % Merging
Precrash2 (critical event):	
25 % Critical event initiated by this vehicle in another vehicle's lane traveling in same direction with higher speed.	Critical event initiated by this vehicle encroaching into another vehicle's lane at non-junction: 12 % over left lane line. 13 % over right lane line.
18 % Critical event initiated by other vehicle encroaching into this vehicle's lane at non-junction over right lane line	Critical event initiated by other vehicle already in this vehicle's lane (same direction) traveling: 12 % with lower speed. 19 % with higher speed
Critical event initiated by this vehicle encroaching into other vehicle's lane at non-junction: 14 % over left lane line. 12 % over right lane line.	26 % Critical event initiated by other vehicle encroaching into this vehicle's lane at non-junction over left lane line

Precrash2 (continued\):	
12 % Other events not listed specifically in table.	12 % Other events not specifically listed in table.
Precrash3:	
80 % No corrective action	83 % No corrective action
7 % Braked/slowed	6% Braked/slowed
1 % Steered to right	
12 % Unknown	12 % Unknown
Precrash4:	
80 % No corrective action	83 % No corrective action
2 % Control maintained	6% Control maintained
6 % Longitudinal slide/skid	
12 % Unknown	12 % Unknown
PrecrashS:	
80 % No corrective action	83 % No corrective action
8 % Remained in same travel lane	6% Remained in same travel lane
12 % Unknown vehicle path	12 % Unknown vehicle path
Speed:	
6 % 20 MPH	6% 3 MPH
1 % 35 MPH	6% 15 MPH
1% 40 MPH	1% 20 MPH
2 % 60 MPH	6% 30 MPH
6 % 65 MPH	6% 55 MPH
84 % Unknown	74 % Unknown
Accident Type	
25 % Striking a slower vehicle	25 % Rearended by faster moving vehicle
11 % Striking a decelerating vehicle	11 % Rearended while decelerating
18 % Going straight ahead	12 % Going straight ahead
13 % Lane change to right	12 % Lane change to right
13 % Lane change to left	18 % Lane change to left
20 % Other specifics	20 % Other specifics
Damage Severity:	
0 % None	0% None
18 % Minor	26 % Minor
18 % Functional	18 % Functional
9 % Disabling	0% Disabling
55 % Unknown	55 % Unknown

Initial Point of Impact

51 % Front	6 % Front
18 % Right side	21 % Right side
19 % Left side	29 % Left side
6 % Front right corner	43 % Back
6 % Front left corner	

Vehicle STYLE

87 % Cars, light trucks, vans	92 % Cars, light trucks, vans
6 % Trailering trucks	8 % Trailering trucks
6 % Straight trucks	

Damage Area

0 % No damage	0 % No damage
64 % Front and other	6 % Front and other
12 % Right side and other	21 % Right side and other
13 % Left side and other	29 % Left side and other
0% Back	31 % Back
12 % Unknown	12 % Unknown

Body Type (major types):

19 %	Unknown automobile type	13 %
27 %	4-door sedan, hardtop	24 %
12 %	2-door sedan, hardtop, coupe	24 %
	Unknown utility type	6%
12 %	Unknown type pickup truck	
6%	Truck tractor (cab only)	8%

Vehicle Defects:

88 %	None	88 %
12 %	Unknown (includes hit and run)	12 %

Driver's Sex:

75 %	Male	64 %
25 %	Female	36 %

Driver's Age:

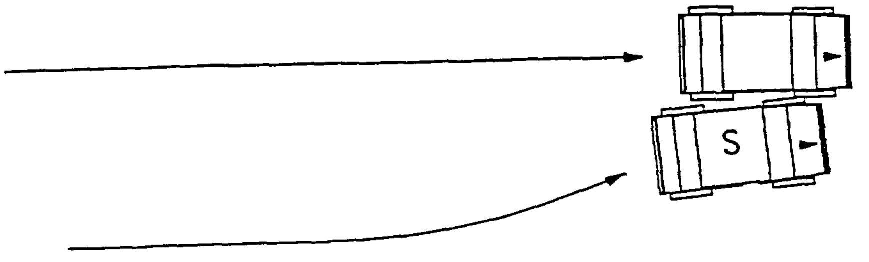
17 %	21 or less	12 %
36 %	22 to 30	37%
20 %	31 to 40	18 %
15 %	41 to 50	3%
13 %	51 to 65	19 %
0%	over 65	12 %

Driver Impairment

88 %	None	94 %
12 %	Unknown	6%

Driver Injury Severity:		
92 %	None (0)	82 %
7 %	Possible injury (C)	18 %
Driver Restraint System Use:		
6%	None	1%
70 %	Restraint system used	93 %
24 %	Unknown	6 %
Driver Violations Charged:		
80 %	None	93 %
8%	Reckless driving	0 %
6%	Hit and run (no information)	6 %
6%	Other violations	1%

7. SIDESWIPE: 78,859 GES Weighted (585 Observations)



LCM7: the vehicle which is changing lanes or merging strikes another vehicle going straight

16 ≤ PCRASH11 ≤ 17
MANCOL1 = 5 (sideswipe, same direction)
PCRASH12 ≠ 16
PCRASH12 ≠ 17

ACCIDENT VARIABLES

Relation to Junction:
69 % Non-junction
12 % Intersection
12 % Intersection related
3 % Driveway or alley access
1 % Entrance/exit ramp
3 % Interchange related

Traffic Control
79 % None
12 % Traffic control signal on colors
6 % Other traffic signal/sign
2 % Stop sign
1 % Yield sign

Alcohol Involvement:
5 % Yes
95 % No

Interstate Highway:
84 % No
16 % Yes

Maximum Injury Severity:

87 % None (0)
10 % Possible injury (C)
3 % Nonincapacitating evident injury (B)
1 % Incapacitating injury (A)
1 % Unknown severity

Land Use:

9 % Area population 25,000 to 50,000
8 % Area population 50,000 to 100,000
40 % Area population 100,000 plus
39 % Other area
5 % Unknown

Roadway Alignment:

96 % Straight
4 % Curve

Roadway Surface Condition:

77 % Dry
20 % Wet
1 % Snow or slush
2 % Ice or snow/ice combined

Roadway Profile:

73 % Level
24 % Grade
2 % Hillcrest

Light Condition:

74 % Daylight
7 % Dark
17 % Dark but lighted
1 % Dawn
1 % Dusk

Atmospheric Conditions:

84 % No adverse atmospheric conditions
14 % Rain
2% Snow

Number of Travel Lanes:

1% One
24 % Two
19 % Three
27 % Four
12 % Five
2 % Six
1% Seven
14 % Unknown

Trafficway Flow:
40 % Two-way trafficway (not physically divided)
34 % Divided highway
6 % One-way trafficway
20 % Unknown

Speed Limit:
9 % 25 MPH or less
36 % 30 or 35 MPH
23 % 40 or 45 MPH
29 % 50 or 55 MPH
4 % 65 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
16 % Hit and Run	0 % Hit and Run
79 % No avoidance maneuver	97 % No avoidance maneuver
1 % Vehicle in road	
3 % Unknown	3 % Unknown
Driver's Vision Obscured by	
79 % Not obscured	96 % Not obscured
16 % Hit and Run	0 % Hit and Run
4 % Unknown	4 % Unknown
Driver Distracted by	
80 % Not distracted	97 % Not distracted
16 % Hit and Run	3 % Unknown
3 % Unknown	
Precrash 1:	
93 % Changing lanes	91 % Going straight
7 % Merging	2 % Slowing/stopping in lane
	5 % Stopped in lane
	1 % Passing/overtaking
	1 % Negotiating a curve
Precrash2 (critical event):	
Critical event initiated by this vehicle encroaching into another vehicle's lane: at non-junction from adjacent lane (same direction):	Critical event initiated by other vehicle encroaching into this vehicle's lane: at non-junction from adjacent lane (same direction):
46 % over left lane line.	45 % over left lane line,
45 % over right lane line.	44 % over right lane line.

Precrash3:	
86 % No corrective action	93 % No corrective action
2 % Braked	2% Braked
1 % Steered to left	
2 % Steered to right	
9 % Unknown	4 % Unknown
Precrash4:	
86 % No corrective action	93 % No corrective action
2 % Control maintained	1 % Control maintained
1 % Longitudinal slide/skid	
1 % Other	
10 % Unknown	5 % Unknown
Precrash5:	
86 % No corrective action	93 % No corrective action
2 % Remained in same travel lane	2 % Remained in same travel lane
3 % Stayed on roadway but left travel lane	1 % Stayed on roadway but left travel lane
9 % Unknown vehicle path	4 % Unknown vehicle path
Speed:	
3 % 15 MPH	5% 0 MPH (stopped)
4 % 25 MPH	6 % 25 MPH
3 % 30 MPH	5 % 30 MPH
5 % 35 MPH	6% 35MPH
4 % 55 MPH	5 % 55 MPH
63 % Unknown	55 % Unknown
Accident Type:	
11 % Going straight ahead	96 % Going straight ahead
45 % Changing lanes, right	
40 % Changing lanes, left	
4 % Other specifics	4 % Other specifics
Damage Severity:	
3 % None	2 % None
48 % Minor	48 % Minor
26 % Functional	33 % Functional
5 % Disabling	6 % Disabling
18 % Unknown	10 % Unknown

Initial Point of Impact:

13 % Front	2% Front
33 % Right side	35 % Right side
32 % Left side	47 % Left side
11 % Front right corner	1% Back
7% Front left corner	6% Front right corner
1% Back right corner	3% Front left corner
2% Back left corner	2% Back right corner
	3% Back left corner

Vehicle STYLE

84 % Cars, light trucks, vans	93 % Cars, light trucks, vans
12 % Trailering trucks	5% Trailering trucks
3 % Straight trucks	1% Straight trucks

Damage Area

4 % No damage	2% No damage
35 % Front and other	16 % Front and other
24 % Right side and other	35 % Right side and other
27 % Left side and other	46 % Left side and other
0% Back	0 % Back
10 % Unknown	1% Unknown

Body Type (major types):

27 %	Unknown automobile type	30 %
14 %	4-door sedan, hardtop	20 %
13 %	2-door sedan, hardtop, coupe	20 %
5%	Unknown van type	3%
7%	Unknown type pickup truck	4%
	Compact pickup truck	3%
12 %	Truck tractor (cab only)	5%

Vehicle Defects:

83 %	None	96 %
16 %	Unknown	4 %

Driver's Sex:

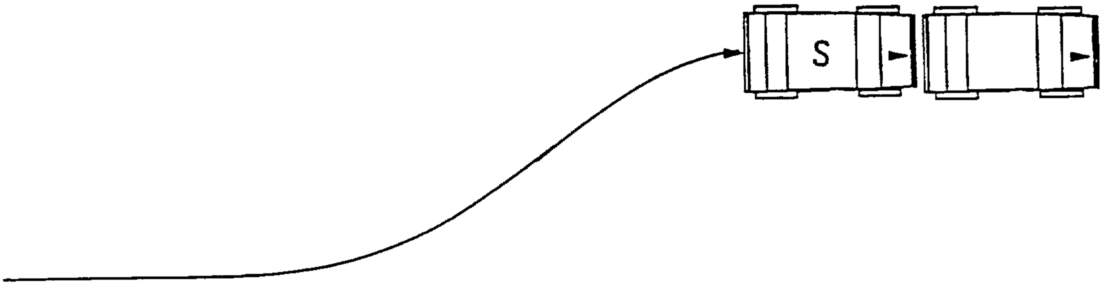
70 %	Male	60 %
30 %	Female	40 %

Driver's Age:

25 %	21 or less	13 %
20 %	22 to 30	25 %
21 %	31 to 40	26 %
16 %	41 to 50	17 %
12 %	51 to 65	13 %
6%	over 65	5 %

Driver Impairment:		
86 %	None	100 %
14 %	Unknown	
Driver Injury Severity:		
95 %	None (0)	91 %
4 %	Possible injury (C)	7%
0 %	Nonincapacitating evident injury (B)	2%
1%	Injured, severity unknown	0 %
Driver Restraint System Use:		
6%	None	3%
70 %	Restraint system used	87 %
24 %	Unknown	10 %
Driver Violations Charged:		
47 %	None	98 %
1%	Alcohol or drugs	
2%	Reckless driving	
2%	Failure to yield right-of-way	
13 %	Hit and run (no information)	
34 %	Other violations	2%

8. REAREND STRIKING: 16,351 GES Weighted (135 Observations)



LCM8: the vehicle changing lanes or merging strikes another vehicle in the rear end

$16 \leq$ PCRASH11 ≤ 17
MANCOL1 = 1 (rearend)
PCRASH12 $\neq$ 16 and PCRASH12 $\neq$ 17

ACCIDENT VARIABLES
Relation to Junction:
54 % Non-junction
10 % Intersection
15 % Intersection related
8 % Driveway or alley access
7 % Entrance/exit ramp
6 % Interchange related
Traffic Control
74 % None
17 % Traffic control signal on colors
7 % Yield sign
Alcohol Involvement:
4 % Yes
96 % No
Interstate Highway:
72 % No
28 % Yes

Maximum Injury Severity:
64 % None (O)
24 % Possible injury (C)
7 % Nonincapacitating evident injury (B)
4 % Incapacitating injury (A)
1 % Fatal injury (K) (1.23 % in this case)

Land Use:
10 % Area population 25,000 to 50,000
12 % Area population 50,000 to 100,000
29 % Area population 100,000 plus
45 % Other area
4 % Unknown

Roadway Alignment:
88 % Straight
12 % Curve

Roadway Surface Condition:
75 % Dry
24 % Wet
1 % Ice or snow/ice combined

Roadway Profile:
75 % Level
22 % Grade
3 % Hillcrest

Light Condition:
82 % Daylight
6 % Dark
7 % Dark but lighted
5 % Dusk

Atmospheric Conditions:
83 % No adverse atmospheric conditions
16 % Rain
1% Snow

Number of Travel Lanes:
9% One
15 % Two
10 % Three
31 % Four
13 % Five
4 % Six
18 % Unknown

Trafficway Flow:
28 % Two-way trafficway (not physically divided)
47 % Divided highway
9 % One-way trafficway
17 % Unknown

Speed Limit:
9 % 25 MPH or less
35 % 30 or 35 MPH
14 % 40 or 45 MPH
40 % 50 or 55 MPH
2 % 60 or 65 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
7 % Hit and Run	3 % Hit and Run
87 % No avoidance maneuver	96 % No avoidance maneuver
3 % Vehicle in road	
4 % Unknown	2 % Unknown
Driver's Vision Obscured bv	
87 % Not obscured	96 % Not obscured
7 % Hit and Run	2 % Hit and Run
5 % Unknown	2 % Unknown
Driver Distracted bv	
80 % Not distracted	96 % Not distracted
7 % Hit and Run	2 % Hit and run
4 % Other internal distractions	
5 % Other external distractions	
4 % Unknown	2 % Unknown
Precrash 1:	
95 % Changing lanes	30 % Going straight
5 % Merging	29 % Slowing or stopping
	33 % Stopped
	7 % Turning right

Precrash2 (critical event):	
Critical event initiated by this vehicle in another vehicle's lane (same direction) traveling:	Critical event initiated by other vehicle already in this vehicle's lane (same direction) traveling:
9 % with lower speed.	69 % with higher speed.
72 % with higher speed.	8 % with lower speed.
10 % encroaching over right lane line.	7 % encroaching over left lane line.
Precrash3:	
73 % No corrective action	93 % No corrective action
10 % Braked	4 % Braked
3 % Steered to left	
1 % Steered to right	
2 % Braked, steered left	
2 % Braked, steered right	
7 % Unknown	4 % Unknown
Precrash4:	
73 % No corrective action	93 % No corrective action
13 % Control maintained	4 % Control maintained
4 % Longitudinal slide/skid	
1 % Other	
9 % Unknown	4 % Unknown
Precrash5:	
73 % No corrective action	93 % No corrective action
16 % Remained in same travel lane	4 % Remained in same travel lane
4 % Stayed on roadway but left travel lane	
7 % Unknown vehicle path	4 % Unknown vehicle path
Speed:	
5 % 10 MPH	33 % 0 MPH (stopped)
4 % 25 MPH	5% 5 MPH
4 % 30 MPH	
3 % 45 MPH	
69 % Unknown	44 % Unknown

Accident Type

32 % Going straight ahead, rearending vehicle which was stopped	32 % Rearended, stopped
32 % Going straight ahead, rearending vehicle going more slowly	32 % Rearended, going more slowly
25 % Going straight ahead, rearending decelerating vehicle	25 % Rearended, decelerating

Damage Severity:

0 % None	4 % None
26 % Minor	36 % Minor
35 % Functional	25 % Functional
14 % Disabling	10 % Disabling
26 % Unknown	26 % Unknown

Initial Point of Impact:

100 % Front	100 % Back

Vehicle STYLE

95 % Cars, light trucks, vans	93 % Cars, light trucks, vans
4 % Trailering trucks	4 % Trailering trucks
	1 % Straight trucks

Damage Area:

0 % No damage	4 % No damage
95 % Front and other	2 % Front and other
0 % Right side and other	17 % Right side and other
0 % Left side and other	17 % Left side and other
0 % Back and other	57 % Back and other
0 % All	1 % All
5 % Unknown	2 % Unknown

Body Type 9 major types:

29 %	Unknown automobile type	28%
18 %	4-door sedan, hardtop	21 %
16 %	2-door sedan, hardtop, coupe	15 %
7%	Unknown type pickup truck	
5%	3-doer/2-door hatchback	
	Minivan	6%
	Compact pickup truck	5%

Vehicle Defects:

93 %	None	94 %
1%	Tire failure	
7%	Unknown	6%

Driver's Sex:		
69 %	Male	63 %
31 %	Female	37 %
Driver's Age:		
27 %	21 or less	15 %
33 %	22 to 30	23 %
21 %	31 to 40	24 %
16 %	41 to 50	24 %
2%	51 to 65	9%
2%	over 65	4 %
Driver Impairment:		
92 %	None	98 %
1%	Drowsy, sleepy, tired	
1%	Other	
6%	Unknown	2 %
Driver Iniurv Severity:		
87 %	None (0)	77 %
8%	Possible injury (C)	**18 %**
3%	Nonincapacitating evident injury (B)	3 %
2%	Incapacitating injury (A)	2 %
	Fatal injury (K)	1%
Driver Restraint Svstem Use:		
7 %	None	1%
80 %	Restraint system used	94 %
13 %	Unknown	5 %
Driver Violations Charged:		
54 %	None	97 %
3%	Alcohol or drugs	
16 %	Speeding	
1%	Alcohol/drugs and speeding	
7%	Hit and run (no information)	2 %
19 %	Other violations	1%
Driver's Drug Involvement:		
Drugs Not Involved		91 %
Drugs Involved		0.1 %
Unknown		9 %

A.2 One-Vehicle Backing Crashes from the GES

A.2.1 Segregating the One-Vehicle Backing Crashes from the GES

A one-vehicle backing crash is a crash involving one motor vehicle in transport and another person/object which is not a motor vehicle in transport. This includes crashes involving pedestrians, pedacyclists, parked cars and both fixed and non-fixed objects.

The following steps are followed in the construction of the data set BACK from the data set GES.GES92:

> First, the observations to be examined and those in which the vehicle role is striking and the driver is present.are identified.
>
> Then the observations for which the Precrashl action is backing (other than for parking) or the accident type is that of a backing crash (striking) are identified.

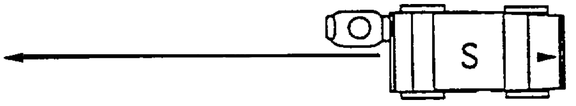
The data set BACK is then subsequently sorted by the criteria set for each of the one-vehicle backing crashes.

There is no limit to the number of motor vehicles which may be involved. In order to verify that a limitation on the number of motor vehicles involved is not necessary, the same cases were run with a one-vehicle limit. No significant differences emerged.

5.2.1 One-Vehicle Backing Crash Descriptive Statistics

In the following descriptive statistics, driver impairment will only be noted when it is observed in the database. In general, no driver impairment is noted. Driver's drug involvement is noted only in BACK1 and BACK8 when it is observed in the database. Generally, none is noted.

STRIKING PEDESTRIAN: 3,177 GES Weighted (50 Observations)



BACKl: The vehicle which is backing strikes a pedestrian so that vehicle most harmful event is striking a pedestrian; [either Precrashl = 13 (backing other than parking) or Accident Type = 92 (backing crash)] and vehicle most harmful event is striking a pedestrian.

(P-CRASH1 = 13 (backing other than parking) or

ACC_TYPE = 92 (backing crash)
and
V-EVNT-H = 21 (striking a pedestrian)

ACCIDENT VARIABLES

Alcohol Involvement:
2 % Yes
98 % No

Manner of Collision:
98 % Not collision with motor vehicle in transport
2 % Other

Maximum Iniury Severity (including: pedestrian injuries):
40 % Possible injury (C)
49 % Nonincapacitating evident injury (B)
11 % Incapacitating injury (A)
1 % Fatal injury (K) (0.77 % in this case)

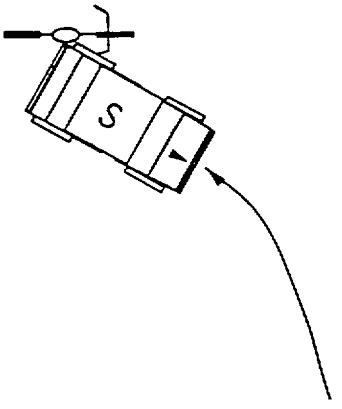
Driver Maneuvered to Avoid:
33 % Hit and Run
67 % No avoidance maneuver

Driver's Vision Obscured by:
67 % Not obscured
33 % Hit and Run
Driver Distracted bv:
67 % Not distracted
32 % Hit and Run
1 % Other internal distraction
First Harmful Event:
99 % Collision with object not fixed - pedestrian
1 % Collision with object not fixed - parked motor vehicle
Precrash 1:
100% Backing other than parking
Precrash2 (critical event):
72 % Critical event initiated by non-motorist in roadway
3 % Critical event initiated by non-motorist approaching roadway
3 % Critical event initiated by non-motorist-location unknown
21 % Critical event initiated by other event
Precrash3:
81 % No corrective action
19 % Unknown
Precrash4:
81 % No corrective action
19 % Unknown
Precrash 5:
81 % No corrective action
19 % Unknown
Speed:
15% 5MPH
5 % 10 MPH
9 % 20 MPH
66 % Unknown
Accident Type:
85 % Backing
15 % Forward impact striking pedestrian
Point of Impact:
80 % Back
12 % Left Side
3 % Right Side
3 % Back Right Corner

Damage Area :
43 % No damage
1 % Front and somewhere else
2 % Right side and somewhere else
11 % Left side.
4 % Back and somewhere else
37 % Unknown (presumed to include the 33 % hit and run)
Interstate highway:
100 % No
Land Use:
1 % Area population 25,000 to 50,000
4 % Area population 50,000 to 100,000
53 % Area population 100,000 plus
39 % Other area
Roadway Alignment:
88 % Straight
12 % Curve
Roadway Surface Condition:
99 % Dry
1 % Wet
Roadway Profile:
77 % Level
23 % Grade
1 % Hillcrest
Light Condition:
88 % Daylight
4 % Dark
6 % Dark but lighted
2 % Dusk
Atmospheric Conditions:
99 % No adverse atmospheric conditions
1 % Rain
Number of Travel Lanes:
3 % One
21 % Two
10 % Three
2 % Four
64 % Unknown
Trafficway Flow:
47 % Two-way trafficway (not physically divided)
6 % Divided highway
10 % One-way trafficway
37 % Unknown

Speed Limit:
41 % 25 MPH or less
31 % 30 or 35 MPH
11 % 40 or 45 MPH
18 % 50 or 55 MPH
Body Type (5 maior types):
25 % Unknown automobile type
23 % 2-door sedan, hardtop, coupe
13 % 4-door sedan, hardtop
13 % Large pickup truck
9 % Unknown type of light truck
Vehicle Defects:
68 % None
32 % Unknown (includes hit and run)
Driver's Sex:
70 % Male
30 % Female
Driver's Age:
17 % 21 or less
26 % 22 to 30,
30 % 31 to 40
5 % 41 to 50
11 % 51 to 65
11 % over 65
Driver Impairment:
68 % None
32 % Unknown
Driver In iurv Severity:
99 % None (0)
1 % Nonincapacitating evident injury (B)
Driver Restraint System Use:
8 % None
42 % Restraint system used
50 % Unknown
Driver Violations Charged:
64 % None
1 % Alcohol or drugs
23 % Hit and run (no information)
14 % Other violations
Driver's Drue Involvement:
67 % Drugs Not Involved
1 % Drugs Involved (actually 0.6 %)
33 % Unknown

STRIKING PEDACYCLIST: 815 GES Weighted (CAUTION! 11 Observations)



BACK2: The backing vehicle strikes a pedacyclist so that vehicle most harmful event is striking a pedacyclist; [either Precrashl = 13 (backing other than parking) or Accident Type = 92 (backing crash)] and vehicle most harmful event is striking a pedacyclist.

(P-CRASH1 = 13 (backing other than parking)
or
ACC_TYPE = 92 (backing crash)}
and
V-EVNT-H = 22 (striking a pedacyclist)

ACCIDENT VARIABLES

Alcohol Involvement:
3 % Yes
98 % No

Manner of Collision:
100% Not collision with motor vehicle in transport

Maximum Injury Severity (including pedacyclist injuries):
70 % Possible injury (C)
31 % Nonincapacitating evident injury (B)

Driver Maneuvered to Avoid:
38 % Hit and Run
60 % No avoidance maneuver
3 % Unknown

Driver's Vision Obscured by:
60 % Not obscured
38 % Hit and Run
3 % Unknown

Driver Distracted by:
60 % Not distracted
38 % Hit and Run
3 % Unknown
First Harmful Event:
100% Collision with object not fixed - pedacyclist
Precrash 1:
94 % Backing other than parking
6 % Other
Precrash2 (critical event):
55 % Critical event initiated by pedacyclist in roadway
35 % Critical event initiated by this vehicle encroaching into another vehicle's lane, at junction from Driveway, alley access, etc. - straight across path
7 % Other
4 % Critical event initiated by pedestrian in roadway
Precrash3:
98 % No corrective action
3 % Unknown
Precrash4:
98 % No corrective action
3 % Unknown
Precras h 5:
98 % No corrective action
3 % Unknown
Speed:
35% 4MPH
65 % Unknown
Initial Point of Impact:
59 % Back
38 % Back Right Corner
4 % Back Left Corner
Accident Type:
57 % Backing
43 % Forward impact striking pedestrian
Damage Area:
14 % No damage
35 % Right side and back
3 % Left side and back
14 % Back
35 % Top
Interstate highway:
100 % No

Land Use:
3 % Area population 25,000 to 50,000
38 % Area population 100,000 plus
22 % Other area
37 % Unknown

Roadway Alignment:
100 % Straight

Roadway Surface Condition:
65 % Dry
35 % Ice or snow/ice combined

Roadway Profile:
100 % Level

Light Condition:
62 % Daylight
38 % Dusk

Atmospheric Conditions:
65 % No adverse atmospheric conditions
35 % Sleet

Number of Travel Lanes:
3 % One
6% Two
91 % Unknown

Trafficway Flow:
3 % Divided highway
97 % Unknown

Speed Limit:
22 % 25 MPH or less
78 % 30 or 35 MPH

Body Type (major types):
41 % Unknown automobile type
35 % 2-door sedan, hardtop, coupe
8 % 4-door sedan, hardtop
8 % Unknown van type

Vehicle Defects:
97 % None
3 % Unknown

Driver's Sex:
78 % Male
22 % Female

Driver's Age:

3 % 21 or less
75 % 22 to 30
11 % 31 to 40
7 % 41 to 50
3 % 51 to 65
0 % over 65

Driver Impairment:

62 % None
38 % Unknown

Driver Injury Severity:

100 % None (0)

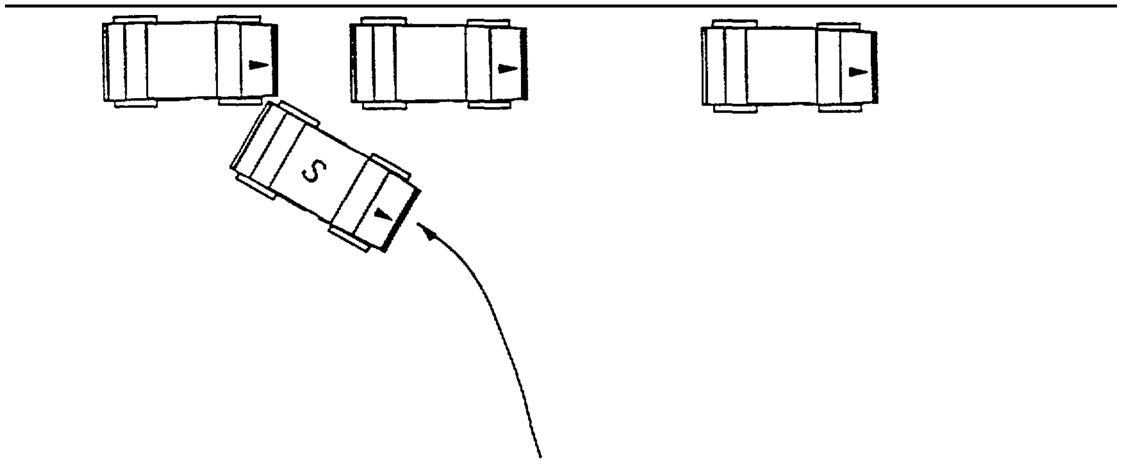
Driver Restraint System Use:

0 % None
59 % Restraint system used
41 % Unknown

Driver Violations Charged:

53 % None
3 % Failure to yield right-of-way
38 % Hit and run (no information)
6 % Other violations

STRIKING A PARKED CAR: 69,676 GES Weighted (269 Observations)



BACK4: The backing vehicle strikes a parked car so that vehicle most harmful event is striking a parked car; [either Precrashl = 13 (backing other than parking) or Accident Type = 92 (backing crash)] and accident first harmful event is striking a parked car.

{P-CRASH1 = 13 (backing other than parking)
or
ACC-TYPE = 92 (backing crash)}
and
EVENTl-1 = 26 (striking a parked car)

ACCIDENT VARIABLES

Alcohol Involvement:
4% Yes
96 % No

Manner of Collision:
98 % Not collision with motor vehicle in transport
2 % Other

Maximum Iniury Severity:
98 % None (0)
2 % Possible injury (C)

Driver Maneuvered to Avoid:
21 % Hit and Run
77 % No avoidance maneuver
3 % Unknown

Driver’s Vision Obscured by:
73 % Not obscured
21 % Hit and Run
3 % Unknown

Driver Distracted by:
75 % Not distracted
21 % Hit and Run
3 % Unknown

First Harmful Event:
100% Collision with parked motor vehicle

Precrash 1:
74 % Backing other than parking
21 % Other
3 % Entering a parked position
2 % Leaving a parked position

Precrash2 (critical event):
14 % Critical event initiated by’ this vehicle traveling over right edge of roadway
6 % Critical event initiated by this vehicle traveling over edge of roadway - unknown which edge
5 % Critical event initiated by this vehicle in another vehicle’s lane traveling in opposite direction
11 % Critical event initiated by this vehicle encroaching into another vehicle’s lane, at non-junction from parallel/diagonal parking lane
22 % Critical event initiated by this vehicle encroaching into another vehicle’s lane, at junction from driveway, alley access, etc.- intended path unknown
10 % This vehicle initiated critical event - details unknown
11 % Other

Precrash3:
87 % No corrective action
13 % Unknown

Precrash4:
87 % No corrective action
13 % Unknown

Precrash 5:
87 % No corrective action
13 % Unknown

Speed:
4 % 3MPH
11% 5MPH
74 % Unknown

Initial Point of Impact:

2 % Noncollision
9 % Right side
4 % Left side
69 % Back
1 % Front Right Corner
1 % Front Left Corner
10 % Back Right Corner
5 % Back Left Corner

Accident Type:

93 % Backing
7 % Forward impact into a parked vehicle

Damage Area:

22 % No damage
3 % Front and somewhere else
19 % Right side and somewhere else
10 % Left side and somewhere else
23 % Back and somewhere else
6 % Top
18 % Unknown

Interstate Highway:

100 % No

Land Use:

6 % Area population 25,000 to 50,000
12 % Area population 50,000 to 100,000
31 % Area population 100,000 plus
47 % Other area
4 % Unknown

Roadway Alignment:

98 % Straight
2 % Curve

Roadway Surface Condition:

83 % Dry
14 % Wet
2 % Ice or snow/ice combined

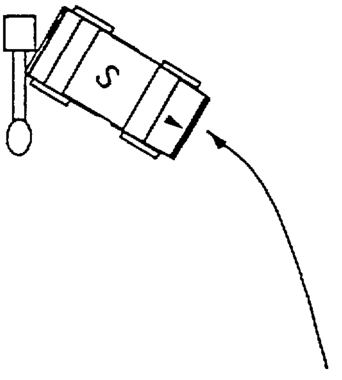
Roadway Profile:

83 % Level
15 % Grade
1 % Hillcrest

Light Condition:
68 % Daylight
10 % Dark
21 % Dark but lighted
2 % Dusk
Atmospheric Conditions:
88 % No adverse atmospheric conditions
9 % Rain
2 % Snow
1 % Fog
1 % Other
Number of Travel Lanes:
4% One
43 % Two
2 % Three
1 % Four
50 % Unknown
Trafficway Flow:
54 % Two-way trafficway (not physically divided)
2 % One-way trafficway
44 % Unknown
Speed Limit:
66 % 25 MPH or less
26 % 30 or 35 MPH
3 % 40 or 45 MPH
4 % 55 MPH
Body Type (5 maior types):
22 % Unknown automobile type
13 % 2-door sedan, hardtop, coupe
12 % 4-door sedan, hardtop
12 % Unknown type of pickup truck
10 % Unknown van type
Vehicle Defects:
78 % None
22 % Unknown (includes hit and run)
Driver's Sex:
64 % Male
36 % Female

Driver's Age:
13 % 21 or less
23 % 22 to 30
17 % 31 to 40
25 % 41 to 50
12 % 51 to 65
11 % over 65
Driver Impairment:
76 % None
1 % Other
23 % Unknown
Driver Injury Severity:
99 % None (O)
1 % Possible injury (C)
Driver Restraint System Use:
9 % None
48 % Restraint system used
43 % Unknown
Driver Violations Charged:
55 % None
1 % Alcohol or drugs
20 % Hit and run (no information)
23 % Other violations

STRIKING A FIXED OBJECT: 12,499 GES Weighted (68 Observations)



BACK8: The backing vehicle strikes a fixed object so that vehicle most harmful event is striking a fixed object; [either Precrashl = 13 (backing other than parking) or Accident Type = 92 (backing crash)] and accident first harmful event is striking a fixed object.

P-CRASH1 = 13 (backing other than parking)
or
ACC-TYPE = 92 (backing crash)}
and
31 - EVENTl-I - 59 (striking a fixed object)

ACCIDENT VARIABLES

Alcohol Involvement:

13 % Yes
88 % No

Manner of Collision:

98 % Not collision with motor vehicle in transport
2 % Other

Maximum Injury Severity:

92 % None (0)
6 % Possible injury (C)
1 % Nonincapacitating evident injury (B)
1 % Incapacitating injury (A)

Driver Maneuvered to Avoid:

21 % Hit and Run
79 % No avoidance maneuver
1 % Animal in road

Driver's Vision Obscured bv:

77 % Not obscured
21 % Hit and Run
2 % Other

Driver Distracted by:
80 % Not distracted
21 % Hit and Run
First Harmful Event (what object was struck):
7 % Building
28 % Sign post or utility pole
6 % Culvert or ditch
16 % Fence
9 % Wall
4 % Fire hydrant
14 % Other fixed object
Precrash 1:
74 % Backing other than parking
26 % Other
Precrash2 (critical event):
7 % Critical event initiated by this vehicle; loss of control due to other or unknown reason
9 % Critical event initiated by this vehicle traveling over left edge of roadway
13 % Critical event initiated by this vehicle traveling over right edge of roadway
9 % Critical event initiated by this vehicle traveling over edge of roadway - unknown which edge
7 % Critical event initiated by this vehicle encroaching into another vehicle's lane, at junction entering driveway, alley access, etc.
10 % Critical event initiated by this vehicle encroaching into another vehicle's lane, at junction from driveway, alley access, etc. intended path unknown
8 % This vehicle initiated critical event - details unknown
17 % Other
6 % Unknown
Precrash3:
84 % No corrective action
3 % Backed
3 % Accelerated
1 % Braked or slowed
9 % Unknown
Precrash4:
84 % No corrective action
2 % Control maintained
1 % Vehicle rotated
13 % Unknown

Precrash 5:
84 % No corrective action
6 % Vehicle departed roadway
9 % Unknown
Speed:
11% 5 MPH
3 % 10MPH
5% 15MPH
79 % Unknown
Initial Point of Impact:
5 % Front
6 % Right side
4 % Left side
75 % Back
3 % Undercarriage
2 % Front left corner
3 % Back Left Corner
Accident Type:
95 % Backing
2 % Left roadside departure, control/traction loss
3 % Other
Damage Area:
22 % No damage
10 % Front and somewhere else
12 % Right side and somewhere else
10 % Left side and somewhere else
23 % Back and somewhere else
8 % Top
2 % Undercarriage
1 % All areas damaged
12 % Unknown
Interstate Highway:
100 % No
Land Use:
11 % Area population 25,000 to 50,000
9 % Area population 50,000 to 100,000
31 % Area population 100,000 plus
48 % Other area
1 % Unknown
Roadway Alignment:
96 % Straight
4 % Curve

Roadway Surface Condition:
85 % Dry
15 % Wet
Roadway Profile:
72 % Level
26 % Grade
2 % Hillcrest
Light Condition:
60 % Daylight
11 % Dark
27 % Dark but lighted
1 % Dawn
1 % Dusk
Atmospheric Conditions:
90 % No adverse atmospheric conditions
10 % Rain
Number of Travel Lanes:
7 % One
36 % Two
1 % Three
4 % Four
52 % Unknown
Trafficway Flow:
26 % Two-way trafficway (not physically divided)
4 % Divided highway
70 % Unknown
Speed Limit:
45 % 25 MPH or less
30 % 30 or 35 MPH
9 % 40 or 45 MPH
15 % 50 or 55 MPH
Body Type (5 major types):
25 % 2-door sedan, hardtop, coupe
15 % Unknown automobile type
15 % Unknown type pickup truck
15 % 4-door sedan, hardtop
9 % Unknown type of medium/heavy truck
Vehicle Defects:
84 % None
1 % Brake failure
1 % Other
15 % Unknown

Driver’s Sex:

68 % Male
32 % Female

Driver’s Age:

20 % 21 or less
18 % 22 to 30
28 % 31 to 40
17 % 41 to 50
11 % 51 to 65
6 % over 65

Driver Impairment:

82 % None
2 % Ill, blackout
1 % Other
15 % Unknown

Driver Iniury Severity:

93 % None (0)
6 % Possible injury (C)
1 % Incapacitating injury (A)%

Driver Restraint System Use:

22 % None
43 % Restraint system used
35 % Unknown

Driver Violations Charged:

46 % None
11 % Alcohol or drugs
3 % Reckless driving
1 % Failure to yield right-of-way
18 % Hit and run (no information)
21 % Other violations

Driver’s Drug Involvement:

81 % Drugs Not Involved
3 % Drugs Involved
16 % Unknown

A.3 Two-Vehicle Backing Crashes from the GES

A.3.1 Segregating the Two-Vehicle Backing Crashes from the GES

A two-vehicle backing crash involves two motor vehicles in transport.

The following steps are guide the construction of the data set BACK from the data set GES.GES92:

> First, the observations to be examined are identified as those in which the first harmful event is a collision between two motor vehicles in transport.
>
> Then, the records for which "person type = l", implying that the driver is present, are chosen.

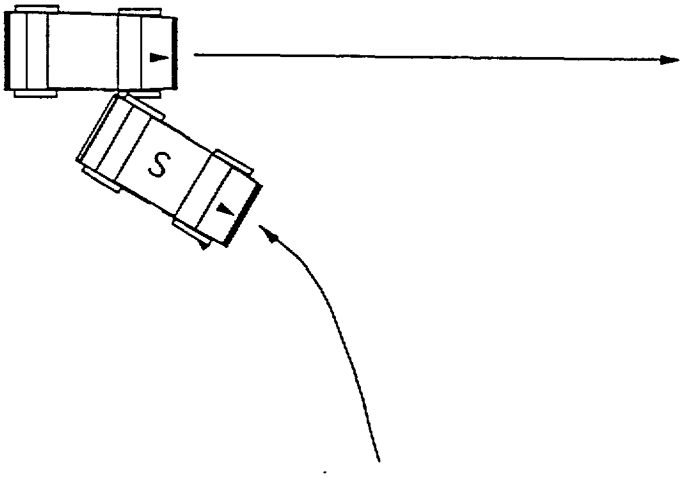
The resulting data set BACK now contains two observations for each case number, one observation corresponding to each driver.

The data set BACKS is constructed from data set BACK by combining the information from both observations, so that now each case number is represented by only one entry into BACKS but the total information content is preserved. Each observation in set BACKS contains 185 variables. In addition, BACKS is constructed so that vehicle 1 is always the striking vehicle and vehicle 2 is always the struck vehicle. Cases in which a vehicle is identified as both striking and struck or in which both vehicles are identified as striking are automatically deleted. This should not cause difficulties for cases involving only two vehicles. All the subsets BACKx discussed below (x is the scenario number) are derived directly from this set BACKS by sorting using the criteria for each of the two-vehicle backing crash categories.

As in the study of lane change/merge crashes, the final character. in each variable name in data set BACKS identifies the vehicle represented by that character. For example, PCRASHll is the Precrashl variable for vehicle 1 and PCRASH12 is the Precrashl variable for vehicle 2. (Names may metamorphosize slightly at times but generally are preserved in spirit.)

A.3.2 Two-Vehicle Backing Crash Descriptive Statistics

BACKING AND STRIKING: 101,728 GES Weighted (464 Observations)



BACK3: The vehicle which is backing strikes another motor vehicle in transport.

EVENT1_I = 25 (collision with motor vehicle in transport)
and
{PCRASH11 = 13 (backing other than parking)
or
ACCTYPE1 = 92 (backing crash)}

The following conditions are required to remain as general as possible while excluding members of the dataset BACK5.

SPEED2 > 0 OR RELJCT1 = 0 OR (3 ≤ RELJCT1 ≤ 4) OR RELJCT1 > 5 OR TRFCON1 = 0

ACCIDENT VARIABLES

Relation to Junction:
34 % Non-junction
14 % Intersection
6 % Intersection related
45 % Driveway, alley access, etc.

Traffic Control:
87 % None
15 % Traffic control signal on colors
7 % Stop sign

Manner of Collision:
25 % Rear-End (front-to-rear)
68 % Angle and sideswipe, same direction
7 % Other

Alcohol Involvement:
2 % Yes
98 % No

Interstate Highway:
100 % No

Maximum Injury Severity:
94 % None (0)
4 % Possible injury (C)
2 % Nonincapacitating evident injury (B)

Land Use:
6 % Area population 25,000 to 50,000
11 % Area population 50,000 to 100,000
26 % Area population 100,000 plus
53 % Other area
4 % Unknown

Roadway Alignment:
97 % Straight
3 % Curve

Roadway Surface Condition:
83 % Dry
14 % Wet
2 % Ice or snow/ice combined
1 % Other

Roadway Profile:
77 % Level
21 % Grade
1 % Hillcrest

Light Condition:
86 % Daylight
4 % Dark
8 % Dark but lighted
1 % Dawn
1 % Dusk

Atmospheric Conditions:
89 % No adverse atmospheric conditions
10 % Rain
1 % Fog

Number of Travel Lanes:
4 % One
49 % Two
4 % Three
5 % Four
2 % Five
1 % Six
35 % Unknown

Trafficway Flow:
64 % Two-way trafficway (not physically divided)
4 % Divided highway
2 % One-way trafficway
31 % Unknown

Speed Limit:
53 % 25 MPH or less
32 % 30 or 35 MPH
6 % 40 or 45 MPH
9 % 50 or 55 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
7 % Hit and Run	0 % Hit and Run
92 % No avoidance maneuver	98 % No avoidance maneuver
	1 % Vehicle in road
1 % Unknown	1 % Unknown
Driver's Vision Obscured bv:	
86 % Not obscured	97 % Not obscured
7 % Hit and Run	0 % Hit and Run
1 % Parked vehicle	
2 % Other - no specifics	
3 % Unknown	2 % Unknown
Driver distracted bv:	
91 % Not distracted	99 % Not distracted
7 % Hit and Run	0 % Hit and Run
1 % Unknown	1% Unknown
Precrash 1:	
68 % Backing(not for parking)	50 % Going straight
1 % Entering a parked position	33 % Stopped in traffic lane
4 % Leaving a parked position	5 % Turning left
27 % Other	3 % Other

Precrash2 (critical event):	
28 % Critical event initiated by this vehicle encroaching into another vehicle's lane from driveway, alley etc-intended path unknown	Critical event initiated by other vehicle already in this vehicle's lane: 18 % traveling in opposite direction (backing?). 10 % traveling, higher speed.
Critical event initiated by this this vehicle in another vehicle's lane traveling: 17 % in opposite direction. 11 % in same direction, higher speed. 12 % Critical event initiated by this vehicle encroaching into another vehicle's lane at non-junction from parallel/diagonal parking lane	Critical event initiated by other vehicle encroaching into this vehicle's lane: 22 % at junction from driveway, alley - intended path unknown. 13 % at non-junction from parallel/diagonal parking lane
Precrash3:	
95 % No corrective action 2 % Backed 3 % Unknown	96 % No corrective action 1 % Braked/slowed 2 % Unknown
Precrash4:	
95 % No corrective action 2 % Control maintained 3 % Unknown	96 % No corrective action 2 % Control maintained 2 % Unknown
Precrash5:	
95 % No corrective action 2 % Remained in same travel lane	96 % No corrective action 2 % Remained in same travel lane 1 % Stayed on roadway but unknown if left travel lane
3 % Unknown vehicle path	2 % Unknown vehicle path
Speed:	
4% 2MPH 5% 3MPH 17% 5MPH 5% 10 MPH 63% Unknown	32 % 0 MPH (stopped) 6% 5 MPH 4% 10 MPH 43 % Unknown

Accident Type:

99 % Backing crash-striking	99 % Backing crash-struck
1 % Backing - other	1% Backing - other

Damage Severity:

16 % None	2% None
49 % Minor	52 % Minor
12 % Functional	20 % Functional
1 % Disabling	4% Disabling
23 % Unknown	22 % Unknown

Initial Point of Impact:

71 % Back	30 % Front
8 % Back right corner	32 % Right side
8 % Back left corner	24 % Left side
7 % Right side	4% Back right corner
3 % Left side	4% Back left corner
1 % Front right side	2% Back
1 % Front left side	3% Front right corner
	1% Front left corner

Vehicle STYLE:

89 % Cars, light trucks, vans	97 % Cars, light trucks, vans
4 % Trailering trucks	1% Trailering trucks
5 % Straight trucks	0% Straight trucks

Damage Area:

16 % No damage	2% No damage
3 % Front and other	36 % Front and other
17 % Right side and other	33 % Right side and other
15 % Left side and other	24 % Left side and other
40 % Back	1% Back and other
9 % Unknown	3% Unknown

Body Type (major types):

22 %	Unknown automobile type	31 %
14 %	4-door sedan, hardtop	23 %
14 %	2-door sedan, hardtop, coupe	17 %
8%	Unknown van type	4%
8%	Unknown type pickup truck	5%

Vehicle Defects:

90 %	None	96 %
1%	Brake failure	
1%	0 ther	
9%	Unknown (includes hit and run)	3 %

Driver's Sex:

66 %	Male	50%
34 %	Female	50 %

Driver's Age:

18 %	21 or less	16 %
23 %	22 to 30	22 %
22 %	31 to 40	23 %
14 %	41 to 50	17 %
15 %	51 to 65	12 %
8%	over 65	11 %

Driver Impairment:

92 %	None	100 %
7%	Unknown	

Driver Iniury Severity:

99 %	None (0)	96 %
1%	Possible injury (C)	3%
	Nonincapacitating evident injury (B)	1 %

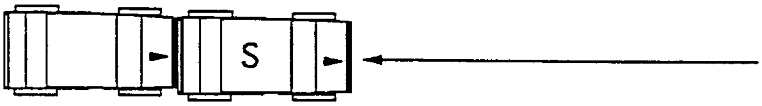
Driver Restraint System Use:

10 %	None	8%
63 %	Restraint system used	74 %
27 %	Unknown	18 %

Driver Violations Charged.

58 %	None	97 %
5%	Failure to yield right-of-way	
6%	Hit and run (no information)	
30 %	Other violations	3 %

BACKING & STRIKING A PARALLEL PATH VEHICLE: 25,920 GES Weighted
(124 Observations)



BACK5: The vehicle which is backing strikes another motor vehicle in transport stopped behind it. The crash occurs at or near a controlled intersection or a railroad crossing.

{PCRASH11 = 13 (backing other than parking)
or
ACCTYPE1 = 92 (backing crash)}
and the following,
EVENT1_I = 25 (striking a motor vehicle in transport)
$1 \leq$ PCRASH12 ≤ 4 (going straight, starting or slowing or stopping or stopped in traffic lane)
SPEED2 = 0
RELJCT1 = 1, 2 OR 5 (intersection, intersection related or railroad crossing)
TRFCON1 > 0 (There exists some kind of control signal or sign.)

ACCIDENT VARIABLES
Relation to Junction:
35 % Intersection
63 % Intersection related
2 % Railroad crossing
Traffic Control:
52 % Traffic control signal on colors
36 % Stop sign
2 % Active device at RR crossing
1 % Passive device at RR crossing
9 % Other devices

Manner of Collision:
80 % Rear-End
16 % Angle
4 % Other
Alcohol Involvement:
4 % Yes
96 % No
Interstate Highway:
100 % No
Maximum Injury Severity:
94 % None (0)
5 % Possible injury (C)
1 % Incapacitating injury (A)
Land Use:
7 % Area population 25,000 to 50,000
20 % Area population 50,000 to 100,000
36 % Area population 100,000 plus
37 % Other area
Roadway Alignment:
98 % Straight
2 % Curve
Roadway Surface Condition:
83 % Dry
13 % Wet
1 % Snow or slush
2 % Ice or snow/ice combined
Roadway Profile:
72 % Level
26 % Grade
1 % Hillcrest
1 % Other
Light Condition:
80 % Daylight
3 % Dark
15 % Dark but lighted
1 % Dusk
Atmospheric Conditions:
92 % No adverse atmospheric conditions
8 % Rain

Number of Travel Lanes:
1% One
38 % Two
7 % Three
10 % Four
6 % Five
1 % Six
2 % Seven
34 % Unknown

Trafficway Flow:
61 % Two-way trafficway (not physically divided)
12 % Divided highway
3 % One-way trafficway
25 % Unknown

Speed Limit:
38 % 25 MPH or less
35 % 30 or 35 MPH
23 % 40 or 45 MPH
3 % 55 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
13 % Hit and Run	2 % Hit and Run
86 % No avoidance maneuver	98 % No avoidance maneuver
1 % Unknown	
Driver's Vision Obscured by:	
80 % Not obscured	98 % Not obscured
13 % Hit and Run	2 % Hit and Run
1 % Moving vehicle	
3 % No specifics	
3 % Unknown	
Driver Distracted by:	
85 % Not distracted	98 % Not distracted
13 % Hit and Run	2 % Hit and Run
1 % Unknown	
Precrash 1:	
80 % Backing(not for parking)	100% Stopped in traffic lane
19 % Exiting to the roadway from private property	
2 % Leaving a parked position	

Precrash2 (critical event):

Critical event initiated by this vehicle in another vehicle's lane:
22 % traveling in same direction with higher speed.
50 % traveling in opposite direction.

Critical event initiated by this vehicle encroaching into another vehicle's lane at non-junction:
4 % from parallel/diagonal parking lane.

9 % Miscellaneous other event.

7 % Critical event initiated by this vehicle stopped in another vehicle's lane

Critical event initiated by other vehicle already in this vehicle's lane:
5 % traveling in same direction with lower speed.
19 % traveling in same direction at higher speed.
52 % traveling in opposite direction.
4 % Critical event initiated by other vehicle encroaching from parking lane.

I

Precrash3:

95 % No corrective action
1 % Backed
4 % Unknown

100% No corrective action

Precrash4:

95 % No corrective action
1 % Control maintained
4 % Unknown

100% No corrective action

Precrash5:

95 % No corrective action
1 % Remained in same travel lane
4 % Unknown vehicle path

100 % No corrective action

Speed:

3 % 1MPH
6% 2MPH
9% 3MPH
15% 5MPH
64 % Unknown

100% 0 MPH (stopped) (Condition of sorting)

Accident type

100% Backing crash-striking

100% Backing crash-struck

Damage Severity:

32 % None	2 % None
36 % Minor	42 % Minor
7 % Functional	28 % Functional
0 % Disabling	3 % Disabling
26 % Unknown	25 % Unknown

Initial Point of Impact:

94 % Back	84 % Front
1 % Back right corner	6 % Right side
3 % Back left corner	8 % Left side
2 % Left side	1 % Front right corner
	1 % Front left corner

Vehicle STYLE:

80 % Cars, light trucks, vans	100% Cars, light trucks, vans
8 % Trailering trucks	
8 % Straight trucks	

Damage Area

34 % No damage	2 % No damage
0 % Front and other	83 % Front and other
2 % Right side and other	6 % Right side and other
4 % Left side and other	7 % Left side and other
48 % Back	0 % Back
14 % Unknown	1 % Unknown

Body Type (5 maior types):

12 %	Unknown automobile type	19 %
10 %	4-door sedan, hardtop	24 %
	2-door sedan, hardtop, coupe	27 %
10 %	Unknown van type	
12 %	Unknown type pickup truck	6%
10 %	Large pickup truck	
	Compact pickup truck	5%

Vehicle Defects:

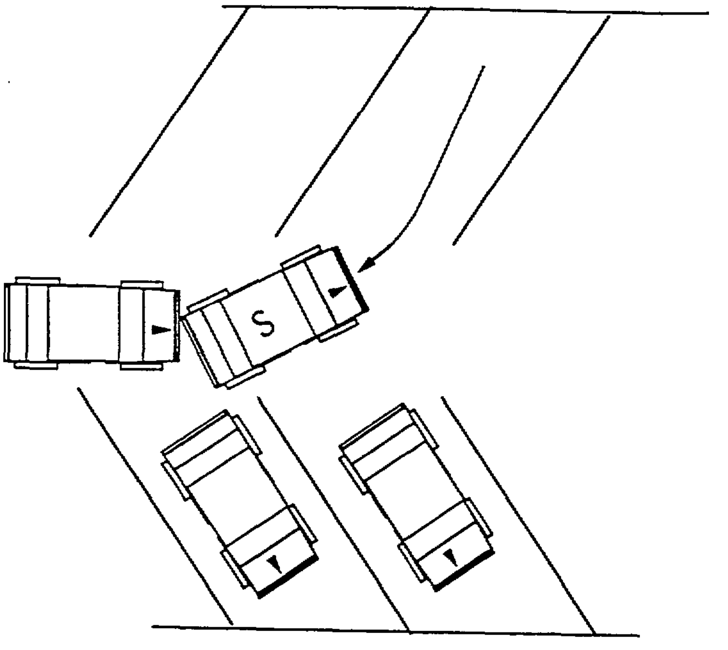
90 %	None	94%
1%	Other lights	
1%	Other	
9%	Unknown	6%

Driver's Sex:

74 %	Male	53 %
26 %	Female	47 %

Driver's 'Age:		
13 %	21 or less	17 %
27 %	22 to 30	25 %
28 %	31 to 40	28 %
11 %	41 to 50	17 %
9%	51 to 65	12 %
13 %	over 65	
Driver Impairment:		
89 %	None	99 %
11 %	Unknown	1%
Driver Injury Severity:		
100 %	None (0)	94 %
	Possible injury (C)	5%
	Incapacitating injury (A)	1%
Driver Restraint Svstem Use:		
99 %	None	99 %
99 %	Restraint system used	99 %
99 %	Unknown	99 %
Driver Violations Charged:		
48 %	None	94 %
2%	Alcohol or drugs	
1%	Failure to yield right-of-way	
12 %	Hit and run (no information)	
37 %	0 ther violations	6%

LEAVING A PARKING SPACE: 4,500 GES Weighted
(CAUTION! 14 Observations)



BACK6: The vehicle which is backing out of a parking place strikes another motor vehicle in transport.

EVENTl-I = 25 (collision with motor vehicle in transport), and
ACCTYPE = 92 (backing crash), and
PCRASHl = 7 (leaving a parked position)

ACCIDENT VARIABLES
Relation to Junction:
74 % Non-junction
21 % Intersection related
6 % Driveway, alley access, etc.
Traffic Control:
91 % None
9 % Stop sign
Manner of Collision:
94 % Angle
6 % Sideswipe, same direction
Alcohol Involvement:
100% No

Interstate Highway:
100 % No
Maximum Injury Severity:
100 % None (0)
Land Use:
18 % Area population 50,000 to 100,000
82 % Other area
Roadway Alignment:
100 % Straight
Roadway Surface Condition:
94 % Dry
6 % Ice or snow/ice combined
Roadway Profile:
91 % Level
9 % Grade
Light Condition:
100 % Daylight
Atmospheric Conditions:
100 % No adverse atmospheric conditions
Number of Travel Lanes:
12 % Two
15 % Four
73 % Unknown
Trafficway Flow:
88 % Two-way trafficway (not physically divided)
12 % Unknown
Speed Limit:
78 % 25 MPH
22 % 30 or 35 MPH

VEHICLE VARIABLES

Striking Vehicle:	Struck Vehicle:
Driver Maneuvered to Avoid:	
100% No avoidance maneuver	100% No avoidance maneuver
Driver's Vision Obscured by:	
80 % Not obscured	100% Not obscured
7 % Parked Vehicle	
6 % Vision obscured-no details	
7 % Other obstruction	
Driver Distracted bv:	
100% Not distracted	100% Not distracted

Precrash 1:	100% Leaving a parked position	57 % Going straight 27 % Stopped in traffic lane 15 % Entering a parked position
Precrash2 (critical event):	6 % Critical event initiated by this vehicle encroaching into another vehicle's lane from driveway, alley etc-intended path unknown. 8 % Critical event initiated by this vehicle in another vehicle's Iane traveling in opposite direction. Critical event initiated by this vehicle encroaching into another vehicle's lane at non-junction 12 % from adjacent lane (same direction) over left lane line. 68 % from parallel/diagonal parking lane.	8 % Critical event initiated by other vehicle already in this vehicle's lane: traveling in opposite direction. Critical event initiated by other vehicle encroaching into this vehicle's lane at non-junction: 6 % from adjacent lane (same direction) over left lane line 6 % from adjacent lane (same direction) over right lane line. 75 % from parallel/diagonal parking lane. 6% from driveway, alley access-intended path unknown.
Precrash3:	100% No corrective action	100% No corrective action
Precrash4:	100% No corrective action	100% No corrective action
Precrash5:	100 % No corrective action	100 % No corrective action
Speed:	7% 2MPH 18% 5MPH 75 % Unknown	27 % 0 MPH (stopped) 6 % 5 MPH 15 % 10 MPH 9 % 18 MPH 43 % Unknown

Accident type:

100% Backing crash-striking	100% Backing crash-struck

Damage Severity:

29 % None	0 % None
32 % Minor	36 % Minor
0 % Functional	7 % Functional
9 % Disabling	6 % Disabling
30 % Unknown	52 % Unknown

Initial Point of Impact:

41 % Back	6 % Front
9 % Back right corner	67 % Right side
14 % Back left corner	21 % Left side
23 % Left side	6 % Back right corner
14 % Front left corner	

Vehicle STYLE:

100% Cars, light trucks, vans	94 % Cars, light trucks, vans
0 % Trailering trucks	6 % Trailering trucks

Damage Area:

29 % No damage	0 % No damage
9 % Front and other	6 % Front and other
0 % Right side and other	72 % Right side and other
37 % Left side and other	14 % Left side and other
18 % Back	0 % Back
8 % Unknown	8 % Unknown

Body Type (5 maior types):

23 %	Unknown automobile type	21 %
8%	4-door sedan, hardtop	34 %
12 %	2-door sedan, hardtop, coupe	21 %
35 %	Unknown van type	9%
9%	Unknown type pickup truck	9%
8%	Station wagon	

Vehicle Defects:

100 %	None	100 %

Driver's Sex:

56 %	Male	56 %
44 %	Female	44 %

Driver's Age:

31 %	21 or less	15 %
12 %	22 to 30	17 %
24 %	31 to 40	22 %
13 %	41 to 50	9%
6 %	51 to 65	26 %
14 %	over 65	12 %

Driver Impairment:

100 %	None	100 %

Driver Iniury Severity:

100 %	None (0)	100 %

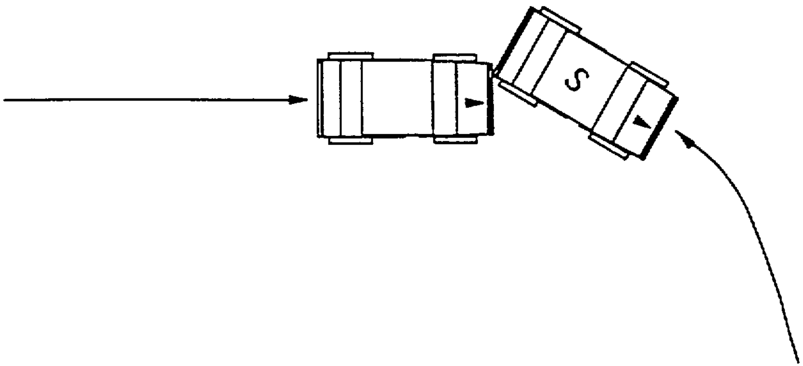
Driver Restraint System Use:

21 %	None	17 %
68 %	Restraint system used	71 %
11 %	Unknown	12 %

Driver Violations Charged:

77 %	None	91 %
23 %	Other violations	9%

BACKING AND STRUCK: 14,529 GES Weighted (106 Observations)



BACK7: The vehicle which is backing is struck by another motor vehicle in transport.

EVENT1_I = 25 (collision with motor vehicle in transport), and
{PCRASH12 = 13 (backing other than parking) or
ACCTYPE2 = 92 (backing crash)}

ACCIDENT VARIABLES

Relation to Junction:
23 % Non-junction
9 % Intersection
2 % Intersection related
65 % Driveway, alley access, etc.

Traffic Control:
96 % None
3 % Traffic control signal on colors
1 % Stop sign

Manner of Collision:
12 % Rear-End
4 % Head-on
84 % Angle

Alcohol Involvement:
3 % Yes
97 % No

Interstate Highway:
100 % No
Maximum Injury Severity:
73 % None (0)
13 % Possible injury (C)
11 % Nonincapacitating evident injury (B)
4 % Incapacitating injury (A)
Land Use:
2 % Area population 25,000 to 50,000
6 % Area population 50,000 to 100,000
29 % Area population 100,000 plus
60 % Other area
4 % Unknown
Roadway Alignment:
93 % Straight
7 % Curved
Roadway Surface Condition:
75 % Dry
16 % Wet
9 % Ice or snow/ice combined
Roadway Profile:
74 % Level
19 % Grade
7 % Hillcrest
Light Condition:
63 % Daylight
9 % Dark
24 % Dark but lighted
4 % Dawn
1 % Dusk
Atmospheric Conditions:
90 % No adverse atmospheric conditions
10 % Rain
Number of Travel Lanes:
58 % Two
1 % Three
8 % Four
6 % Five
27 % Unknown
Trafficway Flow:
64 % Two-way trafficway (not physically divided)
4 % Divided highway
32 % Unknown

Speed Limit:
38 % 25 MPH or less
32 % 30 or 35 MPH
16 % 40 or 45 MPH
15 % 50 or 55 MPH

VEHICLE VARIABLES

Striking Vehicle:

Driver Maneuvered to Avoid:
6 % Hit and Run
94 % No avoidance maneuver

Driver's Vision Obscured by:
93 % Not obscured
6 % Hit and Run
1 % Curve or hill

Driver Distracted by:
91 % Not distracted
6 % Hit and Run
2 % Other external distractions

Precrash 1:
73 % Going straight
5 % Turning right
7 % Backing (not parking)
3 % Negotiating a curve
11 % Other-entering a roadway from driveway, etc.

Precrash2 (critical event):
6 % Critical event initiated by this vehicle in another vehicle's lane (opposite direction).
Critical event initiated by other vehicle in this vehicle's lane at junction:
8 % encroaching entering driveway, alley access.
36 % encroaching from driveway, alley access, etc.-intended path unknown. encroaching at junction entering driveway, alley access.

Struck Vehicle:

2 % Vehicle in road
98 % No avoidance maneuver

100% Not obscured

100% Not distracted

55 % Backing (not parking)
41 % Other - entering a roadway from driveway, etc.
2 % Leaving a parked position
2 % Entering a parked position

Critical event initiated by this vehicle encroaching into another vehicle's lane:
8 % at non-junction, from parallel/diagonal parking lane.
8 % at junction, entering driveway, alley, etc.
35 % at junction, from driveway, alley access, etc.-intended path unknown.
7 % traveling in opposite direction.

Precrash2 (continued):	
Critical event initiated by other vehicle in this vehicle's lane at non-junction:	6 % Critical event initiated by other vehicle already in this vehicle's lane traveling in the opposite direction.
7 % traveling in opposite direction.	
9 % encroaching from parallel/ diagonal parking lane.	
Precrash3:	
82 % No corrective action	90 % No corrective action
7 % Braked/slowed	8 % Backed
3 % Steered to right	
4 % Unknown	2 % Unknown
Precrash4:	
82 % No corrective action	90 % No corrective action
7 % Control maintained	8 % Control maintained
5 % Longitudinal slide/skid	
1 % Other	
6 % Unknown	2 % Unknown
Precrash5:	
82 % No corrective action	90 % No corrective action
9 % Remained in same travel lane	8 % Remained in same travel lane
2 % Stayed on roadway but left travel lane	
1 % Stayed on roadway but unknown if left travel lane	
3 % Vehicle departed roadway	
4 % Unknown vehicle path	2 % Unknown vehicle path
Speed:	
5 % 25 MPH	7 % 5 MPH
8 % 35 MPH	4 % 10 MPH
4 % 45 MPH	
5 % 50 MPH	
67 % Unknown	82 % Unknown
Accident Type:	
12 % Backing crash-striking	85 % Backing crash-striking
85 % Backing crash-struck	12 % Backing crash-struck
3 % Backing - other	3 % Backing - other

Damage Severity:

4 % None	0 % None
28 % Minor	36 % Minor
28 % Functional	28 % Functional
13 % Disabling	9 % Disabling
27 % Unknown	26 % Unknown

Initial Point of Impact:

2 % Non-collision	9 % Front
53 % Front	44 % Right side
7 % Right side	18 % Left side
9 % Left side	15 % Back
9 % Back	2 % Top
7 % Front right corner	4 % Front right corner
8 % Front left corner	5 % Back right corner
2 % Back right corner	3 % Back left corner
3 % Back left corner	

Vehicle STYLE:

97 % Cars, light trucks, vans	91 % Cars, light trucks, vans
	4 % Trailering trucks
	5 % Straight trucks

Damage Area:

4 % No damage	0 % No damage
67 % Front and other	18 % Front and other
10 % Right side and other	45 % Right side and other
9 % Left side and other	21 % Left side and other
4% Back	7 % Back
5 % Unknown	2 % Top
	6 % Unknown

Body Type (major types):

31 %	Unknown automobile type	20 %
18 %	4-door sedan, hardtop	22 %
20 %	2-door sedan, hardtop, coupe	9 %
5 %	Unknown type pickup truck	10 %
6 %	3-door/2-door hatchback	
5 %	Large pickup truck	8%

Vehicle Defects:

94 %	None	96 %
	Power train	1%
6 %	Unknown	4%

Driver's Sex:

56 %	Male	63 %
44 %	Female	37 %

Driver's Age:		
28 %	21 or less	18 %
24 %	22 to 30	27 %
15 %	31 to 40	14 %
14 %	41 to 50	20 %
16 %	51 to 65	12 %
4%	over 65	9%
Driver Impairment:		
96 %	None	100%
4 %	Unknown	
Driver Injury Severity:		
85 %	None (0)	84 %
8%	Possible injury (C)	10 %
5%	Nonincapacitating evident injury (B)	5%
2%	Incapacitating injury (A)	1%
Driver Restraint System Use:		
13 %	None	13 %
57 %	Restraint system used	65 %
30 %	Unknown	22 %
Driver Violations Charged:		
83 %	None	67 %
	Alcohol or drugs	1%
1%	Speeding	
	Failure to yield right-of-way	5%
5%	Hit and run (no information)	
10 %	Other violations	27 %

APPENDIX B: Various Forms Generated during the Hard Copy Analyses.

Form 1: CDS Input Variable Form for Lane Change/Merge Crashes

Case Number: ______________ Number of Vehicles: _________

Case Weight: ______________

Definitions:
Unk = Unknown
LCM VEHICLE = vehicle which was changing lanes/merging

In this case, the LCM vehicle is V-.
There are — GENERAL VEHICLE FORMS.

From the CASE SUMMARY, please describe the accident sequence and sketch the ACCIDENT COLLISION DIAGRAM below. Include VEHICLE VELOCITIES, weather, light conditions, road curvature or contour and any other condition contributing to the collision.

After reading through the case, which of the 8 lane change/merge categories does this case fall into ? _______________

Was the LCM vehicle a _________ principal
or _________ bystander in the accident?

Was the LCM vehicle ________ changing lanes
or ________ merging?

Was the LCM vehicle ________ "striking"? (NOTE: This may require
or ________ "struck"? a judgment from
or ________ "not clear which"? investigator.)
Comments:

Was either the LCM vehicle or driver rendered ineffective?
If yes, in what way?

Was the LCM driver avoiding another crash? — Yes — No ---Unk

When did LCM driver first detect the possibility of a crash?

Was a blind spot involved? _____ Yes ___NO___ _____ Unknown

Would an LCM CAS have prevented the crash? — Yes — No — Unk

The following are taken from GENERAL VEHICLE FORMS:

Did the LCM driver try to avoid? pg. 1, item 14
— Yes — No — Unknown

Accident Type: pg. 1, item 15
Accident type assigned LCM vehicle ________
Accident type assigned other vehicle ________

Orientations: pg. 2, items 27 and 28
Heading for LCM vehicle ________
Heading for other vehicle ________
Remainder vehicle headings (as required) ________

Computer crash reconstruction: pg.3, items 29 to 34
Computation Method: — CRASH (damage only routine)
— CRASH (damage and trajectory routines)
— Other

Total Delta V:
LCM vehicle ________
Other vehicle ________

Longitudinal Component of Delta V:
LCM vehicle ________
Other vehicle ________

Lateral Component of Delta V:
LCM vehicle ________
Other vehicle ________

Energy absorption (100 ft-Ibs):
LCM vehicle ________ Other vehicle __________

Confidence Level in Reconstruction Program Results: _______

Drugs/Alcohol involvement: pg. 4, items 37 to 39

Was drug involvement suspected or tested for ? ____________
Results? ____________________

++

From looking at the EXTERIOR VEHICLE FORMS, where is the initial point of impact

on the LCM vehicle? ______________________________
on the other vehicle? ____________________________
Comments:

____

From looking at the INTERVIEW FORMS and/or UPDATE FORMS, what are the most important factors with respect to crash avoidance system effectiveness in this case?

____

From looking at the OCCUPANT ASSESSMENT FORMS, was anyone hurt?

Comments:

CASENUM									
CONFIG									
ES1									
ES2									
α									
PS									
NSE									
NSV									
NSD									
V1 AGE/SEX									
V2 AGE/SEX									
V1 IMPACT									
V2 IMPACT									
V1 TYPE									
V2 TYPE									
CITATION 1									
CITATION 2									
LOCATION									
RESPONSIVE?									
(TO CAS)									

CONFIG: designates relative orientation of vehicles
ES1, ES2: estimated speeds, vehicle 1 and vehicle 2
α: angle specified in CONFIG to give more precise orientation
PS: posted speed limit
NSE: exception to "standard environment" which is clear, dry, daylight, straight and flat (level).
NSV: exception to "standard vehicle" or defect noted.
NSD: exception to "standard driver" or impairment or mention/citation of drugs or alcohol
V1 AGE/SEX, V2 AGE/SEX: age and sex of drivers of vehicle 1 an[d 2]
V1 IMPACT, V2 IMPACT: point of impact on vehicles 1 and 2
V1 TYPE, V2 TYPE: body type of vehicles 1 and 2
CITATION1, CITATION2: any citations issued
LOCATION: for example, ON ROAD, DRIVEWAY, ALLEY, SHOULDER, e[tc.]