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SIDE IMPACTS OF PASSENGER CARS: AN ANALYSIS OF FARS & NCSS DATA

Robert E. Scott
James O'Day
Wendell Young

APRIL 1981

THE UNIVERSITY OF MICHIGAN
HIGHWAY SAFETY RESEARCH INSTITUTE

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by

Robert E. Scott
and
James O'Day

University of Michigan
Highway Safety Research Institute

Ann Arbor, Michigan

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16. Abstract

This report is one of a series devoted to the subject of side impacts as observed in several sets of available accident data. In this report, major use is made of both the Fatal Accident Reporting System (FARS) and the National Crash Severity Study (NCSS) to estimate the frequency and severity of side impacts to passenger cars.

The report discusses side impacts of passenger cars with respect to where, when, how, and why they occur. Many comparisons are presented between side impacts and all other collision types, and between single- and multi-vehicle side collisions.

Side impacts of passenger cars produce higher injury rates than do other impacts. Car-to-car side-impact crashes account for only one-third of all serious injuries and fatalities in side-impacts; the remainder occur in collisions with fixed objects or large vehicles. Occupant ejection in side impacts is relatively frequent, and highly associated with injury and fatality.

Selected fatal side-impact accidents reported in the NCSS program are clinically reviewed and presented in the appendix.

Side impacts resulting in serious injury are a diverse group of crashes that are not easily represented by a single test configuration.

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Summary

This report is devoted to the subject of side impacts to passenger cars as observed in the Fatal Accident Reporting System (FARS) for 1979, and the first phase of the National Crash Severity Study (NCSS), both by the National Highway Traffic Safety Administration.

The report is intended to describe the phenomena of side impact with resect to where, when, how, and why they occur. To a limited extent, the characteristics of occupants of side-impacted vehicles and their injury consequences are reported. The distributions observed in the two national data sets should serve as a basis for considering methods of reducing injury to occupants of side-impacted cars, and for judging the appropriateness of vehicle design modifications and associated tests.

The total number of occupants killed on side-impacted cars in 1979 was 5,930, or 24.8% of all passenger-car occupants. Of these, 30.4% were killed in single-vehicle accidents. Of all passenger car occupants in the NCSS data, 1.4% were injured at the AIS-4 level or greater. 32.3% of such injuries were to occupants of side-impacted cars. Of the occupants of side-impacted cars with an AIS of 4 or greater, 34.3% were in cars struck by another car. 46.1% were in fixed object crashes or collisions with heavy trucks or buses. The results for the side impact fatalities in FARS are similar, with 30.8% from impacts with other passenger cars, and 50.0% from single-vehicle accidents or impacts with heavy trucks or buses.

Among fatally injured occupants in side impacts reported in FARS, 15.5% were ejectees. For those in single-vehicle accidents, 22.5% were ejected; in multi-vehicle accidents 12.5% were ejected. Corresponding figures for seriously injured (AIS = 4+) occupants in the NCSS data are 26.8%, 39.1%, and 21.9% respectively. 78.6% of all side-impacted fatal ejections in the NCSS data were occupants of cars in single-vehicle crashes, or those struck by large trucks or railroad trains. In such crashes, 44% of all fatalities were ejections even though only 4.3% of the occupants of such crashes were ejected.

Tests which effectively simulate side collisions between passenger cars would not address the bulk of the ejection problem. Collisions with other passenger cars account for only 32.3% of the ejections in side impact, and only 19.0% of the fatal ejections in the NCSS data. Single-vehicle accidents account for 45.1% of all ejections and 47.6% of the fatal ejections. Impacts with large trucks provide another 21.4% of the fatal ejections.

While impacts involving only the front or rear of the side (and not the passenger compartment) account for 49% of the occupants in side impacts, they account for only 21% of the injuries of AIS-4 or greater. Occupants of cars with damage distributed from the front to the rear areas have the highest probability of sustaining AIS-4 or greater injuries; seven times as great as for occupants of vehicles struck in the side front or side rear. 2.3% of near-side occupants--those seated on the side which was impacted--received injuries of AIS-4 or greater, compared to only 1.4% for far-side occupants.

Nearly two thirds of the multi-vehicle side-impacts had impact force directions of either two or ten o'clock. Two thirds also had relative vehicle headings of ninety degrees, suggesting that the most common side-impact collision is a classical intersection accident with approximately equal vehicle velocities. Single vehicle impacts have dominate force directions of twelve and one o'clock for right-side impacts, and ten and eleven o'clock for left-side hits. Furthermore, there are more single-vehicle impacts to the right side than to the left side. This asymmetry of direction, together with the higher frequency of right-side impacts, presents a quandary as to the "best" configuration for testing the crashworthiness of passenger cars in side impacts.

Clinical reviews were conducted of 53 fatal side impacts with 64 fatalities. Extensive intrusion into the passenger compartment was common. In single-vehicle crashes, and also in two vehicle crashes with a large truck as the impacting vehicle, nearly half of the fatal occupants were ejected. By contrast , there was relatively little ejection in car-car crashes. a review of the relevance of restraints to the fatal injuries suggests that between 25% and 58% were relevant. The range of uncertainty of the potential benefit of restraints results from the substantial number of cases with injury data insufficient to make a judgement.

Conclusions

Side-impacted passenger cars are defined in this report as those cars for which the first impact involved direct damage to the right or left side. Rollovers constitute a small proportion of these, but they have been eliminated from the analysis presented here. The likelihood

of an occupant's receiving serious injury (at the level AIS-4 or greater) in a side-impact crash is about 40% greater than in all other crashes taken together. Twenty-three percent of all reported passenger car fatalities result from these side impacts.

Within the side-impact group, impacts by other passenger cars account for only one-third of the serious injuries and fatalities. Impacts with heavy trucks or fixed objects produce about half of such losses.

There is no single impact type or configuration of relative heading or impact force direction which represents a large fraction of the casualties in side impacts. Some identifiable groups are (1) single-vehicle impacts with a force vector direction of 1 or 11 o'clock (13% of the serious injuries and fatalities) and (2) impacts between passenger cars with a relative heading or 3 or 9 o'clock (21% of these casualties).

Occupant ejection from the vehicle involved in a side impact remains a substantial problem. Over 15% of the side-impact fatalities in FARS, and 27% of the AIS-4 and greater casualties in NCSS are ejections

The potential for increased use of current three-point restraints in preventing fatality cannot be determined precisely without much better reporting of the details of fatal injuries and their sources. A clinical review of NCSS fatal cases suggests, however, that no more than 58% and possibly as few as 25% of the fatalities would be prevented with universal restraint usage.

An observation that pervades the study is that side impacts resulting in serious injury are diverse crashes, and are not easily represented by a single test configuration. The proximate cause of injury in these cases is similarly diverse.

1.0 Introduction

This report is one of a series[1] devoted to the subject of side impacts as observed in several sets of available accident data. In the present report major use is made of both the Fatal Accident Reporting System (FARS) as prepared by the National Highway Traffic Safety Administration (NHTSA), and of the National Crash Severity Study (NCSS) from the same agency.

Analyses in this report are concentrated on side-impacted passenger cars, and include both statistical tabulations and case reviews. NCSS data from the first phase of that program only are used, indicated in the tables as "NCSS1". Later cases from Phase 2 NCSS include light trucks and vans as case vehicles, and these will be included in a subsequent report. FARS data from 1978 are considered an almost complete set of U. S. fatal traffic accidents, and as such present no inference difficulties. NCSS data, on the other hand, emanate from a judgment sample intended to represent the actual urban/rural mix of the U. S. towed passenger car accidents. NCSS distributions may be looked at as a surrogate for a national population of towaway passenger cars with some reservations. The problems of drawing inferences from the NCSS data are discussed in some detail in a report to NHTSA.[2]

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[1] FARS Data and Side Impact Collisions, J. O'Day and R. Kaplan, University of Michigan Report UM-HSRI-79-36, June 1979.

[2] Gimotty, P.A., Campbell, K. L., Chirachavala, T., Carsten, O., and O'Day, J. Statistical Analysis of the National Crash Severity Study Data, Final Report. HSRI, August 1980. Report No. UM-HSRI-80-38. Sponsored by the National Highway Traffic Safety Administration. Contract No. DOT-HS-8-01944.

This report is intended to describe the phenomenon of side impact of passenger cars with respect to where, when, how, and why they occur. To a limited extent the characteristics of persons involved in side-impact accidents will be reported, as well as the injury consequences of side-impact crashes. The distributions observed in these two national data sets should serve as a basis for considering methods of reducing injury to occupants of side-impacted cars, and for judging the appropriateness of vehicle design modifications and associated tests. One factor not included in the statistical presentations is the identification of injury-producing contacts to occupants of cars impacted in the side. This omission results from the relatively large proportion of missing data for this variable. In a detailed review of certain case reports the injury contacts were identified to the extent possible, and they are reported for certain individual cases in the appendix to this report.

1.1 Definition of Terms

Side-impacted vehicles are identified in the FARS data as those with "principal" damage in the side--coded as 2, 3, 4, or 8, 9, 10 o'clock in the FARS reports. Only side-impacted vehicles in which at least one occupant was fatally injured are included. When occupant counts for FARS side-impacted vehicles are presented, all occupants of the fatal vehicle are included unless otherwise noted. Although the same coding scheme is not used in the NCSS data, a selection process was devised which is believed to be nearly equivalent. Up to two Collision Deformation Classification (CDC) codes may be assigned to a vehicle in the NCSS case, in order of severity of damage to the car. The subset chosen for analysis here includes all cases coded "right" or "left" on

the first letter of either CDC, as long as that CDC represents the first chronological crash event. Cases identified as rollover by either CDC have been excluded, although some rollover accidents appear in the subset. These are evidently crashes involving more than one vehicle, with the other (not the side-impacted) vehicle experiencing the rollover. This is roughly equivalent to the above FARS clock-direction codes.

Occupant exposure to impacted surfaces, as either near-side or far-side impacts, has been derived from the side struck and seated location. Center seated occupants are classified as near-side if there were no intervening occupants, otherwise they are treatedas far-side.

Injuries are coded in NCSS using the Occupant Injury Classification[3] scheme in conjunction with the Abbreviated Injury Scale,[4] and by a separate severity classification (Hospitalized, Treated and Released, etc.). In some analyses NCSS injury codes have been grouped into two categories (e.g., AIS-0-2 vs. AIS-3 or greater). This permits recovery of a substantial number of cases in which injury was not completely reported in the NCSS data, and this relieves some of the limitations on the use of the original AIS variable. The FARS data are used here primarily to study fatalities in side-impact crashes, but injuries to other (non-fatal) occupants of side-struck cars are reported using the usual police reporting (KABCO) scale.

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[3] Marsh, J.C. "Vehicle Occupant Injury Classification." Hit Lab Reports, Vol. 4, No. 1, September 1973, pp. 1-11.

[4] The Abbreviated Injury Scale - 1980 Revision. American Association for Automotive Medicine, 1980. 57p.

The NCSS data provide a basis for definition and measurement of passenger compartment compromise. The code "intrusion" has been used to indicate any reduction in size of the passenger compartment, displacement of components such as the steering column, and/or entry of a foreign object into the passenger compartment. In the individual case reviews intrusion is treated in a descriptive manner, and certain statistics will be presented showing the distribution of points and amounts of maximum penetration.

In order to place side impacts in perspective, the distribution of General Area of Damage among towed-for-damage passenger cars (taken from the NCSS data) is shown in Table 1. The first column displays the weighted distribution for crashed passenger cars, and the second column tabulates fatal occupants. The classification in the table is based on the first CDC listed. Side impacts are those with either "right" or "left" damage. All rollovers (as given by the sixth column of the CDC) are grouped together regardless of whether they occurred in side impacts, top impacts, etc. Most of the rollovers were associated with top damage, 1695 of the towed vehicles and 94 of the fatally injured occupants. Side impacts account for 27.2% of all towaway vehicles, but 35.7% of the fatal occupants. This results in part from the underrepresentation of fatalities in rear-damaged vehicles, and it is possible that side-impacted vehicles are somewhat less likely to be towed for minor damage than front- or rear-damaged cars. In any case, the proportion of fatalities occurring in side-struck passenger cars is substantial and deemed worthy of further study.

TABLE 1

Distribution of Point of Most Severe Impact
in Fatal and Towed Passenger Cars
(NCSS 27-month Data)

Impact Point	Towed Vehicles		Fatal Occupants	
Front	33193	62.2	435	49.0
Side	14512	27.2	317	35.7
Rear	2896	5.4	13	1.5
Top	126	0.2	17	1.9
Undercarriage	668	1.3	3	0.3
Rollover	1984	3.7	103	11.6
Total	53379	100.0	888	100.0
M.D.	13955	-	29	-

The two principal data sources frequently report information using the same variable name but with somewhat different categories. Sometimes the categories bear the same names, but the actual measurement has been made under a different protocol. For example, the terms "rural" and "urban" as used in FARS are identified by the nature of the political jurisdiction in which the accident occurred. By contrast, the NCSS assignment of these terms depends on the investigator's judgment as to the nature of the surroundings of the accident site. NCSS provides a second rural-urban indicator which is common to an entire team area. None of these three definitions is precisely the same as any other. In

this report we will attempt to note such interpretation problems, but the reader should be aware that these variations in reporting method exist.

For the most part no statistical significance tests are shown in connection with the tables presented. For the FARS tests such tests are not really appropriate, since the FARS represents a census of the accidents under consideration, and observed differences are by definition true. For the NCSS cases, a simple chi-square test is inappropriate because the data presented are weighted by the inverse of the sampling rates applied in the field. Another reason is that nearly all of the tabulations involve substantial numbers of cases (for either FARS or NCSS), and thus any observed differences would be statistically significant. Whether they are of practical significance depends on the magnitude of the differences shown, and some such differences will be cited.

The remainder of this report is organized as follows: Section 2 presents a comparison of side-impacted passenger cars with cars involved in other collision types. Section 3 presents a set of detailed descriptive statistics for side-impacted passenger cars. Emphasis is placed on differences between single- and multiple-vehicle side-impact crashes. The appendix presents information resulting from a clinical (case by case) review of fatal accidents among the NCSS side-impacted cars. The appendix also contains individual case reviews of these NCSS-reported fatal side-impact crashes, drawing on the original case reports for more detailed damage and injury information.

1.2 Principal Findings

This report presents descriptive statistics relative to side-impacted passenger cars in the fatal accident set (from the 1979 FARS files) and in a sample of towaway accidents (from the first phase of the NCSS program). These descriptive statistics are divided into two groups. The first shows side-impacted vehicles relative to all vehicles in accidents of comparable severity (fatal or towaway). The second shows side-impacted vehicles in single-vehicle crashes relative to those in multi-vehicle crashes.

The general purpose of this work has been to study available accident data relative to the possible standards and test procedures for ensuring appropriate protection to passenger car occupants in side-impact collisions. The advance notice of proposed rulemaking[5] was used as a guide to this analysis.

The displays of these two comparisons indicate that, for many characteristics, there are only minor differences. While such non-differences may be of interest in particular applications, the reader is referred to Sections 2 and 3 of the report to identify these. In this summary attention will be given mainly to those few distributions which exhibit differences. Some summary statistics from both FARS and NCSS will be presented first; then individual comments will be given for findings relevant to the proposed standards for side-impact protection.

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[5]"Federal Motor Vehicle Safety Standard: Side Impact Protection," Federal Register, Vol. 44, No. 236, pg. 70204, Dec. 6, 1979.

1979 FARS Overview

At the time these analyses were done, the available 1979 FARS file was about 90% complete, with most of the missing cases from the end of the year (November and December). The reader should be aware that the totals presented for FARS will not be directly comparable with other published values which cover the entire year. Differences in the distributions shown, however, should be minimal.

For the 1979 FARS data studied the following statistics obtain:

* The total number of persons killed as occupants of passenger cars was 23,872.

* The total number of persons killed in side-impacted cars (without rollover) was 5,930 (24.8% of the 23,872).

* Of the 5930, 1801 (30.4%) were in single-vehicle accidents and 4129 (69.6%) were in multi-vehicle accidents.

* For perspective, the number of fatalities in side-damaged vehicles with rollover is 575 (in single-vehicle accidents) and 171 (in two-vehicle accidents)

* The number of fatalities in passenger cars side-impacted by another passenger car is 1800, which is 30% of all passenger car side-impact fatalities, or 7.5% of all passenger car occupant fatalities.

* Of the 4129 fatalities in multi-vehicle accidents (without rollover), 3718 were in two-vehicle accidents. In these cases the "other vehicle" type could be determined.

NCSS1 Overview

The NCSS file used in this study consisted of cases reported during the first fifteen months of the NCSS program. Accidents were investigated over this period in seven regions of the United States, and represent the approximate urban/rural distribution of all accidents in the country. Accidents were sampled according to a simple stratified sampling scheme, and analyses may be made on both unweighted and

weighted populations. The latter represent the total accident population in the study areas over the 15-month period. Statistics below will generally be identified as either weighted or unweighted.

* The totals in the NCSS1 file were 6,683 Accidents (unweighted), 8708 Case Vehicles (unweighted), 8661 (unweighted) and 39614 (weighted) passenger cars.

* The number of passenger cars impacted in the side on the first impact (coded as either the first or second Collision Deformation Code), excluding rollovers, was 2042 (unweighted) or 8755 (weighted)--22.1% of the 39,614.

* The number of occupants in side-impacted cars was 14,423 (weighted); the number of occupants in other passenger cars was 47,893 (weighted). Occupants in side-impacted cars represent 23.1% of the total.

* Of all occupants (weighted) in the NCSS data, 3.6% were injured at the AIS-3 level or greater.

* 4.7% of occupants in side impacts were injured at the AIS-3 level or greater.

* Of all occupants (weighted) in the NCSS data, 1.4% were injured at the AIS-4 level or greater.

* 1.9% of occupants in side impacts were injured at the AIS-4 level or greater.

* 30.9% of those occupants injured to AIS-3 or greater were in side impacts.

* 32.3% of those occupants injured to AIS-4 or greater were in side impacts.

* For side-impacted cars in single-vehicle crashes, or struck by large trucks or railroad trains:

  4.3% of all occupants were ejected
  44.0% of all fatalities were ejected
  78.6% of side-impact fatal ejections were in this group

Nearside and Farside Occupants

There are more farside occupants in side-impacted vehicles, evidently because there is a slightly higher incidence of right-side impacts, and a predominance of cars with only the driver (left-side

seat) present. For all side-impacted vehicles, however, the nearside occupant is more likely to sustain a serious or fatal injury, as shown in Table 2. In the FARS data, 63.2% of those fatally injured in side impacts were nearside occupants.

TABLE 2

NCSS 1
Side-Impact Occupant Exposure and Injury
(Weighted Exposure Counts)

	Exposure to Impact	
	Near Side	Far Side
Number of Occupants . . .	6925	7328
Proportion with AIS-4+ Injuries	2.3%	1.4%
Proportion with Fatal Injuries	1.5%	0.9%

Notes: (1) The numbers of occupants omit 182 with other, unclassifiable, or unknown exposure.

(2) The proportion computations exclude occupants with unknown injury severity or exposure.

Injuries vs. Point of Impact on the Vehicle

Side-impacted vehicles have been selected for this study using the first letter of the Collision Deformation Code. Those cases coded as "R" (for right) and "L" (for left) impact have been included. The second letter of the CDC provides more detail as to the actual point(s) of impact within the defined side according to the following scheme:

D = distributed (whole side)
Y = front + passenger compartment
Z = back + passenger compartment

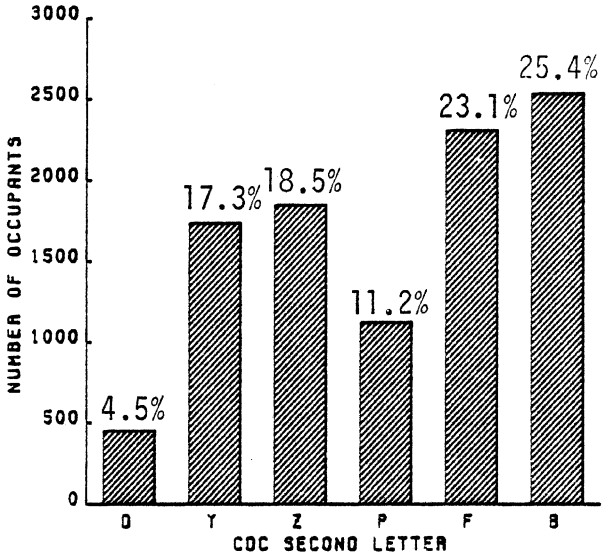
P = passenger compartment only
F = front only (not passenger compartment)
B = back only (not passenger compartment)

The likelihood of injury for each of these crash types is different, and is illustrated in Figures 1 through 3. Figure 1 shows the total number of (exposed) occupants of side-impacted vehicles by the CDC second letter, indicating that the largest groups are those struck only in the front or back. Figure 2 shows the number of persons seriously injured for the same variable, with the largest group comprising the "front and passenger compartment" damage. Figure 3 represents the ratio of the first two graphs, and indicates that occupants of cars with distributed side damage are much more likely to sustain serious injuries than others, about seven times more likely than occupants of vehicles struck in the side front or side rear. Distributed damage is some indication of a generally more severe (or higher speed) crash, but the injury rates are high any time there is passenger compartment involvement.

Delta-V Distributions

One of the parameters determined for vehicles in the NCSS study is the change of velocity during impact, generally identified as Delta-V. This quantity is computed from descriptions of the damage of the vehicle or vehicles using the CRASH2 algorithm.

Figure 4 shows the computed cumulative Delta-V distributions for occupants of side-impacted passenger cars in single-vehicle and multiple-vehicle crashes separately. The Delta-V is computed using certain assumptions about the crush characteristics of each vehicle, and it is difficult to assess the absolute accuracy of the values obtained in the NCSS data. Note particularly that, at least for the multi-



D = distributed (whole side)
Y = front + passenger compartment
Z = back + passenger compartment
P = passenger compartment only
F = front only (not passenger compartment)
B = back only (not passenger compartment)

FIGURE 1

NCSS 1 - Number of Occupants in Side Impacts by Second Letter of the CDC

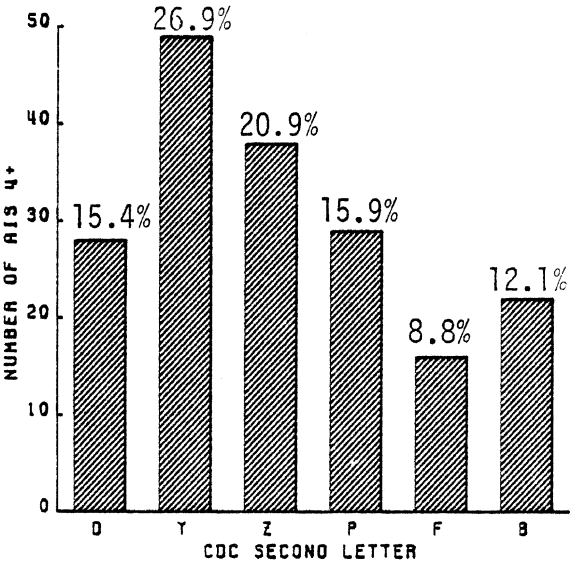


FIGURE 2

NCSS 1 - Number of Occupants in Side Impacts With Severe Injury by Second Letter of the CDC

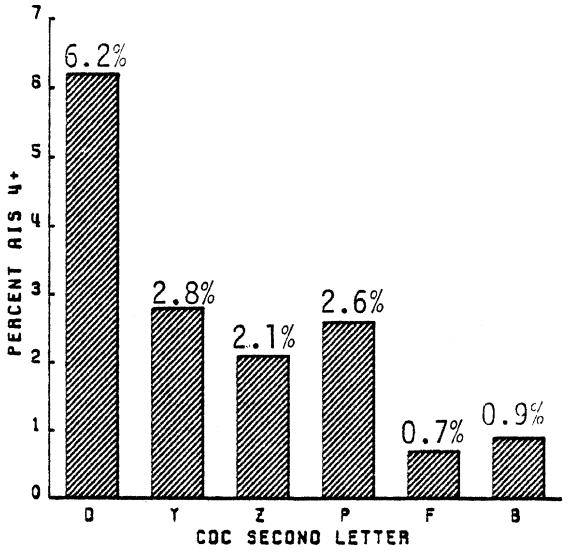


FIGURE 3

NCSS 1 - Proportion of Occupants with Severe Injury by Second Letter of the CDC

vehicle crashes, Delta-V is not the impact speed of either vehicle, but rather the velocity change of the struck car. For single-vehicle crashes it may be a reasonable approximation of the impact speed.

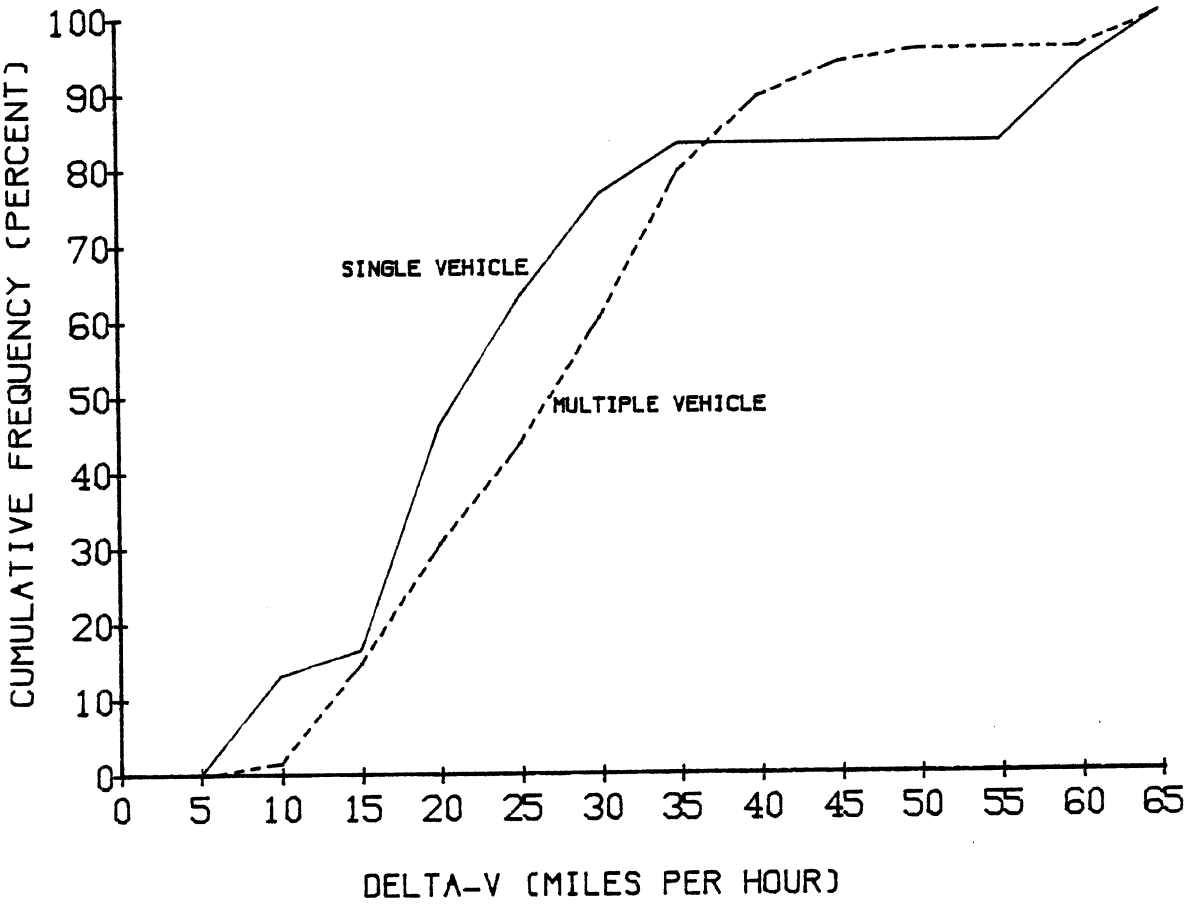


FIGURE 4
NCSS 1 - Distribution of Delta-V for Single and Multi-Vehicle Side Impacts

For the single-vehicle crashes plotted, 50% of the serious (AIS-4 or greater) injuries occur at Delta-V's below about 20 miles per hour. This is as opposed to a Delta-V about five mph higher for multi-vehicle crashes. This suggests that something other than Delta-V alone is operating to produce a higher injury probability in single-vehicle crashes. Among other differences, the proportion of ejected occupants

is much higher, the impact vector direction distribution is different, and the relative frequency of distributed side damage is much higher for side-impacted cars in single-vehicle collisions.

There are, of course, various uncertainties as to the accuracy and precision of the Delta-V estimates. In the present analysis, the difference in missing data rates by impact type (more missing data for Delta-V for two-vehicle crashes) may be important. Delta-V is unreported in the NCSS data for about 50% of the cases; sometimes because it was not defined for that crash type, and sometimes because of unavailability of the necessary data. Finally, the vehicle structural models used for reference in computing Delta-V are questionable when applied to specific impact areas. Nevertheless, the combination of a lower Delta-V value and generally higher injury rates for single vehicle side-impacted vehicles suggests that single-vehicle crashes should be considered separately from the multiple-vehicle crashes.

Ejections, Accident Configurations, and Injuries

Among fatally injured occupants in side impacts reported in FARS, 15.5% were ejectees. For those in single-vehicle accidents, 22.5% were ejected; in multi-vehicle accidents 12.5% were ejected. Corresponding figures for seriously injured (AIS = 4+) occupants in the NCSS data are 26.8%, 39.1%, and 21.9% respectively.

In the NCSS1 (weighted) data, single-vehicle side-impact crashes comprised 17.7% of all side-impacted cars. Figures 5 and 6 show the distribution of the object struck (or striking) for all ejected occupants and fatally ejected occupants, respectively. Among all side-impact ejected occupants, this single-vehicle group accounts for 45.1%

of all ejectees, and 47.6% of all fatally injured ejectees. Large trucks (as the impacting object) account for a larger proportion of fatal ejectees than do passenger cars.

Impacts by passenger cars and light trucks account for 44.7% of all ejections, but only 21.4% of all fatal ejectiions. Thus tests which effectively simulate side collisions between passenger cars would not address the bulk of the ejection problem.

Fatalities and Serious Injuries by Object Struck or Striking

The side-impacted vehicles discussed in this report can be classified into groups identifying the kinds of striking or struck objects. Although the coding details in FARS and NCSS are somewhat different, a common grouping of the "objects" is presented here in four major categories. These are single-vehicle/fixed object crashes, cars struck by light trucks, cars struck by heavy trucks or buses, and cars struck by other cars. The distributions across this categorization are shown in Figure 7 for AIS-4 and greater injuries (from NCSS), and in Figure 8 for fatalities (from FARS).

In both instances only about one-third of the fatalities or serious injuries are accounted for by impacts with passenger cars. Fifty percent of the fatalities (and 46% of the serious injuries in NCSS) occur in collisions with fixed objects, heavy trucks, or buses. If cars were to be designed to minimize ejection in side impacts, the most appropriate tests would seem to be those simulating non-crushable objects.

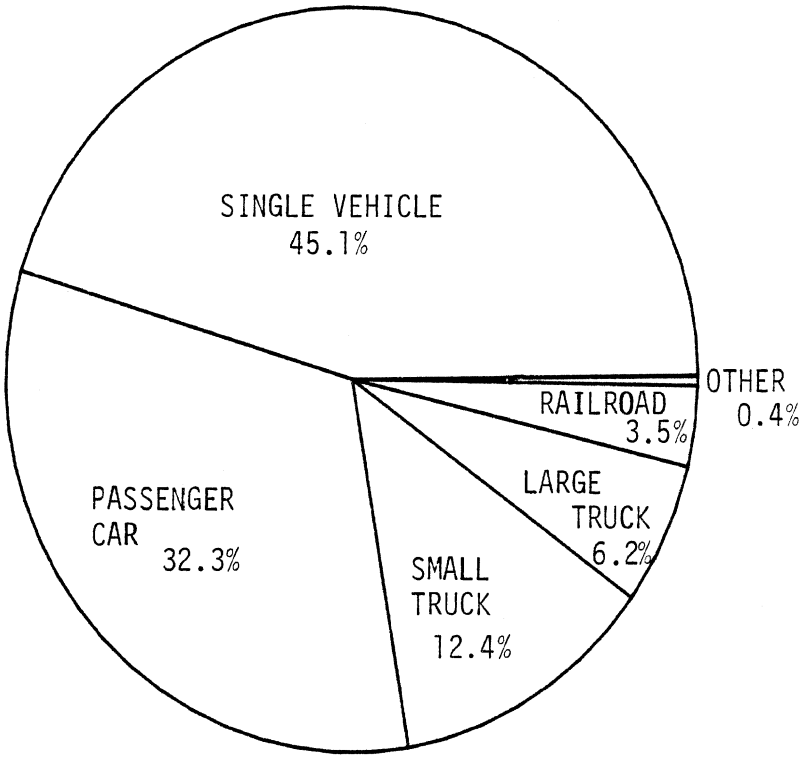


FIGURE 5

Distribution of Striking/Struck Object
for All Ejected Occupants

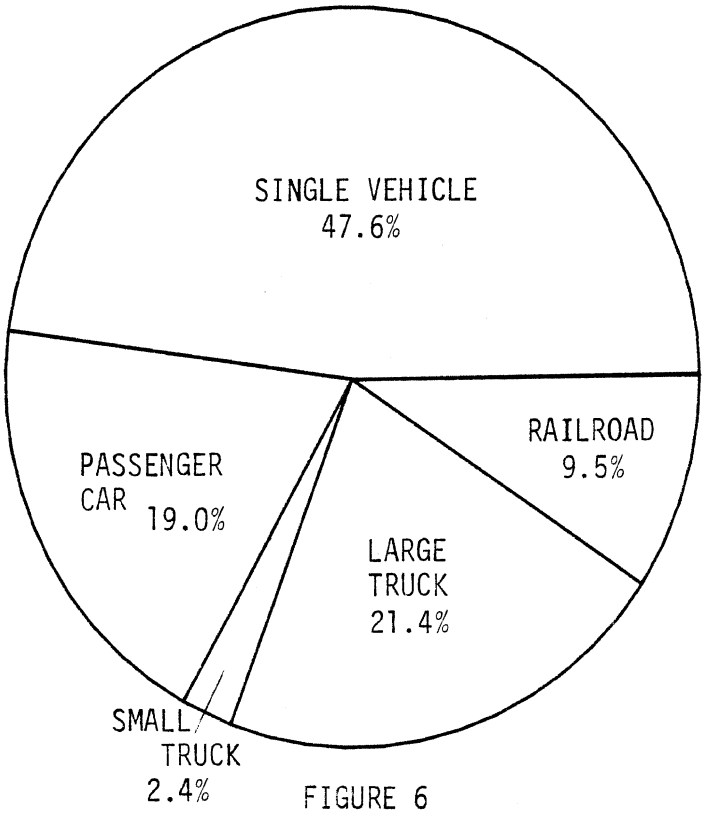


FIGURE 6

Distribution of Striking/Struck Object
for Fatally Ejected Occupants

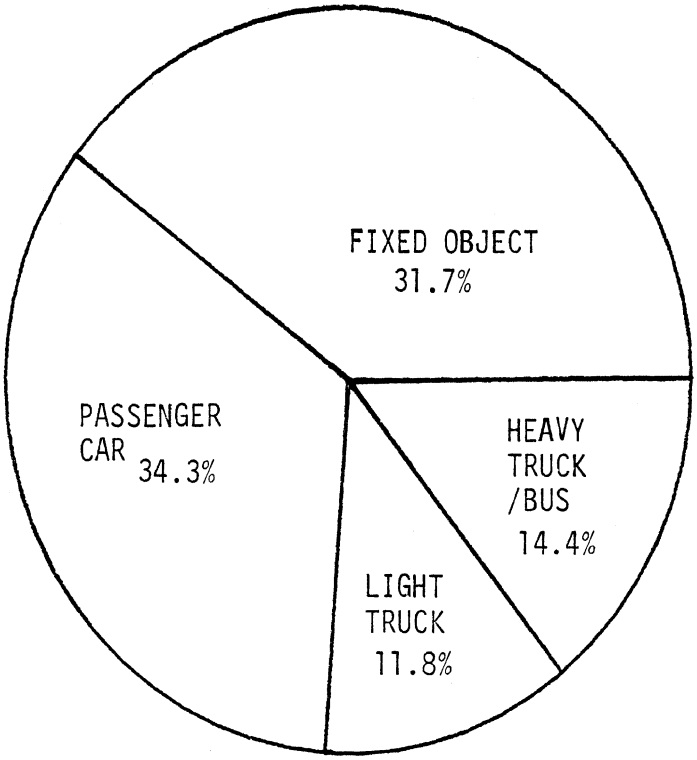


FIGURE 7

AIS 4+ Injury by Object Struck

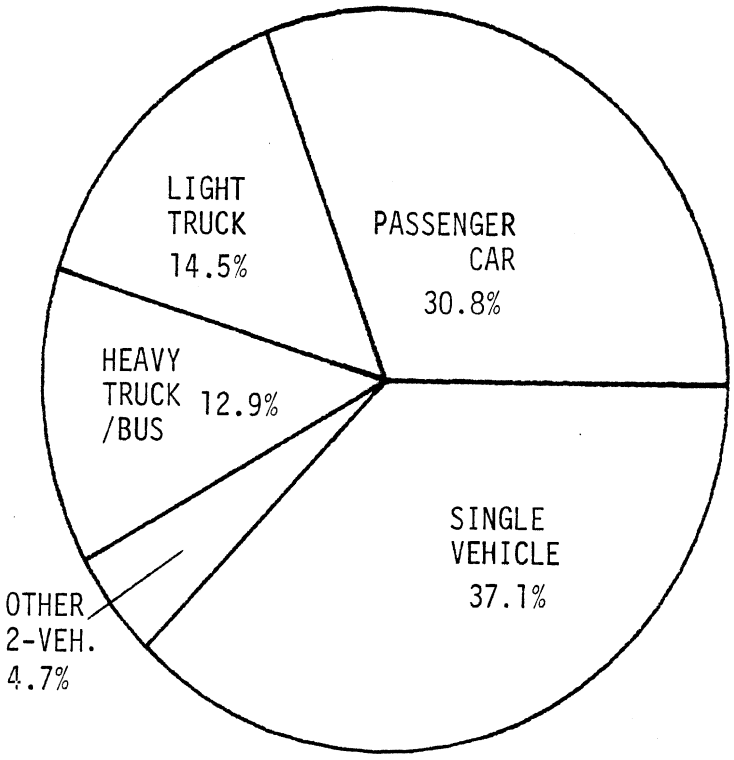


FIGURE 8

Fatalities by Object Struck

Impact Force Direction and Heading Angle

In two-vehicle collisions the clock direction reported in the Collision Deformation Classification (CDC) may be analyzed to produce the relative heading of the two vehicles at the time of impact. The distributions of impact vector direction and relative heading are of interest in defining an appropriate test or simulation for a two-vehicle side-impact collision.

Figure 9 displays both the impact-vector and relative-heading distributions, and allows a direct comparison of the two. Most (61%) of the impact force directions in two-vehicle accidents are contained in the two and ten o'clock groups, representing forces with a longitudinal component. By contrast, the most frequent (64%) relative headings for two-vehicle side impacts are at three and nine o'clock. A simulation of a two-vehicle collision, for test or evaluation purposes, should consider both of these factors. The most common collision is apparently a classical intersection accident, and the impact vector distributions suggests that the velocities of the two vehicles are approximately equal.

The impact-vector distribution may be plotted for single-vehicle crashes, but the relative heading distribution is not relevant. Figure 10 shows the distribution of impact force directions for single-vehicle side impacts in NCSS, and it is clearly asymetrical, as well as being less peaked than the two-vehicle case. Further the clock direction with the largest number of impacts is one o'clock, suggesting a strong forward component for right-side collisions; on the left side the

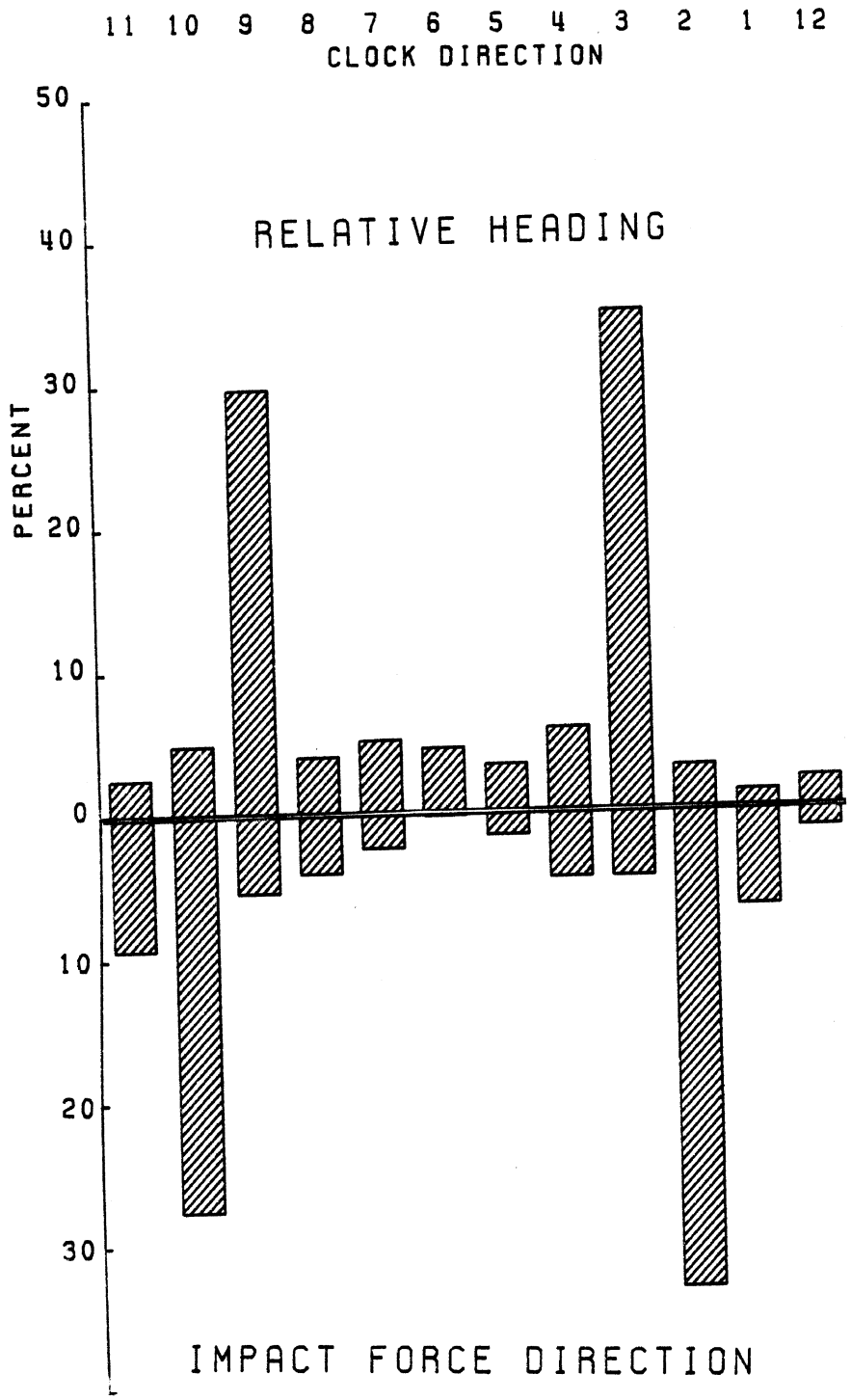


FIGURE 9

Comparison of Relative Heading and Impact Force Direction for Two-Vehicle Side Impacts

dominant direction is ten o'clock. This introduces a quandary as to a "best" configuration for testing the protective nature of passenger cars for-fixed object side impacts.

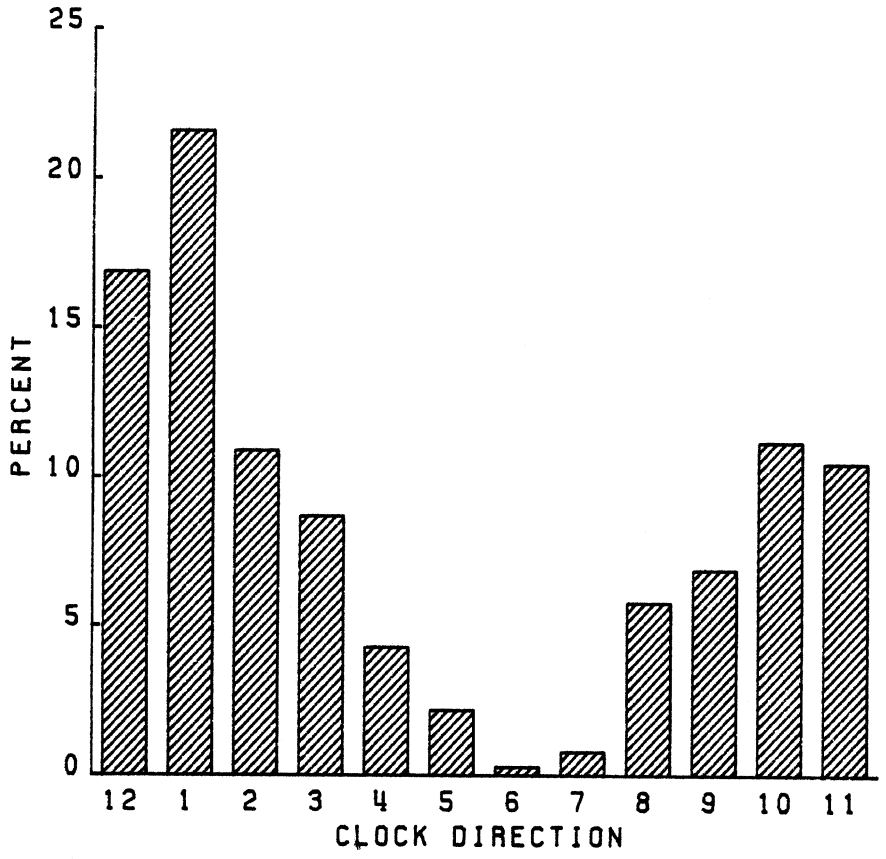


FIGURE 10
Impact Force Direction of Single-Vehicle Side Impacts

Clinical Case Reviews

Case reviews of 53 fatal side-impact crashes with 64 fatalities are presented in the Appendix to this report. While the sample is not large, and perhaps not truly representative of the national population of side-impact accidents, certain observations are in order.

The fatal crashes illustrated involve, of course, quite severe vehicular damage; but since two-thirds of the AIS-4 and greater injuries result in fatalities, they may exemplify the challenge for protection of

the occupants of side-impacted passenger cars. Extensive intrusion into the passenger compartment is common. In single-vehicle crashes, and also in two-vehicle crashes with a large truck as the impacting vehicle, nearly half of the fatal occupants were ejected. By contrast, there was relatively little ejection in car-car crashes. Belt use, as in other fatal accident populations, was negligible. Cases were reviewed with respect to the likelihood of fatal injury had full restraints been employed, and it is judged that no more than 58%, and possibly as few as 25%, would have been prevented by restraint use. The uncertainty results because a substantial number of cases had insufficient details on the injuries and their causes to draw conclusions.

2.0 Comparison of Side-Impacted Passenger Cars with Other Collision Types

In this section of the report the characteristics of side-impact accidents are compared with those of other collision types. These comparisons are divided into four sub-sections: Accident-, environment-, vehicle-, and occupant-related factors.

2.1 Accident Factors

Tables 3 and 4 show the time-of-day distribution for side-impacted cars in three-hour groups for FARS and NCSS respectively. Side impacts are more of a day-time phenomena than are other impacts. The distribution of side impacts exceeds that of other impacts in the NCSS data (Table 4) from 9 AM untile 6 PM, with 50.7% of the side impacts occurring in this period compared to 44.5% for other impacts. Among the fatal impacts, he distribution of side impacts exceeds others from 6 AM through 9 PM, with 61.1% of the side impacts occurring in this period compared with only 49.4% of the other impacts. "Other than side impacts," mostly frontals, tend to occur more often late at night or early in the morning.

Collision types are coded somewhat differently in the two sources. The distribution for FARS is shown in Table 5. The category "Not applicable" refers mainly to single-vehicle crashes, and the remainder of the table details various kinds of two-vehicle collisions. Side impacts account for a much smaller proportion of the single-vehicle crashes, but comprise most of the "angle" collisions. Table 6 presents a similar distribution from NCSS, but the categories are somewhat more detailed.

TABLE 3

FARS 1979
Fatal Vehicle Counts for Side Impacts vs. Other Impacts

Hour of Accident

Hour	Side Impacts		Other Impacts	
	N	%	N	%
0001-0300 .	841	16.5	3509	22.4
0301-0600 .	285	5.6	1451	9.3
0601-0900 .	441	8.7	1119	7.1
0901-1200 .	504	9.9	1007	6.4
1201-1500 .	587	11.5	1443	9.2
1501-1800 .	854	16.8	2021	12.9
1801-2100 .	724	14.2	2139	13.7
2101-2400 .	858	16.8	2963	18.9
Total .	5094	100.0	15652	100.0
M.D.	5		354	

Another accident characteristic of interest relative to side and other impacts is the object with which the car interacted. Again, the coding for this characteristic is different in FARS and NCSS, but Tables 7 and 8 present the available information. Table 7, prepared from the FARS data, indicates that side impacts are relatively more likely for railroad train accidents, for two-vehicle accidents, and for single-vehicle impacts with pole and trees. In the NCSS data two-vehicle

TABLE 4

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Hour of Accident

Hour	Side Impacts		Other Impacts	
	N	%	N	%
0001-0300	778	8.9	3361	10.9
0301-0600	295	3.4	1568	5.1
0601-0900	1034	11.8	3692	12.0
0901-1200	1115	12.8	3282	10.7
1201-1500	1478	16.9	4057	13.2
1501-1800	1840	21.0	6346	20.6
1801-2100	1226	14.0	4479	14.6
2101-2400	976	11.2	3984	12.9
Total	8742	100.0	30769	100.0
M.D.	13		90	

crashes are slightly overrepresented among the side-impacted cars, although poles and trees are slightly more likely among non-side-impacted cars.

TABLE 5

FARS 1979
Fatal Vehicle Counts for Side Impacts vs. Other Impacts

Collision type

Two-Vehicle Collision Type	Side Impacts		Other Impacts	
	N	%	N	%
Not Applicable . . .	1626	31.9	8720	55.5
Rear-End	70	1.4	917	5.8
Head-On	369	7.2	3726	23.7
Rear-to-Rear	1	0.0	8	0.1
Angle	2821	55.3	1813	11.5
Sideswipe, Same Dir.	61	1.2	176	1.1
Sideswipe, Opp. Dir.	150	2.9	346	2.2
Total	5099	100.0	15727	100.0
M.D.	1		21	

TABLE 6

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Impact Type

Impact Type	Side Impacts		Other Impacts	
	N	%	N	%
Two-Vehicle Collision:				
Head-on	11	.1	3432	11.3
Angle, Front	39	.4	730	2.4
Side	4602	52.7	6649	22.0
Angle, Side	1092	12.5	1343	4.4
Rear	37	.4	5549	18.3
Sideswipe	347	4.0	271	.9
Fixed Object:				
Front	401	4.6	5115	16.9
Side	927	10.6	547	1.8
Rear	16	.2	71	.2
Other Object	239	2.7	672	2.2
Principal Rollover	174	2.0	1162	3.8
Undercarriage	35	.4	466	1.5
3 or More Vehicles - Chain	12	.1	1904	6.3
3 or More Vehicles - Other	803	9.2	2358	7.8
Total	8735	100.0	30269	100.0
M.D.	20		590	

TABLE 7

FARS 1979
Fatal Vehicle Counts for Side Impacts vs. Other Impacts

Most Harmful Event (object struck)

Harmful Event	Side Impacts		Other Impacts	
	N	%	N	%
Non-collisions:	82	1.6	4522	28.7
Overturn	0	0.0	3838	24.4
Fire/Explosion	42	0.8	235	1.5
Immersion	18	0.4	254	1.6
Gas Inhalation	1	0.0	3	0.0
Fell from Vehicle . . .	20	0.4	162	1.0
Injured in Vehicle . . .	0	0.0	6	0.0
Other Non-collision . .	1	0.0	24	0.2
Collisions:	5013	98.4	11086	70.5
Not Fixed Objects:	3647	71.6	6920	44.0
R.R. Train	192	3.8	119	0.8
Animal	0	0.0	21	0.1
Vehicle in Transport . .	3324	65.2	6198	39.4
Veh. in Other Roadway .	73	1.4	191	1.2
Parked Vehicle	55	1.1	345	2.2
Other Object (not fixed)	3	0.1	46	0.3

Cont'd on next page

TABLE 7 (Cont'd)

Harmful Event	Side Impacts		Other Impacts	
	N	%	N	%
Collisions (cont'd):				
Fixed Objects:	1366	26.8	4166	26.5
Building	29	0.6	92	0.6
Culvert/Ditch	33	0.6	293	1.9
Curb/Wall	19	0.4	150	1.0
Divider	2	0.0	27	0.2
Embankment	37	0.7	319	2.0
Fence	10	0.2	46	0.3
Guard Rail	51	1.0	287	1.8
Light Support	50	1.0	69	0.4
Sign Post	19	0.4	39	0.2
Tree/Shrubbery	641	12.6	1454	9.2
Utility Pole	374	7.3	725	4.6
Other Pole	27	0.5	77	0.5
Impact Attenuator	0	0.0	11	0.1
Other Fixed Object	20	0.4	184	1.2
Bridge/Overpass	54	1.2	393	2.5
Total	5095	100.0	15608	100.0
M.D.	4		119	

TABLE 8

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Object Struck in Impact

Object Struck	Side Impacts		Other Impacts	
	N	%	N	%
Passenger Car:	5755	65.7	17612	57.2
Sub-compact	850	9.7	2693	8.7
Compact	1247	14.2	3913	12.7
Intermediate	1569	17.9	4675	15.2
Standard (Full Size) . .	1727	19.7	4982	16.2
Luxury/Limousine	362	4.1	1349	4.4
Truck:	948	10.8	3084	10.0
Truck (to 10,000 lb) . .	712	8.1	2424	7.9
Truck (over 10,000 lb) .	106	1.2	315	1.0
Tractor-trailer	124	1.4	342	1.1
Tractor	6	0.1	3	0.0
Bus:	21	0.2	167	0.5
School Bus	12	0.1	76	0.2
Other Bus	9	0.1	91	0.3
Other Vehicle:	50	0.6	146	0.5
Trailer (non-commercial)	1	0.0	26	0.1
R. R. Train	22	0.3	52	0.2
Other Vehicle	17	0.2	54	0.2
Motorcycle/Moped	10	0.1	14	0.0
Unknown Vehicle	368	4.2	1574	5.1

Table Cont'd

TABLE 8 Cont'd

Object Struck	Side Impacts		Other Impacts	
	N	%	N	%
Fixed Object:	1239	14.2	7428	24.1
Tree (to 6 in diameter) .	50	0.6	201	0.7
Tree (over 6 in diameter)	275	3.1	1161	3.8
Utility Pole	332	3.8	1890	6.1
Breakaway Pole	12	0.1	72	0.2
Culvert/Ground/ R. R. Tracks/Curb . . .	139	1.6	607	2.0
Abutment/Retaining Wall/ Bridge Support	29	0.3	226	0.7
Embankment	57	0.7	299	1.0
Building	22	0.3	193	0.6
Bridge Rail	48	0.5	373	1.2
Guard Rail	229	2.6	798	2.6
Impact Attenuator	0	0.0	14	0.0
Ground (rollover only) .	0	0.0	1173	3.8
Other Not-movable Object	46	0.5	421	1.4
Movable Object:	374	4.3	800	2.6
Pedestrian	0	0.0	1	0.0
Large Animal	0	0.0	127	0.4
Other Movable Object . .	374	4.3	672	2.2
Total	8755	100.0	30811	100.0
M.D.	0		48	

2.2 Environmental Factors

Both data sources provide information about the environmental characteristics present for side-impact and other accident types. As noted above, the definitions of rural and urban are not quite the same in FARS and NCSS. Nevertheless, in all of these the designation "rural" may be thought of as mostly something other than city streets, and "urban" roughly the opposite.

Table 9, from FARS, shows that, while more than half of the side-impact fatal accidents occurred in rural areas, a much greater proportion of "other than side-impact" crashes occur there. For all (mostly non-fatal) accidents, as shown in Table 10, the side and other distributions are almost alike. Using the second NCSS categorization (in which the entire data collection site has been called rural or urban - Table 11) side impacts are somewhat underrepresented in the large central cities, although these include only Miami and Los Angeles in the NCSS study.

TABLE 9

FARS 1979
Fatal Vehicle Counts for Side Impacts vs. Other Impacts

Urban/Rural

Urban/Rural	Side Impacts		Other Impacts	
	N	%	N	%
Urban . .	2360	47.2	55939	36.4
Rural . .	2638	52.8	97809	63.6
Total	5099	100.0	15727	100.0

TABLE 10

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Urban/Rural

Urban/Rural	Side Impacts		Other Impacts	
	N	%	N	%
Urban . .	6969	79.6	24394	79.1
Rural . .	1786	20.4	6464	20.9
Total	8755	100.0	30858	100.0
M.D.	0		1	

TABLE 11

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Degree of Urbanization

Urbanization	Side Impacts		Other Impacts	
	N	%	N	%
Large Central City	2147	24.5	9532	30.9
Large Suburb . . .	1439	16.4	4497	14.6
Medium SMSA . . .	1877	21.4	6280	20.4
Other	3292	37.6	10550	34.2
Total	8755	100.0	30859	100.0

Highways are also classified differently in the FARS and NCSS files, FARS using categories defined by the jurisdiction responsible for the road, and NCSS using the investigator's opinion of the road type. Column distributions in the two are not directly comparable. In Table 12 (FARS) side impacts are relatively infrequent on Interstate roads, relatively frequent on city streets, and about even everywhere else. Essentially the same observation may be made in the NCSS data (Table 13).

TABLE 12

FARS 1979
Fatal Vehicle Counts for Side Impacts vs. Other Impacts

Class of Highway

Class of Highway	Side Impacts		Other Impacts	
	N	%	N	%
Interstate	193	3.9	1533	10.0
other Limited Access	39	0.8	147	1.0
Other US Route . . .	910	18.4	2691	17.5
Other State Route .	1657	33.4	5610	36.5
Major Artery	141	2.8	278	1.8
County Road	851	17.2	2641	17.2
Local Street	1087	21.9	2104	13.7
Other Road	77	1.6	356	2.3
Total	5099	100.0	15727	100.0

TABLE 13

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Highway Functional Classification

Functional Classification	Side Impacts		Other Impacts	
	N	%	N	%
Freeway/Expressway .	556	6.4	3817	12.5
Arterial Hwy. . . .	920	10.5	3545	11.6
Minor Artery - Major Street/Hwy . . .	2174	24.9	9001	29.5
Collector - Through Street/Hwy. . . .	2023	23.2	6169	20.2
Local Street/Road .	2746	31.5	7400	24.3
Other	303	3.5	567	1.9
Total	8722	100.0	30499	100.0
M.D.	33		360	

Vertical and horizontal alignment of the roadway are reported in more detail in NCSS, but may be compared in the two files. Table 14 (FARS) indicates that side-impact fatal accidents are more likely (than other crash types) to occur on straight and/or level roadways--perhaps because these are associated with urban areas. The differences for non-fatal accidents (Table 15) are not as large, but still side-impact crashes are more likely to occur on straight and level areas.

TABLE 14

FARS 1979
Fatal Vehicle Counts for Side Impacts vs. Other Impacts

Highway alignment

Highway Alignment	Side Impacts		Other Impacts	
	N	%	N	%
HORIZONTAL:				
Straight .	3835	76.1	10315	66.2
On Curve .	1207	23.9	5259	33.8
VERTICAL: .				
Level . . .	3694	75.0	10431	68.4
On Grade .	1234	25.0	4827	31.6

In both fatal (Table 16) and towaway (Table 17) accidents side impacts are more likely to occur in inclement weather. The exception to this is the snow condition in NCSS, where "other" impacts predominate.

TABLE 15

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Highway Alignment - Vertical and Horizontal

Alignment	Side Impacts		Other Impacts	
	N	%	N	%
Straight:	7628	87.3	26285	85.9
Straight - Level .	5822	66.7	19412	63.4
Straight - Uphill .	946	10.8	3248	10.6
Straight - Downhill	860	9.8	3625	11.8
Curve:	1107	12.7	4329	14.1
Right:	439	5.0	2018	6.6
Right - Level . . .	185	2.1	978	3.2
Right - Uphill . .	111	1.3	520	1.7
Right - Downhill .	143	1.6	520	1.7
Left	668	7.6	2311	7.5
Left - Level . . .	312	3.6	1081	3.5
Left - Uphill . . .	171	2.0	465	1.5
Left - Downhill . .	185	2.1	765	2.5
Total	8735	100.0	30614	100.0
M.D.	20		245	

TABLE 16

FARS 1979
Fatal Vehicle Counts for Side Impacts vs. Other Impacts

Surface Condition

Surface Condition	Side Impacts		Other Impacts	
	N	%	N	%
Dry	3688	72.3	12537	79.7
Wet	1065	20.9	2523	16.0
Snow	138	2.7	292	1.9
Ice	172	3.4	263	1.7
Sand,Dirt,Oil	6	0.1	18	0.1
Other	16	0.3	25	0.2
Unknown . . .	14	0.3	69	0.4
Total . .	5099	100.0	15727	100.0

TABLE 17

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Surface Condition

Surface Condition	Side Impacts		Other Impacts	
	N	%	N	%
Dry . . .	5775	66.0	21024	68.2
Wet . . .	2148	24.5	6113	19.8
Ice . . .	548	6.3	1780	5.8
Snow . . .	238	2.7	1722	5.6
Other . .	45	.5	173	.6
Total	8754	100.0	30812	100.0
M.D.	1		47	

2.3 Vehicle Characteristics

Vehicles are coded in both FARS and NCSS by make and model, although the detailed coding is somewhat different. In Table 18 the FARS coding for passenger cars is shown, and four-door vehicles seem to be overrepresented in the side-impact group. Two NCSS breakdowns are shown in Tables 19 and 20--the first by body size, in which the smaller vehicles are somewhat more likely to be struck in the side than are standard or luxury cars. In the second NCSS table (20) there are no remarkable differences for these major groupings.

TABLE 18

FARS 1979
Fatal Vehicle Counts for Side Impacts vs. Other Impacts

Body Type

Body Type	Side Impacts		Other Impacts	
	N	%	N	%
Convertible .	73	1.4	303	1.9
2-Door . . .	3006	59.0	9468	60.2
4-Door . . .	1282	25.1	3420	21.7
Station Wagon	367	7.2	1113	7.1
on/Off Road .	34	0.7	470	3.0
Other	20	0.4	40	0.3
Unknown Type	317	6.2	913	5.8
Total . .	5099	100.0	15727	100.0

TABLE 19

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Vehicle Model Type

Model Type	Side Impacts		Other Impacts	
	N	%	N	%
Intermediate	1676	19.1	5350	17.3
Standard (full size) . . .	1899	21.7	7089	23.0
Luxury/Limousine	297	3.4	1142	3.7
Min-specialty	152	1.7	548	1.8
Personal Luxury	187	2.1	508	1.6
Specialty Pony	921	10.5	2635	8.5
Specialty Intermediate . .	455	5.2	1294	4.2
Compact	1313	15.0	4383	14.2
Sub-compact/Mini (import) .	890	10.2	3426	11.1
Super Sport	70	.8	194	.6
Pickup-car	34	.4	157	.5
Sub-compact/Mini (domestic)	658	7.5	2078	6.7
Foreign Sport	201	2.3	593	1.9
Total	8755	100.0	30859	100.0
Unknown Pass. Car . .	2		1462	

The distributions of the number of occupants in the accident vehicles are shown in Tables 21 and 22. In both data sets side-impacted vehicles tend to have a greater number of occupants.

TABLE 20

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Vehicle Body Style

Body Style	Side Impacts		Other Impacts	
	N	%	N	%
Passenger Car	7832	89.5	27668	89.7
Station Wagon	745	8.5	2648	8.6
Convertible .	144	1.6	386	1.3
Pickup - car	34	.4	157	.5
Total .	8755	100.0	30859	100.0

TABLE 21

FARS 1979
Fatal Vehicle Counts for Side Impacts vs. Other Impacts

Number of Occupants

Occupants	Side Impacts		Other Impacts	
	N	%	N	%
1	2171	42.6	7766	49.4
2	1724	33.8	4594	29.2
3	644	12.6	1713	10.9
4	350	6.9	1049	6.7
5	132	2.6	354	2.3
6	47	0.9	141	0.9
7	19	0.4	50	0.3
8	4	0.1	22	0.1
9	2	0.0	9	0.1
10	1	0.0	4	0.0
11	0	0.0	3	0.0
12	1	0.0	2	0.0
13	0	0.0	3	0.0
15	0	0.0	1	0.0
Unknown	3	0.1	16	0.1
Total	5099	100.0	15727	100.0
Total Occupants by Impact Type . . .	10098	(25.4%)	29630	(76.9%)

TABLE 22

NCSS 1
Vehicle Counts for Side Impacts vs. Other Impacts
(weighted)

Number of Occupants

Occupants	Side Impacts		Other Impacts	
	N	%	N	%
1	5305	60.6	20183	65.4
2	2170	24.8	6852	22.2
3	668	7.6	2306	7.5
4	415	4.7	875	2.8
5	118	1.3	425	1.4
6	41	0.5	128	0.4
7	32	0.4	47	0.2
8	1	0.0	33	0.1
9	4	0.0	6	0.0
11	1	0.0	0	0.0
13	0	0.0	4	0.0
Total	8755	100.0	30859	100.0
Total Occupants by Impact Type . . .	14424	(23.1%)	47897	(76.9%)

2.4 Occupant Characteristics

Occupant age distributions from the two files are shown in Tables 23 and 24. Table 24 shows only trivial differences between the impact types across the age distribution. The fatal accident data show an overrepresentation of older persons in side impacts.

TABLE 23

FARS 1979
Fatal Vehicle Occupant Counts for Side Impacts vs. Other Impacts

Age

Age (years)	Side Impacts		Other Impacts	
	N	%	N	%
0-5	362	3.6	935	3.2
6-10 . . .	278	2.8	630	2.2
11-15 . . .	555	5.6	1383	4.8
16-20 . . .	2561	25.8	8121	28.0
21-29 . . .	2255	22.7	7966	27.5
30-39 . . .	1036	10.4	3447	11.9
40-49 . . .	620	6.2	1978	6.8
50-59 . . .	681	6.9	1691	5.8
60-64 . . .	327	3.3	819	2.8
65-69 . . .	345	3.5	672	2.3
70-74 . . .	326	3.3	524	1.8
75-79 . . .	292	2.9	404	1.4
80 and Over	284	2.9	402	1.4
Total .	9922	100.0	28972	100.0
M.D.	91		324	

Females are clearly overrepresented in the side-impact category in both the FARS (Table 25) and NCSS (Table 26) data. The detailed breakdown of females into "pregnant," etc. is rather uncertain, but is

TABLE 24

NCSS 1
Occupant Counts for Side Impacts vs. Other Impacts
(weighted)

Occupant Age

Age (years)	Side Impacts		Other Impacts	
	N	%	N	%
0-4 . . .	432	3.0	1487	3.2
5-9 . . .	479	3.4	1151	2.5
10-14 . .	611	4.3	1375	2.9
15-19 . .	3082	21.7	10403	22.3
20-24 . .	2651	18.7	9582	20.5
25-34 . .	2770	19.5	9439	20.2
35-44 . .	1517	10.7	4294	9.2
45-54 . .	1156	8.1	3957	8.5
55-64 . .	774	5.4	2559	5.5
65-74 . .	426	3.0	1672	3.6
Over 74 .	307	2.2	749	1.6
Total	142053	100.0	46668	100.0
M.D.	218		1225	

included here because the "not pregnant" group includes many older women, and that group is evidently more likely to be involved in side impacts.

Restraint usage is tabulated in Tables 27 (for FARS) and 28 (for NCSS). Coding is essentially equivalent in the two files, but the source of data is different. FARS reports come primarily from police accident reports; the NCSS entries result from the investigators' weighted judgment, considering police reports, interviews, and other evidence. In the fatal accident set fewer than 3% of the entries show

TABLE 25

FARS 1979
Fatal Vehicle Occupant Counts for Side Impacts vs. Other Impacts

Sex

Sex	Side Impacts		Other Impacts	
	N	%	N	%
Male . . .	6185	61.8	19797	67.6
Female . .	3828	38.2	9496	32.4
Total	10013	100.0	29293	100.0
M.D.	0		3	

TABLE 26

NCSS 1
Occupant Counts for Side Impacts vs. Other Impacts
(weighted)

Occupant Sex

z	Side Impacts		Other Impacts	
	N	%	N	%
Male	7767	54.3	28435	60.1
Female	6536	45.7	18855	39.9
Female - Not Pregnant . .	5440	38.0	15100	31.9
Female - Pregnant	49	.3	287	.6
Female - pregnancy Unknown	1047	7.3	3468	7.3
Total	14303	100.0	47290	100.0
M.D.	120		603	

any kind of restraint use compared with about 8% in NCSS. The slight differences between side-impact and other collision configurations are not of much practical significance.

TABLE 27

FARS 1979
Fatal Vehicle Occupant Counts for Side Impacts vs. Other Impacts

Restraint Usage

Restraint (active)	Side Impacts		Other Impacts	
	N	%	N	%
None Used	7605	96.9	22818	97.4
Torso Only . . .	8	0.1	31	0.1
Lap Only	111	1.4	258	1.1
Lap and Torso . .	93	1.2	225	1.0
Child Safety Seat	5	0.1	25	0.1
Restraint Used-Type Unknown . .	26	0.3	72	0.3
Total	7848	100.0	23429	100.0
M.D. . . .	2165		5867	

An inversion of the two data sets shows up for ejection. Table 29 displays ejection counts for FARS, and indicates that ejections are more common for other than side-impact accidents. In Table 30 (NCSS) side-impact ejections are more common. Again missing data have been eliminated from the tables, but reporting is relatively complete for this variable. Table 31 displays a more detailed ejection variable from NCSS, along with some entrapment information. Partial ejections

TABLE 28

NCSS 1
Occupant Counts for Side Impacts vs. Other Impacts
(weighted)

Restraint Used

Restraint	Side Impacts		Other Impacts	
	N	%	N	%
None Used	11443	86.9	33973	84.7
Torso Only . . .	20	0.2	0	0.0
Lap Only	470	3.6	1559	3.9
Lap and Torso . .	603	4.6	1694	4.2
Child Safety Seat	12	0.1	89	0.2
Passive Belt . .	4	0.0	11	0.0
Not Equipped . .	613	4.7	2764	6.9
Total . . .	13165	100.0	40090	100.0
M.D. . . .	1258		7803	

(generally defined by having a part of an occupant's body beyond the normal boundary of the passenger compartment) represent less than a quarter of all reported ejections in either NCSS or FARS. Table 32 shows the proportion of occupants with injuries of AIS-3 or greater, and AIS-4 or greater. The incidence of injuries above either severity threshold is substantially higher in the side-impacted cars. The table also shows the proportion of ejected or unejected occupants who sustain injuries at or above the same severities. Differences between side and other impacts are small, but the ejected occupants are more than ten

times as likely to sustain severe injuries than those not ejected. The differences are, of course, partly related to crash severity--accidents involving ejection being more severe than others. But the ejection effect is likely to be important in itself. Among the (NCSS) occupants who sustained injuries of AIS-3 or greater, 19.9 percent of those in side impacts were ejected as compared with 14.0 percent for other impacts. The corresponding figures for occupants with AIS of 4 or greater are 26.8% and 24.5%, respectively.

TABLE 29

FARS 1979
Fatal Vehicle Occupant Counts for Side Impacts vs. Other Impacts

Occupant Ejection

Ejection	Side Impacts		Other Impacts	
	N	%	N	%
Not Ejected	8663	87.2	22690	78.4
Totally Ejected . .	1045	10.5	5365	18.5
Partially Ejected .	221	2.2	871	3.0
(Both Ejections)	(1266)	(12.7)	(6236)	(21.5)
Total	9929	100.0	28926	100.0
M.D.	84		370	

Entrapment is reported separately from ejection in FARS (Table 33) and in NCSS (Table 34). Although the label "extrication" is used in FARS and "entrapment" in NCSS, these are taken as equivalent. There is

TABLE 30

NCSS 1
Occupant Counts for Side Impacts vs. Other Impacts
(weighted)

Occupant Ejection

Ejected	Side Impacts		Other Impacts	
	N	%	N	%
No	14012	98.4	46908	99.2
Yes . . .	226	1.6	388	0.8
Total	14238	100.0	47296	100.0
M.D.	185		597	

little difference in this variable for side and other impact types, although entrapment is clearly associated with the more severe (fatal) crashes.

Injuries are reported in FARS using the usual police (KABCO) scale, and in NCSS in several ways. The FARS police scale is shown in Table 35, and fatal injuries are slightly underrepresented in the side-impact column, although the differences in the two distributions are probably not of much practical significance. By contrast, fatal injuries are overrepresented in side impacts in the NCSS data (Table 36). Note that the FARS data represent cars in which at least one person was fatally injured, whereas the NCSS data represent all cars towed for damage as the result of a crash. There are relatively few uninjured persons in cars in which a person has been killed, but there are a number of towaways in which there were no injuries at all.

TABLE 31

NCSS 1
Occupant Counts for Side Impacts vs. Other Impacts
(weighted)

Ejection/Entrapment

Ejection/Entrapment	Side Impacts		Other Impacts	
	N	%	N	%
Not Ejected or Trapped .	13889	97.5	46593	98.5
Complete Ejection . . .	165	1.2	303	.6
Partial Ejection	57	.4	73	.2
Partially Ejected and Trapped	3	.0	5	.0
Ejected - Degree Unknown	1	.0	7	.0
Trapped	123	.9	315	.7
Total	14238	100.0	47296	100.0
M.D.	185		597	

TABLE 32

NCSS 1
Injury and Ejection for Occupants in
Side Impacts vs. Other Impacts

	Side Impacts	Other Impacts
All Occupants:		
Percent with AIS = 3+ . .	4.7	3.3
Percent with AIS = 4+ . .	1.9	1.2
Ejected Occupants:		
Percent with AIS = 3+ . .	50.0	50.9
Percent with AIS = 4+ . .	26.9	35.1
Non-Ejected Occupants:		
Percent with AIS = 3+ . .	3.3	2.6
Percent with AIS = 4+ . .	1.1	0.8

TABLE 33

FARS 1979
Fatal Vehicle Occupant Counts for Side Impacts vs. Other Impacts

Occupant Extrication

Extrication Required	Side Impacts		Other Impacts	
	N	%	N	%
No	8811	89.0	25207	87.6
Yes . . .	1087	11.0	3579	12.4
Total	9898	100.0	28786	100.0
M.D.	115		510	

TABLE 34

NCSS 1
Occupant Counts for Side Impacts vs. Other Impacts
(weighted)

Occupant Entrapment

Trapped	Side Impacts		Other Impacts	
	N	%	N	%
No	14112	99.1	46976	99.3
Yes . . .	126	0.9	320	0.7
Total	14238	100.0	47296	100.0
M.D.	185		597	

TABLE 35

FARS 1979
Fatal Vehicle Occupant Counts for Side Impacts vs. Other Impacts

Occupant Injury Severity - Police Scale

Injury Severity	Side Impacts		Other Impacts	
	N	%	N	%
No Injury (0)	202	2.0	692	2.4
Possible injury (C) . . .	375	3.7	1009	3.4
Non - Incapacitating Injury (B)	1237	12.4	3296	11.3
Incapacitating Injury (A)	2257	22.5	6299	21.5
Fatal (K)	5932	59.3	17940	61.3
Injured - Severity Unknown	6	0.1	40	0.1
Died Prior to Accident .	0	0.0	1	0.0
Total	10009	100.0	29277	100.0
M.D.	4		19	

TABLE 36

NCSS 1
Occupant Counts for Side Impacts vs. Other Impacts
(weighted)

Occupant Fatality/Treatment

Fatality/Treatment	Side Impacts		Other Impacts	
	N	%	N	%
Fatal	180	1.3	318	0.7
Hospitalized Overnight .	870	6.1	2469	5.2
Transported and Released	2886	20.1	9726	20.4
Other Treatment	1359	9.5	4699	9.9
Not Transported - No Treatment	8566	59.6	27837	58.4
Not Transported - Treatment Unknown . .	517	3.6	2589	5.4
Total	14378	100.0	47638	100.0
M.D.	45		255	

3.0 Detailed Descriptive Statistics for Side-Impacted Passenger Cars

In this section of the report detailed descriptive statistics for side-impacted vehicles will be presented. These tabulations come from both FARS and NCSS, although the bulk of the material will be from the latter source. The principal comparisons will be made between vehicles involved in multi-vehicle collisions and those in single-vehicle collisions. This choice was made in part because of the finding reported in the Kaplan/O'Day study that single-vehicle side-impact collisions were relatively more severe. In Section 4, individual fatal side-impact cases will be reviewed in some depth, and one purpose of the presentation in Section 3 set the stage for this review

Impact Descriptors

Table 37 displays the distribution of damage on the right and left sides of side-impacted passenger cars in the NCSS Phase 1 data. It can be observed that single-vehicle cases are a little more than one-sixth of the total, and that multi-vehicle crashes account for relatively few of the distributed damage cases. Note that there are higher proportions of center only or distributed damage among the single-vehicle crashes.

Table 38 is a comparable display taken from FARS. As in the NCSS data, there are more single-vehicle right impacts. Of more importance is the fact that 30.6% of the fatal side-impacted vehicles resulted from single-vehicle crashes as opposed to 17.6% in the towaway set.

In the NCSS multi-vehicle group the right and left sides are divided about equally. But in the single-vehicle group there are 35% more right-side than left-side impacts--887 compared to 657. Note also that the distribution of damage along the side is different in the

TABLE 37

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Side of Vehicle Impacted

Side	Single		Multi	
	N	%	N	%
Right	887	(57.4)	3634	(50.3)*
Front . . .	272	30.7	1305	35.9
Rear . . .	115	13.0	276	7.6
Distributed	204	23.0	209	5.8
Center . .	154	17.4	239	6.6
Frt./Ctr. .	86	9.7	851	23.4
Rear/Ctr. .	56	6.3	754	20.7
Left	657	(42.6)	3589	(49.7)*
Front . . .	168	25.6	1291	36.0
Rear . . .	80	12.2	321	8.9
Distributed	201	30.6	279	7.8
Center . .	109	16.6	270	7.5
Frt./Ctr. .	45	6.8	808	22.5
Rear/Ctr. .	54	8.2	620	17.3
Total .	1544	(100.0)	7223	(100.0)

* Percentages in parentheses are for the total right and left impacts. Other percentages total 100% within each side.

single- and multi-vehicle groups. The distributed and center patterns account for 43% of the singles, but only 14% of multis. On the other hand, damage to the front two-thirds or rear two-thirds is much more common in the multi-vehicle impacts.

TABLE 38

FARS 1979
Fatal Side Impacted Vehicle Counts For
Single-Vehicle vs. Multi-Vehicle Involvements

Point of Principal Impact

Side of Vehicle Struck	Location on Side	Single		Multi	
		N	%	N	%
Right		819	52.5	1714	48.4
	Front	132	8.5	249	7.0
	Center	623	39.9	1372	38.8
	Rear	64	4.1	93	2.6
Left		741	47.5	1824	51.6
	Front	95	6.1	262	7.4
	Center	609	39.0	1463	41.4
	Rear	37	2.4	99	2.8
Total		1560	100.0	3538	100.0

Other components of the CDC are compared for single- and multiple-vehicle crashes in Tables 39, 40, 41, and 42. Table 39 indicates a quarter of the single-vehicle side-impacted cars are coded with distributed damage as opposed to 7.1% of the multi-vehicle group. Table 40 shows the distribution of vertical location of damage, and only cars in single-vehicle crashes sustain a substantial proportion of the damage in the upper regions of the vehicle structure. The frame level is involved in nearly all side impacts--92% of the single-vehicle and 97% of the multi-vehicle crashes.

TABLE 39

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Specific Horizontal Area of Impact

Specific Area	Single		Multi	
	N	%	N	%
(F) Front	446	28.9	2556	35.4
(B) Rear	214	13.9	656	9.1
(D) Distributed	394	25.5	514	7.1
(P) Pass. Compartment	230	14.9	474	6.6
(Y) Front Pass. Comp.	117	7.6	1598	22.1
(Z) Rear Pass. Comp.	142	9.2	1425	19.7
Total	1543	100.0	7223	100.0

Table 41 represents the fourth letter of the Collision Deformation Classification (CDC) code, and it can be seen that the multiple-vehicle crashes exhibit the largest proportion of wide impact damage. Only 15.7% of the cars in single-vehicle crashes sustain "narrow" damage.

Table 42 indicates the clock direction of impact force for the two types of crashes. It is clear that in the multiple-vehicle impacts the direction of force was most often at 10 o'clock or 2 o'clock, whereas for single-vehicle crashes it was most often between 11 and 1 o'clock.

Relative Heading of Vehicles at Impact

A simulated multi-vehicle impact compliance test as proposed by NHTSA would require selection of geometric configurations for the impacts. Selecting test configurations that represent actual collisions, or just dangerous actual collisions, would require knowledge of both the directions of impact force vectors and the relative orientation of vehicles at impact. The direction of the impact-force vector is given by the clock direction of the CDC (in 30 degree increments) in the NCSS files. The relative headings of the vehicles are not given, except in the small number of cases in which scene data were provided for CRASH2 reconstruction. Even for these latter cases, the data have not been included in the computer files.

The relative angular orientation of th two vehicles at impact can be derived from the force directions if a simple assumption is allowed. The instantaneous forces on two colliding vehicles are equal and opposite. Although the crush represented by the CDC does not necessarily result from a single force constant in either direction or time, we normally interpret--and assign--the impact force direction on the basis of a single principal force. If we assume this simplification

is valid, and that the principal forces on the two vehicles are equal and opposite, we can derive the angle between the two longitudinal axes of the vehicles at impact from the two CDC clock directions, since each clock direction is the angle between the longitudinal axis and the (common) line of principal force.

HSRI has constructed a two-vehicle file of NCSS cases from the first fifteen months of data, complete with occupant data on up to seven occupants per vehicle. For use in this study, the relative heading angle has been derived in 30 degree increments for case vehicles side-impacted by another vehicle, and the results added to the data files as additional variables. The derivations were limited to those case vehicles struck in the side in the first impact (if there was more than one) and for which the side impact was listed as the most severe impact--i.e., the higher delta-V. Valid heading angles were computed for 1238 case vehicles. The relative heading angle was not derived for single-vehicle side impacts.

The relative heading is given relative to a clock aligned with 12 along with the +X axis of the vehicle in a manner analogous to the direction of principal force, except that the force vector is replaced by the +X axis of the striking vehicle.

The distribution of relative headings is shown in Table 43 along with the distribution of the direction of the principal impact force. Over 60 percent of the force directions are either 2 or 10 o'clock, while 63% of the relative headings are at 3 or 9 o'clock. Thus nearly two-thirds of the two-vehicle collisions involving side-impacts are intersection-type collisions in which the vehicles are oriented at right angles at impact.

TABLE 40

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Vertical Location of Damage

Location	Single		Multi	
	N	%	N	%
(A) Entire Height .	290	18.8	231	3.2
(H) Top of Frame to Top of Vehicle .	15	1.0	15	0.2
(E) Everything Below Glass	1041	67.4	6765	93.7
(L) Top of Frame, Frame, and Below	84	5.4	0	0.0
(M) Top of Frame to Glass or Hood . .	114	7.4	212	2.9
Total	1544	100.0	7223	100.0

A measure of crash severity is available in the NCSS data as the reported Delta-V (the change in velocity at impact). Table 44 shows this distribution in 5-mile-per-hour groups. The differences are mixed, and these could possibly be explained by differences in the method of computing Delta-V as well as by real differences. Cars in multi-vehicle crashes show a substantially higher frequency between 6 and 15 mph.

TABLE 41

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Type of Damage Distribution

Type	Single		Multi	
	N	%	N	%
(W) Wide Area Impact .	851	55.1	6236	86.3
(N) Narrow Area Impact	242	15.7	86	1.2
(S) Sideswipe	415	26.9	651	9.0
(E) Corner	36	2.3	250	3.5
Total	1544	100.0	7223	100.0

Objects struck by (or striking) the side impacted car are shown in Tables 45 and 46. Table 45 (from FARS) identifies trees, utility poles, and railroad trains as the most frequent offending object. These three items account for 73% of the single-vehicle fatal cars. The multiple-vehicle coding is not very detailed, and adds little information.

Table 46 provides a breakdown of striking vehicle types for NCSS with a coding similar to FARS for fixed objects. Of interest is the fact that guardrails account for 13.8% of the towed single vehicles as compared with only 3% of the fatal single vehicles. Railroad trains are grouped with two-vehicle crashes in NCSS, but account for only a small percentage of the towaways in any case.

TABLE 42

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Direction of Impact Force

Direction (clock points)	Single		Multi	
	N	%	N	%
00 (non-horizontal)	30	1.9	11	0.2
1	327	21.6	569	7.9
2	165	10.9	2270	31.5
3	131	8.7	261	3.6
4	65	4.3	279	3.9
5	34	2.2	157	2.2
6 (rear)	4	.3	21	.3
7	12	.8	243	3.4
8	88	5.8	334	4.6
9	104	6.9	384	5.3
10	169	11.2	1714	23.8
11	159	10.5	803	11.1
12 (front)	256	16.9	177	2.5
Total	1514	100.0	7212	100.0

Door performance is noted in Tables 47 and 48. Table 44 indicates that in single-vehicle crashes doors opened 17% of the time as compared with 8.7% in multi-vehicle crashes. The left front door is the one which is reported to have opened most often. Table 48 indicates

TABLE 43

NCSS 1
Distribution of Derived Relative Headings of Vehicles
Striking Case Vehicles

Clock Direction	Relative Heading		Impact Force Direction	
	N	%	N	%
12	20	1.6	19	1.3
1	11	0.9	100	6.7
2	42	3.4	497	33.3
3	419	33.8	67	4.5
4	64	5.2	67	4.5
5	33	2.7	23	1.5
6	53	4.3	2	0.1
7	41	3.3	35	2.3
8	57	4.6	59	4.0
9	363	29.3	79	5.3
10	66	5.3	411	27.5
11	69	5.6	138	9.2
TOTAL	1238	100	1492	100

relatively little differences between single- and multiple-vehicle crashes, but reports the left front door latch/hinge damage more often. This is interesting, since Table 37 indicated more right-side impacts.

Intrusion was coded by major component in the Phase 1 portion of NCSS. This is displayed in Table 49. While the overall proportion of intrusion is about the same in single-and multiple-vehicle crashes (40%), multi-vehicle crashes account for all of the sill override cases, and single-vehicle crashes account for nearly all of the roof involvement.

TABLE 44

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Total Delta-V: Derived From Damage

Delta-V (in mph)	Single		Multi	
	N	%	N	%
1-5 . . .	138	23.8	534	12.4
6-10 . . .	189	32.5	1708	39.5
11-15 . .	119	20.5	1271	29.4
16-20 . .	81	13.9	481	11.1
21-25 . .	31	5.3	162	3.7
26-30 . .	16	2.8	92	2.1
31-35 . .	1	0.2	40	0.9
36-40 . .	2	0.3	22	0.5
41-45 . .	0	0.0	8	0.2
46-50 . .	0	0.0	2	0.0
51-55 . .	0	0.0	0	0.0
56-60 . .	2	0.3	0	0.0
61-65 . .	2	0.3	2	0.0
Total	581	100.0	4322	100.0
M.D.	963		2901	

TABLE 45

FARS 1979
Fatal Side-Impacted Vehicle Counts For
Single-Vehicle vs. Multi-Vehicle Involvements

Most Harmful Event (object struck)

Harmful Event	Single		Multi	
	N	%	N	%
Non-collisions:	53	3.4	29	0.8
Fire/Explosion	27	1.7	15	0.4
Immersion	14	0.9	4	0.1
Gas Inhalation	1	0.1	0	0.0
Fell from Vehicle . . .	10	0.6	10	0.3
Other Non-collision . .	1	0.1	0	0.0
Collisions:	1506	96.6	3506	98.0
Not Fixed Objects:	243	15.6	3403	96.3
R.R. Train	189	12.1	3	0.1
Vehicle in Transport . .	0	0.0	3323	94.0
Veh. in Other Roadway .	0	0.0	73	2.1
Parked Vehicle	51	3.3	4	0.1
Other Object (not fixed)	3	0.2	0	0.0

Cont'd on next page

3.3 Occupant Descriptors

Table 50 shows the distribution of occupant age for single- and multiple-vehicle crashes reported in NCSS. In single-vehicle crashes 44% of the occupants are under the age of 20, as compared with 30% in multi-vehicle crashes. This suggests that the age factor might be considered in comparing injury statistics of single- and multiple-vehicle crashes.

TABLE 45 (Cont'd)

Harmful Event	Single		Multi	
	N	%	N	%
Collisions (cont'd):				
Fixed Objects:	1263	81.0	103	1.7
Building	19	1.2	10	0.3
Culvert/Ditch	29	1.9	4	0.1
Curb/Wall	15	1.0	4	0.1
Divider	2	0.1	0	0.0
Embankment	30	1.9	7	0.2
Fence	9	0.6	1	0.0
Guard Rail	47	3.0	4	0.1
Light Support	45	2.9	5	0.1
Sign Post	17	1.1	2	0.1
Tree/Shrubbery	615	39.4	26	0.7
Utility Pole	337	21.6	37	1.0
Other Pole	27	1.7	0	0.0
Other Fixed Object	19	1.2	1	0.0
Bridge/Overpass	52	3.4	2	0.0
Total	1559	100.0	3535	100.0
M.D.	1		3	

Another major occupant difference is seen in Table 51 where males account for 72% of the occupants in single-vehicle crashes compared with 51% in multiple-vehicle crashes.

Ejection, either partial or complete, is more common in single-vehicle side-impact crashes than in multi-vehicle crashes. Table 52 shows both ejection and entrapment in a single display. Adding the various ejection categories, 4.3% of the occupants in single-vehicle crashes were ejected as contrasted to 1.1% in the multi-vehicle case, a ratio of almost 4 to 1. A similar ratio obtains for entrapment, where the figures are 2.4% (single) and 0.6% (multiple).

TABLE 46

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Object Struck in Impact

Object Struck	Single		Multi	
	N	%	N	%
Passenger car:	0	0.0	5754	79.7
Sub-compact	0	0.0	850	11.8
Compact	0	0.0	1247	17.3
Intermediate	0	0.0	1570	21.7
Standard (Full Size) . .	0	0.0	1727	23.9
Luxury/Limousine	0	0.0	362	5.0
Truck:	0	0.0	948	13.1
Truck (to 10,000 lb) . .	0	0.0	712	9.9
Truck (over 10,000 lb) .	0	0.0	106	1.5
Tractor-trailer	0	0.0	124	1.7
Tractor	0	0.0	6	0.1
Bus:	0	0.0	21	0.3
School Bus	0	0.0	12	0.2
Other Bus	0	0.0	9	0.1
Other Vehicle:	0	0.0	50	0.7
Trailer (non-commercial)	0	0.0	1	0.0
R. R. Train	0	0.0	22	0.3
Other Vehicle	0	0.0	17	0.2
Motorcycle/Moped	0	0.0	10	0.1
Unknown Vehicle	0	0.0	368	5.1

Table Cont'd

Tables 53 and 54 show the ejection rates for seriously injured victims of side impacts. Table 53 gives the rates for fatalities in FARS, and Table 54 for seriously injuries in the NCSS. While the rates

Table 46 Cont'd

Object Struck	Single		Multi	
	N	%	N	%
Fixed Object:	1177	76.2	80	1.1
Tree (to 6 in diameter) .	50	3.2	0	0.0
Tree (over 6 in diameter)	270	17.5	15	0.2
Utility Pole	307	19.9	25	0.3
Breakaway Pole	12	0.8	0	0.0
Culvert/Ground/ R. R. Tracks/Curb . . .	139	9.0	0	0.0
Abutment/Retaining Wall/ Bridge Support	24	1.6	5	0.1
Embankment	57	3.7	0	0.0
Building	12	0.8	10	0.1
Bridge Rail	48	3.1	0	0.0
Guard Rail	213	13.8	16	0.2
Other Not-movable Object	45	2.9	1	0.0
Movable Object	367	23.8	8	0.1
Total	1544	100.0	7223	100.0

are higher in the NCSS data, both Data set indicate the ejections are nearly twice as frequent in single-vehicle as in multi vehicle crashes. The frequency of ejection among the seriously injured is substantial in both sets, 16 percent for fatalities in FARS and 27 percent for AIS = 4+ injuries in The NCSS data, indicating that ejection in side impacts remains a significant problem.

Since ejections differed between the two crash types, it is interesting to look at the portals. Table 55 shows the distribution of ejection portal in the NCSS1 file for single- and multi-vehicle side-impact crashes. The side doors are the majority in both cases, but side

TABLE 47

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Doors Which Opened in Crash
SUMMARY

Door	Single		Multi	
	N	%	N	%
None Opened . . .	1284	83.2	6486	89.8
Left . .	155	10.2	319	4.5
Left Front	153	10.1	307	4.4
Left Rear	2	0.1	30	0.4
Right . .	94	6.2	269	3.8
Right Front . . .	94	6.2	247	3.5
Right Rear	2	0.1	28	0.4
Total (vehicles)	1513	N.A.	7048	N.A.
M.D.	31		175	

windows account for much more of the ejection in multi-vehicle than in single-vehicle accidents. The changes in the other portals are so small that they are of no practical significance.

Assigned AIS injury codes in the NCSS data were not infrequently reported as unknown because the precise value could not be determined. By taking account of other information in the the NCSS reports, many of the unknown injuries could be reassigned to broader groupings, thus reducing the extent of missing data. Two of the these injury distributions are shown in Tables 56 and 57. The first groups all

TABLE 48

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Door Latches or Hinges Damaged
SUMMARY

Latches/Hinges Damaged	Single		Multi	
	N	%	N	%
None Damaged . . .	876	56.7	4005	55.4
Left: .	369	25.3	1603	23.6
Left Front	347	23.8	1486	21.8
Left Rear	45	3.1	351	5.2
Right: .	321	22.0	1403	20.6
Right Front	299	20.5	1278	18.8
Right Rear	50	3.4	353	5.2
Total (vehicles)	1459	N.A.	6801	N.A.
M.D.	85		422	

overall AIS injuries of 0, 1 and 2 together and compares them with those of AIS-3 or above (including all fatalities). The second shows a split one level higher--AIS injuries of 0, 1, 2, and 3 vs. those of 4 and greater. The split in the latter table (grouping injuries of AIS-4 or above) corresponds to the level discussed in the advanced notice of proposed rulemaking. Single-vehicle side-impact crashes account for about twice the proportion of these serious injuries as do multi-vehicle crashes.

TABLE 49

NCSS 1
Side Impacts
Vehicle Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Intruding Components

Component	Single		Multi	
	N	%	N	%
No Intrusion	941	60.9	4289	59.4
Steering Column . . .	2	0.1	5	0.1
A-Pillar	7	0.5	70	1.0
Steering Column and A-Pillar . . .	3	0.2	1	0.0
Side	316	20.5	1632	22.6
Side - with Sill Override . . .	0	0.0	897	12.4
Roof	125	8.1	22	0.3
Rear-end	0	0.0	9	0.1
Other Area Combination	146	9.5	203	2.8
Unknown	4	0.3	95	1.3
Total	1544	100.0	7223	100.0

Table 58 shows the distribution of seat occupancy for side-impacted vehicles in the two crash categories. Cars in multi-vehicle crashes have a somewhat higher rear seat occupancy, and a larger average number of occupants (1.55 occupants per vehicle for single vs. 1.65 for

TABLE 50

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Side Impacts
(weighted)

Occupant Age

Age (years)	Single		Multi	
	N	%	N	%
0-4 . . .	29	1.2	403	3.4
5-9 . . .	42	1.8	437	3.7
10-14 . .	86	3.6	525	4.4
15-19 . .	883	37.4	2199	18.6
20-24 . .	631	26.7	2020	17.0
25-34 . .	378	16.0	2402	20.3
35-44 . .	166	7.0	1352	11.4
45-54 . .	65	2.7	1091	9.2
55-64 . .	58	2.5	717	6.0
65-74 . .	6	.3	420	3.5
Over 74 .	20	.8	287	2.4
Total	2364	100.0	11853	100.0
M.D.	34		184	

multiple). Left-side occupancy is about 1.2% higher than right for those cars in single-vehicle crashes. About two-thirds of all occupants are in left seats in these cars, regardless of the collision type.

TABLE 51

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Occupant Sex

Sex	Single		Multi	
	N	%	N	%
Male	1716	71.6	6063	50.9
Female:	682	28.4	5854	49.1
Female - Not Pregnant . .	588	24.5	4852	40.7
Female - Pregnant	0	0.0	49	0.4
Female - Pregnancy Unknown	94	3.9	953	8.0
Total	2398	100.0	11917	100.0
M.D.	0		120	

A further aspect of the seat location information just presented is whether or not the occupants are on the near side or far side relative to the impact. That relationship in the NCSS data is shown in Table 59, with 48.5 percent of all occupants having nearside exposure. The corresponding exposures among FARS fatalities is 58.9 percent nearside in single-vehicle impacts, and 65.0 percent in multi-vehicle crashes, for an aggregate of 63.2% nearside exposures. The relationships between nearside/farside exposure and injury in these to accident types is shown in Table 60. In every case the proportion of occupants with injuries at or above a given level is about twice as high in nearside exposures as farside. Further, in all cases, the single-vehicle proportions are nearly twice the multi-vehicle proportions. These phenomena are

TABLE 52

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Ejection/Entrapment

Ejection/Entrapment	Single		Multi	
	N	%	N	%
Not Ejected or Trapped .	2184	93.5	11716	98.3
Complete Ejection . . .	72	3.1	94	0.8
Partial Ejection	26	1.1	31	0.3
Partial Ejection and Trapped	2	0.1	1	0.0
Ejected - Degree Unknown	0	0.0	1	0.0
Trapped	53	2.3	70	0.6
Total	2337	100.0	11913	100.0
M.D.	61		124	

essentially independent, so that a nearside occupant in a single-vehicle crash has about four times the risk of a farside occupant in a multi-vehicle accident.

For more than half of the case vehicles reported in the NCSS program, a value of the change of velocity at impact (Delta-V) has been computed. Although there is considerable missing data on this variable, and more missing for single-than multi-vehicle cases, the proportion of injuries by Delta-V is of interest. Table 61 shows the the Delta-V distribution (and the percent injured at AIS-4 or greater) for

TABLE 53

FARS 1979
Fatally Injured Occupants of Side-Impacted Vehicles
for Single-Vehicle vs. Multi-Vehicle Involvements

Occupant Ejection

Ejection	Fatally Injured Occupants			
	Single		Multi	
	N	%	N	%
Not Ejected	1673	77.2	4331	86.7
Ejected	488	22.5	625	12.5
Total Ejection	399	18.4	508	10.2
Partial Ejection	89	4.1	117	2.3
Unknown	7	0.3	37	0.7
Total	2168	100.0	4993	100.0

single- and multi-vehicle impacts. For both accident types half of the occupants were in crashes with a reported Delta-V of ten miles per hour or less. Table 62 shows the same data in a cumulative distribution of Delta-V for occupants injured at the same severity level. Nearly half of the seriously injured occupants were in crashes less than 20 miles per hour (for single-vehicle impacts) and 25 miles per hour for multi-vehicle impacts.

Occupant ejection by type of striking vehicle (and single-vehicle crashes) is shown in Table 63 for all occupants, and for fatalities. The first column -- for both sets of occupants -- is the total number of occupants of the class in cars struck by each type of vehicle. The number (and percent) of these occupants who were ejected are given in

TABLE 54

NCSS 1
Seriously Injured Occupants For Single- vs. Multi - Vehicle Impacts
(weighted)

Ejection Among Occupants With AIS = 4+

Ejection	Single		Multi	
	N	%	N	%
Ejected	25	39.1	32	21.9
Not Ejected	39	60.9	114	78.1
Total	65	100.0	146	100.0
M.D.	16		45	

the next 2 columns. The fourth column of numbers (percent Ejected by Vehicle) is the column percent for ejectees, i.e., the distribution of striking vehicle types among the ejected occupants. The cases with missing data on ejection (labeled M.D.) are not included in the total columns, and thus do not influence the percentages shown.

While impacts by passenger cars account for 32 percent of all ejections (from passenger cars), they account for only 19 percent of the ejections among fatally injured occupants. Single-vehicle accidents and large-truck crashes account for 51 percent of all ejections and 69 percent among the fatalities. This results from the much greater likelihood of ejection from the these crashes, which more than offsets the higher frequency of passenger car impacts.

TABLE 55

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Ejection Portals
(for ejected occupants only)

Portal	Single		Multi	
	N	%	N	%
Side Windows	9	13.0	38	37.6
Side Doors .	49	71.0	54	53.5
Windshield .	4	5.8	1	1.0
Rear Window	1	1.4	6	5.9
Roof	2	2.9	0	0.0
Other . . .	4	5.8	2	2.0
Total . .	69	100.0	101	100.0
M.D. .	31		26	

Tables 64 and 65 give the distribution of the striking vehicle type for side-impact fatalities in FARS, and among all occupants and among those with injuries of AIS = 4+ in NCSS. In both data sets, passenger car impacts account for about one-third of the fatal or serious injuries. On the other hand, single-vehicle and large-truck impacts account for half, and light trucks for about 15 percent.

Table 66 gives the occupant exposure (near side, far side) and injury by the specific horizontal area of impact in the CDC. Near-side occupants received a greater proportion of serious injury than did far-

TABLE 56

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Overall Injury Severity
Greater Than AIS-2

Injury Severity (AIS)	Single		Multi	
	N	%	N	%
0 - 2	1964	92.8	9730	95.9
3 or Greater, or Fatal .	153	7.2	421	4.1
Total .	2117	100.0	10151	100.0
M.D. .	281		1886	

side occupants for all impact areas except front and back. In these cases the injury rate is so low that comparisons are meaningless. Distributed-damage impacts result in substantially more injury than other types. This may result from characteristics of the crashes that produce distributed damage patterns. In general, they require the side-impacted vehicle to have considerable forward velocity. The mean delta-V for the same combinations of exposure and specific impact areas is given in Table 67 vs. injury level. As one might expect from Table 66, the distributed impacts have the highest delta-V's. Furthermore the mean delta-v's for occupants with serious injury (AIS = 4+) are all higher than the highest value for less seriously injured occupants.

TABLE 57

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Overall Injury Severity
Greater Than AIS-3

Injury Severity (AIS)	Single		Multi	
	N	%	N	%
0 - 3	2260	96.6	11615	98.4
4 or Greater, or Fatal .	80	3.4	191	1.6
Total .	2340	100.0	11806	100.0
M.D. .	58		231	

TABLE 58

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Occupant Seat Location

Seat	Single		Multi	
	N	%	N	%
Front:	2170	90.6	10314	86.2
Front - Left	1544	64.5	7232	60.4
Front - Center	90	3.8	449	3.8
Front - Right	536	22.4	2628	22.0
Front - Other/Unknown .	0	0.0	5	0.0
Second:	223	9.3	1650	13.8
Second - Left	78	3.3	632	5.3
Second - Center	38	1.6	309	2.6
Second - Right	94	3.9	622	5.2
Second - Other/Unknown	13	0.5	87	0.7
Third Unknown	2	0.1	4	0.0
Total	2395	100.0	11968	100.0
M.D.	3		69	

TABLE 59

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Exposure of Occupants to (near side,far side) Impact

Exposure	Single		Multi	
	N	%	N	%
Near Side	1100	46.1	5825	49.0
Far Side	1280	53.7	6048	50.9
Other/Unclassifiable	4	0.2	14	0.1
Total	2384	100.0	11887	100.0
M.D.	14		150	

TABLE 60

NCSS 1
Side Impacts
Occupant Injury Severity For Single-vs.
Multi- Vehicle Impacts By Exposure
(weighted)

Occupants With Known Injury Severity	Accident Type			
	Single-Vehicle		Multi-Vehicle	
	Near Side	Far Side	Near Side	Far Side
Proportion With:				
AIS=3-6,Fatal	9.3%	5.2%	5.8%	2.5%
N	91	58	283	130
AIS=4-6,Fatal	3.9%	2.8%	2.0%	1.1%
N	42	35	117	67
Fatal	2.7%	1.9%	1.3%	0.7%
N	30	24	74	45

TABLE 61

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Percent of Occupants with AIS = 4-6,Fatal
by Delta-V

Delta-V (mph)	Single		Multi		Both	
	N (total)	% (inj.)	N (total)	% (inj.)	N (total)	% (inj.)
1-5 . . .	234	0	922	0	1156	0
6-10 . .	285	1.4	2857	0.1	2857	0.2
11-15 . .	202	0.5	1946	0.8	2148	0.7
16-20 . .	115	7.8	695	2.6	810	3.3
21-25 . .	60	8.3	222	6.8	282	7.1
26-30 . .	28	14.3	192	9.9	220	10.5
31-35 . .	2	100.0	53	41.5	55	43.6
36-40 . .	4	0	32	34.4	36	30.6
41-45 . .	0	-	13	38.5	13	38.5
46-50 . .	0	-	2	100.0	2	100.0
51-55 . .	0	-	0	-	0	-
56-60 . .	3	100.0	0	-	3	100.0
61-65 . .	5	40.0	5	100.0	10	70.0
Total	938	3.2	6939	1.6	7877	1.8
M.D.	1402	-	4867	-	6269	-

TABLE 62

NCSS 1
Side Impacts
Occupant Counts For Single- vs. Multi-Vehicle Impacts
(weighted)

Cumulative Distribution of Delta-V for
Injured Occupants With AIS = 4-6,Fatal

Delta-V (mph)	Single		Multi		Both	
	N	%	N	%	N	%
1-5 .	0	0.0	0	0.0	0	0.0
6-10	4	13.3	2	1.8	6	4.2
11-15	5	16.7	17	14.9	22	15.3
16-20	14	46.7	35	30.7	49	34.0
21-25	19	63.3	50	43.9	69	47.9
26-30	25	83.3	91	79.8	116	80.6
31-35	25	83.3	91	79.8	116	80.6
36-40	25	83.3	102	89.5	127	88.2
41-45	25	83.3	107	93.9	132	91.7
46-50	25	83.3	109	95.6	134	93.1
51-55	25	83.3	109	95.6	134	93.1
56-60	28	93.3	109	95.6	137	95.1
61-65	30	100.0	114	100.0	144	100.0

TABLE 63

NCSS 1
Side Impacts
Occupant Ejection by Type of Striking Vehicle
(weighted)

Striking Vehicle	All Occupants					Fatally Inj Occup				
	Occupants (no M.D.)	Ejected		Percent Ejected by Veh.	M.D.	Occupants (no M.D.)	Ejected		Percent Ejected by Veh.	M.D.
		N	%				N	%		
Single Vehicle	2447	102	4.2	45.1	63	43	20	46.5	47.6	17
Passenger Car	9667	73	0.8	32.3	70	39	8	20.5	19.0	13
Small Truck .	1108	28	2.5	12.4	27	8	1	12.5	2.4	14
Large Truck .	369	14	3.8	6.2	17	23	9	39.1	21.4	9
Railroad . . .	39	8	20.5	3.5	2	9	4	44.4	9.5	2
Other	608	1	0.2	0.4	6	2	0	0	0	1
Total . .	14238	226	1.6	100.0	185	124	42	33.9	100.0	56

TABLE 64

FARS 1979
Passenger Car Fatalities by Type
of Striking Vehicle

Striking Vehicle	Fatalities	
	N	%
Passenger Cars	1800	30.8
Light Trucks	848	14.5
Heavy Trucks/Buses	752	12.9
Other two Veh./Unk. Veh.	274	4.7
Single Vehicle Accidents	2168	37.1
Total	5842	100.0

TABLE 65

NCSS1
Side Impacts
Occupant Counts For Type of Striking Vehicle
(weighted)

Striking Vehicle	All Occupants		Occupants with AIS = 4+	
	N	%	N	%
Passenger Cars	9574	67.7	93	34.3
Light Trucks	1111	7.9	32	11.8
Heavy Trucks/Buses	381	2.7	39	14.4
Fixed Objects	2458	17.4	86	31.7
Other	622	4.4	21	7.7
Total	14146	100.0	271	100.0

TABLE 66

NCSS 1
Side Impacts
Front Seat Occupants

Exposure and Injury By Specific Area of Impact

Exposure/Area of Impact	Exposed Occupants	Occupants With AIS = 4+	
		N	%
Near Side	4066	93	2.29
Front (F)	948	8	0.84
Back (B)	1033	4	0.39
Dist. (D)	191	14	7.33
Pass. Comp. (P)	459	20	4.36
Frnt., Pass. (Y)	733	27	3.68
Back, Pass. (Z)	702	20	2.85
Far Side	4766	72	1.51
Front (F)	1000	6	0.60
Back (B)	1284	17	1.32
Dist. (D)	243	12	4.94
Pass. Comp. (P)	568	7	1.23
Frnt., Pass. (Y)	775	19	2.45
Back, Pass. (Z)	896	11	1.23
All Occupants	10012	182	1.82
Front (F)	2310	16	0.69
Back (B)	2539	22	0.86
Dist. (D)	452	28	6.19
Pass. Comp. (P)	1125	29	2.58
Frnt., Pass. (Y)	1737	49	2.82
Back, Pass. (Z)	1849	38	2.06

TABLE 67

NCSS 1
Side Impacts
Front Seat Occupants

Delta-V by Exposure and Specific area
of Impact and Injury Severity

Exposure/Area of Impact	Mean Delta-V (mph)	
	AIS = 0-3	AIS = 4+
Near Side	10.9	25.6
Front (F)	8.6	17.9
Back (B)	10.2	25.8
Dist. (D)	14.1	35.1
Pass. Comp. (P)	11.4	24.0
Frnt., Pass. (Y)	13.1	23.7
Back, Pass. (Z)	12.0	26.1
Far Side	11.4	30.3
Front (F)	9.1	22.2
Back (B)	10.6	24.4
Dist. (D)	14.7	39.7
Pass. Comp. (P)	12.8	33.3
Frnt., Pass. (Y)	13.7	30.8
Back, Pass. (Z)	11.4	31.1
All Occupants	11.1	27.2
Front (F)	8.6	18.8
Back (B)	10.4	25.7
Dist. (D)	14.4	36.2
Pass. Comp. (P)	12.3	26.2
Frnt., Pass. (Y)	13.6	26.3
Back, Pass. (Z)	11.6	26.8

APPENDIX

Clinical Study of 53 Fatal Accidents Involving a Side-Impact to a Passenger Vehicle

For the 53 fatal side-impact crashes reported in the NCSS Phase I program, the original case reports and photographs were reviewed in detail. To the extent possible, information was retrieved for the following aspects:

(1) Case vehicle description--make, model, number of doors, the presence of an upper B-pillar, etc.

(2) A description of the specific area damaged.

(3) The extent that the roof rail and door sill were involved.

(4) The CDC's and Delta-V's.

(5) Door performance--latch, hinge, etc.

(6) Ejection of occupants.

(7) Lateral intrusion in the passenger compartment.

(8) Occupant position, restraint usage, injury and injury causation.

(9) In most cases, a judgment was made as to whether or not the intrusion increased the severity of the injury.

The cases are arbitrarily numbered A-1 through A-53, and are presented in that order. At the upper left corner of each review is the NCSS identifying number with which further material may be retrieved from computer or "hard copy" files. A photograph is included with 45 of the cases.

The cases are grouped by accident type. The four groups (with their case numbers) are:

(1) Single vehicle, A-1 to A-10
(2) Impacts with passenger cars or light trucks, A-11 to A-38
(3) Impacts with large trucks, A-39 to A-46
(4) Impacts with railroad trains, A-47 to A-53

This breakdown is shown in Figure 11, which gives the number of accidents of each type as well as the number of fatalities. The distribution of fatalities by type of accident is compared with the fatalities by type of accident is compared with the fatalities in side-impacted passenger cars in the 1979 FARS file in Table 68. The single-vehicle involvements are substantially lower in the NCSS review sample, while the large-truck and railroad cases are correspondingly greater. While these differences may result from the relatively small number of cases reviewed in the NCSS sample, the differences are statistically significant at the two percent level.

Figures 12 through 15 show each of the four groups broken down by (1) ejection of an occupant, (2) intrusion into the passenger compartment, (3) involvement of the door sill/rocker panel, side-roof rail, or both. The boxes representing empty subgroups are omitted. For example, Case A-3 (single-vehicle crash with no ejection) did not have either the roof rail or sill involved, so there is no division of the no-intrusion group containing only A-3.

Occupants were ejected from 14 (26%) of the vehicles. It is interesting to note that, while the single-vehicle, large truck, and railroad cases had high ejection frequencies (60, 50, and 43 percent respectively), the rate for cars struck by other passenger cars or light trucks was only 3.6 percent. While the number of cases is small, the much lower incidence for collisions with passenger cars is significant and interesting. These figures are based on all occupants in the subject vehicles. Ejection among all fatal occupants of side-impacted cars in the NCSS file is shown in Table A2 for comparison. The percentages shown are the percent of fatally-injured occupants (for each

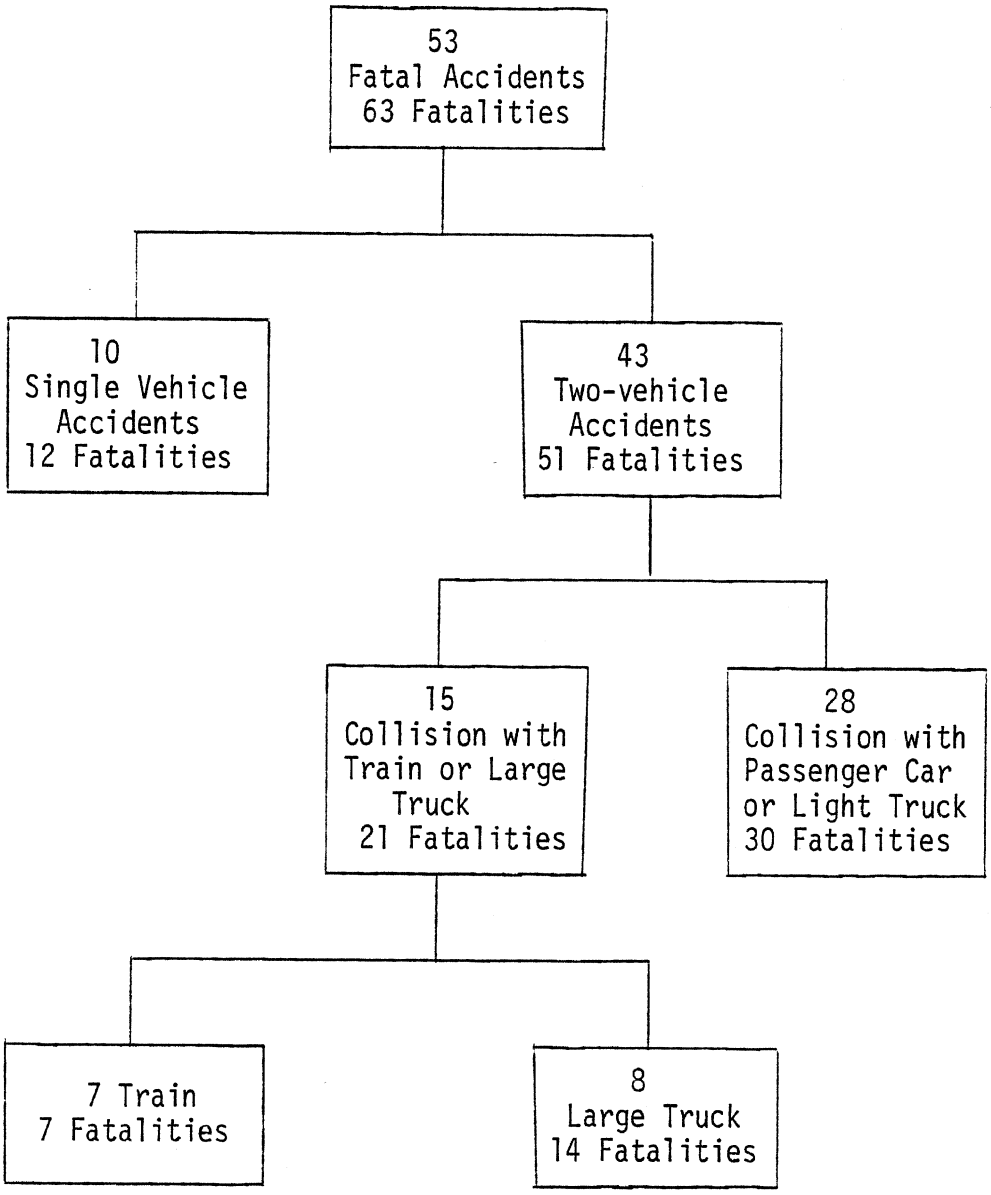


FIGURE 11

Numbers of Vehicles and Fatalities by Type of Accident

Table 68

Comparison of Fatal NCSS Review and FARS 1979

Accident Type	Distribution of Fatalities and Percent			
	NCSS Fatal Review		FARS 1979	
	N	%	N	%
Single Vehicle	30	47.6	1870	33.6
Passenger Car Light Truck .	30	47.6	2648	47.6
Large Truck .	14	22.2	752	13.5
Railroad Train	7	11.1	297	5.3
Total	63	100	5567	100

accident type) who were ejected. The totals exclude the 55 occupants with missing data on ejection. The contrast in ejection rates between collisions with passenger cars and other accident types is not as great in Table 69. Nevertheless, only 21 percent of the fatal ejections resulted from impacts with passenger cars. Nearly half (48%) were in single-vehicle accidents.

The corresponding figures for all occupants are shown in Table 70. Here the relative likelihood of ejection is much lower in collisions with passenger cars than in the other types of accidents. Although the probability of ejection in collisions with passenger cars is low, the large number of collisions of this type results in nearly half of all ejections.

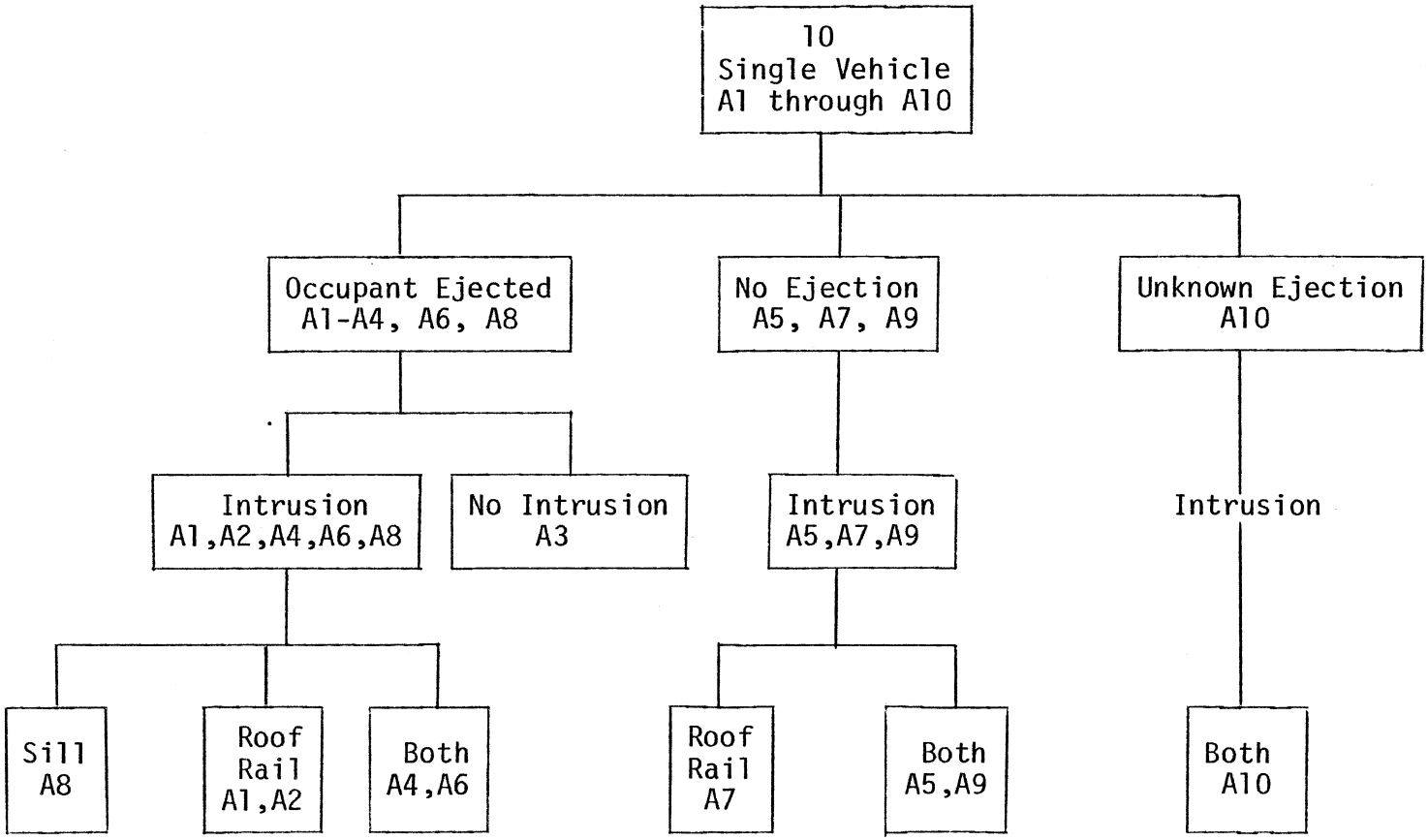


FIGURE 12

Ejections, Intrusions, and Sill/Roof Rail Involvement for Single-Vehicle Impacts

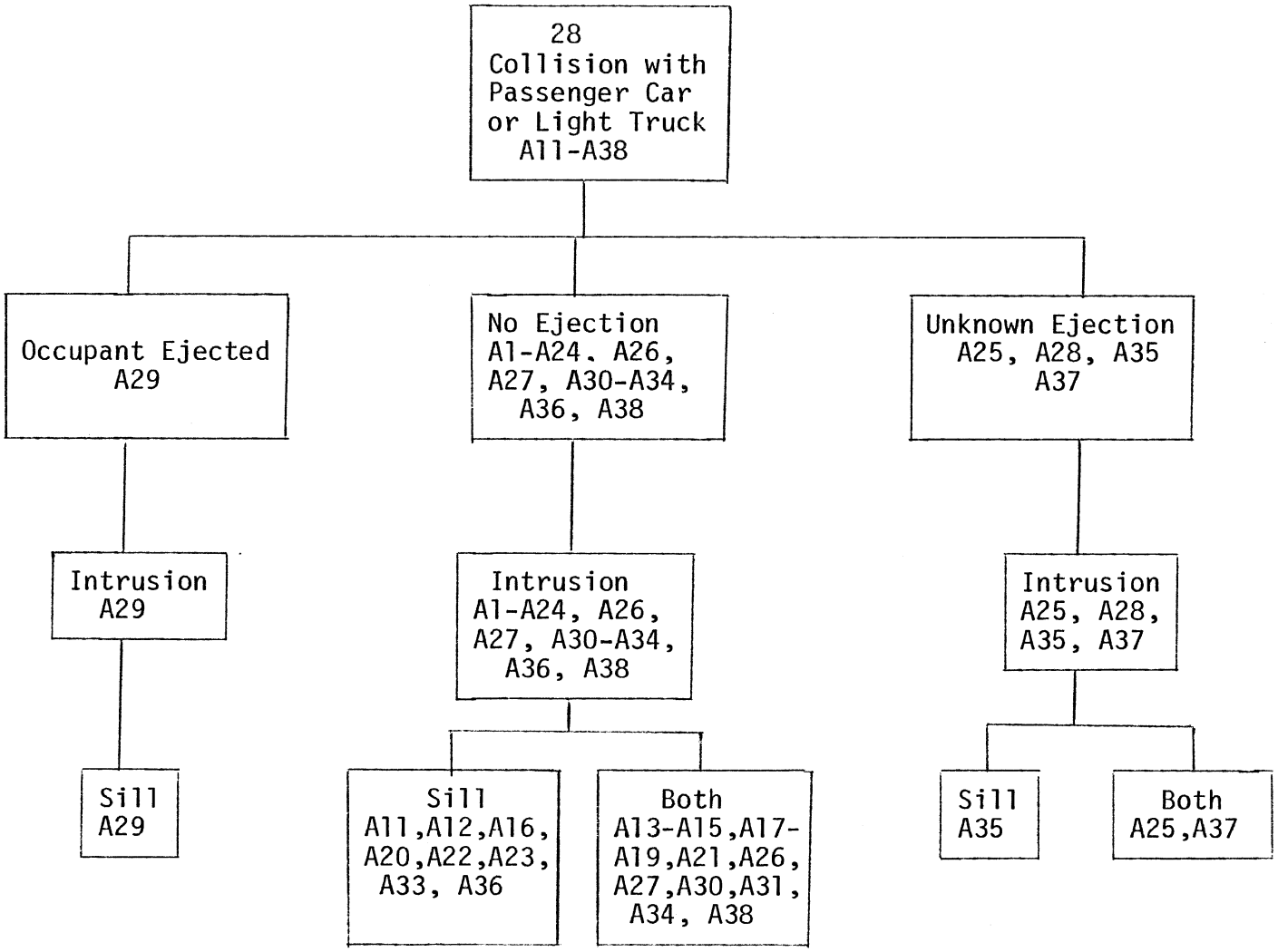


FIGURE 13

Ejections, Intrusions, and Sill/Roof Rail Involvements for Impacts by Passenger Cars or Light Trucks

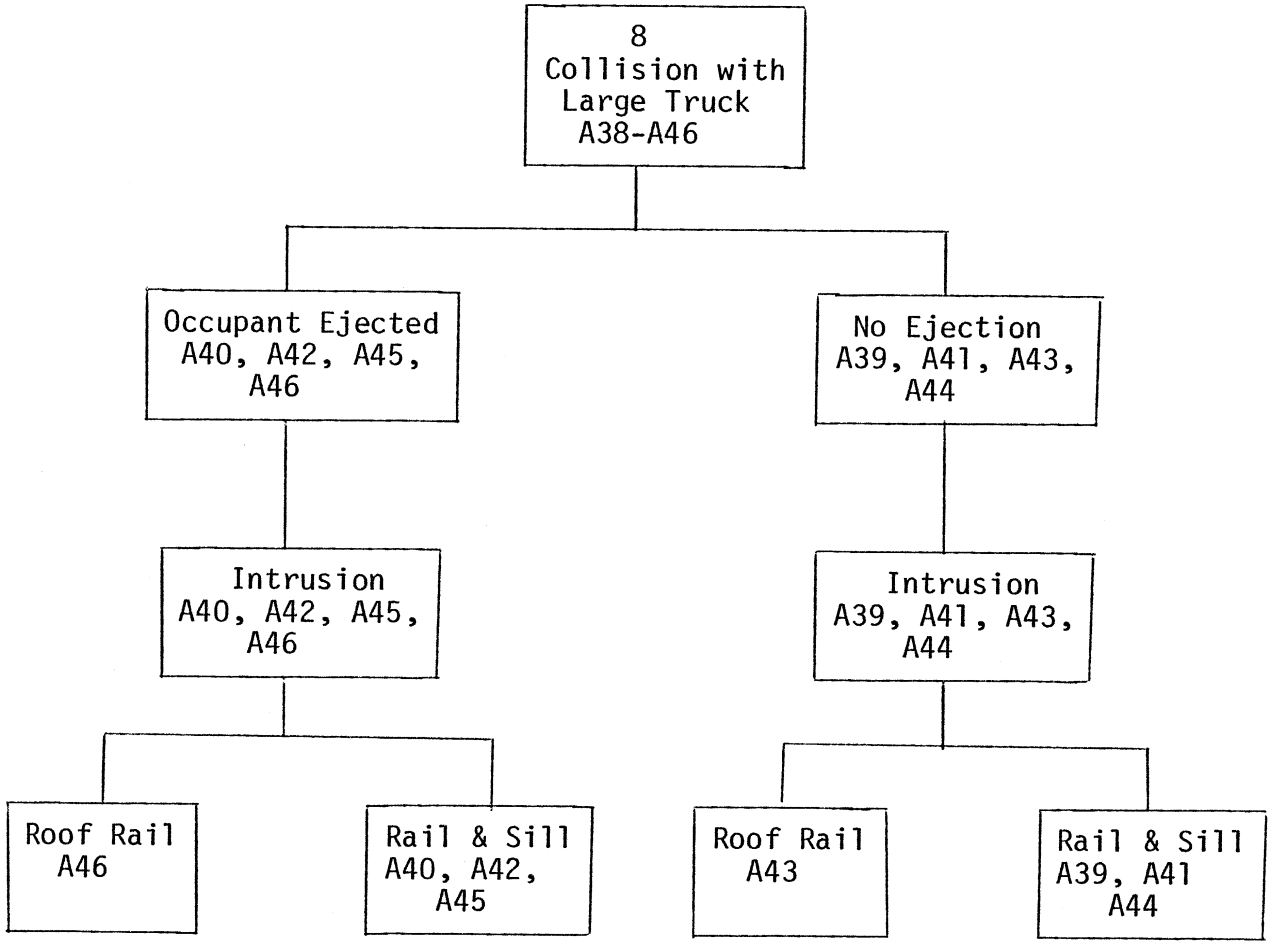


FIGURE 14

Ejections, Intrusions, and Sill/Roof Rail Involvements for Impacts by Large Trucks

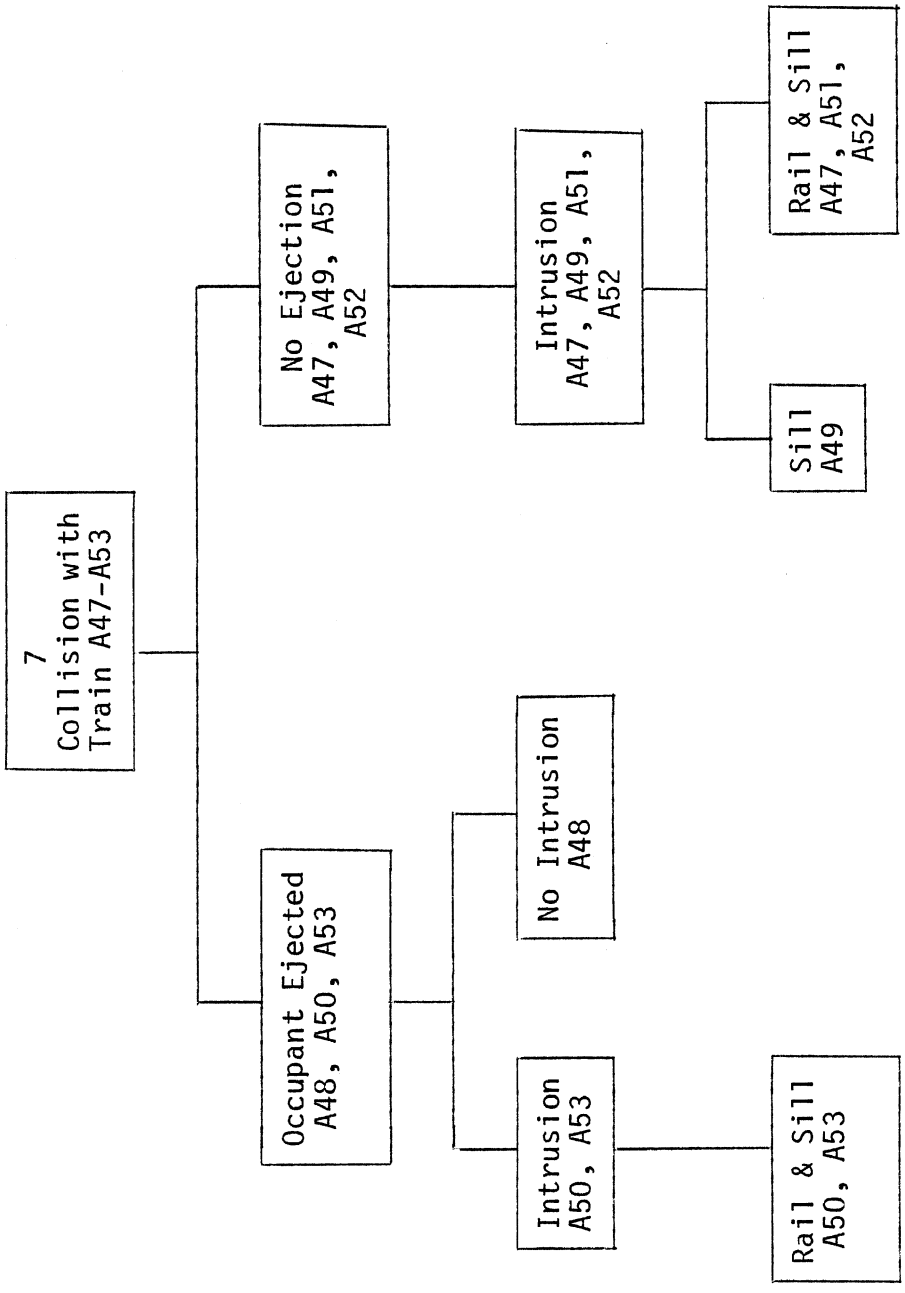


FIGURE 15

Ejections, Intrusions, and Sill/Roof Rail Involvements for Impacts by Railroad Locomotives

Table 69

Fatal Occupants in Side Impacts
Occupant Ejection (weighted)

Accident Type	Ejected Occupants		Total Occupants
	N	%	N
Single-Vehicle	20	46.5	60
Passenger Car or Small Truck	9	19.1	74
Large Truck .	9	39.1	32
Railroad Train	4	44.4	11
Total	42	23.7	177

Table 70

All Occupants in Side Impacts
NCSS1 Occupant Ejection (weighted)

Accident Type	Ejected Occupants		Total Occupants
	N	%	N
Single Vehicle	102	4.2	2447
Passenger Car or Small Truck	101	0.9	10775
Large Truck .	14	3.8	369
Railroad Train	8	20.5	39
Other/Unknown Vehicle . . .	1	0.2	608
Total	226	1.6	14238

These results indicate that, while nearly half of all ejections result from collisions with passenger cars or small trucks, only 21 percent of the fatal ejections result from such collisions. Over twice as many (48 %) of the fatalities resulted from single-vehicle accidents.

The high incidence of ejection among the fatalities in the NCSS data is clearly connected with the low restraint usage among all occupants. This raises the question of how many fatalities might be prevented in side impacts if restraints were universally used. It is not possible to determine with confidence whether a specific fatality would have been prevented if restraints had been worn. This is particularly true when the details of injuries or their sources (contacts) are unreported. Nevertheless, in reviewing these case reports a judgment was attempted as to whether the injury severity might have been reduced by proper restraint use.

In most of the cases of ejection, restraints were judged to be capable of reducing the injury severity. The exceptions were cases in which the fatal injuries resulted from intruding objects before ejection or cases of massive, catastrophic intrusion into the occupant space. Conversely, in the few cases in which the fatally-injured occupant was wearing restraints, they were judged not capable of reducing the injury level. They were also categorized as not relevant if the space occupied by a normally-seated person was severely intruded upon. There was a substantial number of cases for which the investigator was unable to determine the cause of injury, or the injury details themselves were not recorded. In other cases, the photography was not adequate to provide the reviewer with an adequate description of damage in relation to occupant kinematics.

Using these criteria, restraints were judged relevant (their use would likely have reduced the severity of injuries) in 25% of the 64 fatalities. They were judged not relevant in 42% of the cases. The remaining 33% were cases in which judgements were not possible. Depending on the cases for which judgements were not possible, the results of the evaluation of the potential of restraints is that no more than 58% of the fatalities could be prevented by their universal use, while the proportion could be as low as 25%.

Intrusion of side interior surfaces of pillars into the passenger compartment occurred in nearly all of the cases reviewed. The only exceptions were case A-3 (with a CDC of 02-RFEW-7) and A-48 (with a CDC of 03-RFEW-8), both impacts into the side forward of the passenger compartment. Table 71 shows the intrusion in 5-inch increments. Both the number of fatal occupants in each group and the cumulative distribution are given.

The two cases in the 0-5 group are the two front-side impacts not involving the passenger compartment. The two fatalities in these cases (A3 and A48) resulted from ejections. Half of the fatalities occurred in cars with intrusion of over 16 inches, while only 15 percent were associated with intrusion of 10 inches or less.

The reviewers attempted to judge the relevance of intrusion to injury on an individual basis. In some cases the intrusion was clearly not relevant. Examples are cases of ejected occupants or intrusion of a component with which there was no occupant contact. Intrusion was judged not relevant to 35% percent of the fatalities. In a number of cases the intrusion apparently caused an injury or aggravated the

Table 71

Clinical Review
Intrusion into Passenger Compartment

Intrusion (inches)	Number of Fatalities	Cumulative Percent
0-5	2	3.3
6-10	7	15.3
11-15	11	33.9
16-20	9	49.9
21-25	14	72.9
26-30	4	79.7
31-35	6	89.8
36-40	6	100.0
Total	59	-
Missing	4	-

severity. The intrusion was thusly judged relevant to 46 percent of the fatally injured occupants. For the remaining 18 percent of the fatalities, the reviewers were not able to make a judgment.

While intrusion was judged relevant to nearly half the fatalities, it was usually impossible to conclude whether a reduction in intrusion would have prevented the fatality.

The roof side rail was involved (contacted or deformed) in 36 vehicles, while the rocker panel/door sill area was involved in 42. These include 30 cases in which both areas were involved. In only 5 cases was neither involved.

One of the objectives of the clinical review was to establish the probable source for the injury most likely to have caused the fatality. This was possible for 33 of the 63 fatalities. For the remaining 31, either the fatal injury, the associated contacts, or both, were missing in the original accident reports and could not be discerned in the review. The contacted areas for the known cases are shown in Table 72.

Table 72

Clinical Review
Occupant Contacts Associated with Fatal Injury

Contacted Area	Number of Fatalities
Pillars	10
A-Pillar	8
B-Pillar	1
C-Pillar	1
Side Surfaces	10
Roof	1
Side Roof Rail	4
Window Frame	1
Tree	1
Ground	1
Pole	1
Other Vehicle Locomotive	4
Unknown	31

Of the 33 fatalities with non-missing data, 10 resulted from contact with pillars, 10 from the interior side surfaces, 5 from the roof rail or window frame, and 7 from exterior objects. Thus two-thirds

were associated with either pillars or side surfaces. While the number of cases is small, it is evident that a number of objects are involved in the fatal injuries. Side surfaces are the most frequently involved, but represent only a third of the listed fatal contacts. On the other hand, the A-pillar was involved nearly as often.

The major conclusion that is evident from examining these cases is that they are nearly all very severe crashes. In a large majority there was substantial compromise of the integrity of the passenger compartment. They represent only fatal cases, and thus are biased in severity. However, nearly two-thirds of all side-impact occupants with an AIS of 4 or greater become fatalities. Thus these cases reviewed represent a large portion of the AIS-4+ cases.

Side roof rail or door sill/rocker panel area involvement occurred in nearly all of these cases. Sill area involvement was particularly frequent in impacts by other passenger cars, while roof rails were involved in three-quarters of the single-vehicle, large truck, and railroad accidents.

CASES A1-A9
Single Vehicle Side Impact Crashes

CASE # 4711032/A-1

1976 Pontiac Sunbird 2-door with B-pillar slid into a large tree striking the left door near the A-pillar. The vehicle apparently tipped up as it struck--the sill was not engaged, and the roof rail was engaged the full amount. The maximum penetration at the front of the door and the A-pillar was 25 inches.

CDC (Case Vehicle)	11 LYAW 4
Delta-V's	Not Computed

COMMENTS:
The left front door latch released, the door hinges separated, and the door opened. The maximum intrusion was 20 inches at the A-pillar. The driver was ejected through the open door. The roof side rail intruded. Intrusion was regarded as a factor in the injuries..

OCCUPANTS(1):

Driver, 21 years, unrestrained, OAIS-6, FATAL ejected through door, struck tree with head probably before ejection. Fatal injury was head injury from tree. Other injuries from unknown source include: chest, fractured neck, fractured face, fractured left upper arm.

CASE # 3712053/A-2

1975 Oldsmobile Cutlass Supreme 2-door with B-pillar slid into an abutment striking the right side of the vehicle just behind the B-pillar. The maximum penetration was 28 inches (B-pillar).

CDC (Case Vehicle)	02 RZAW 4
Total Delta-V	18 mph.
Long. Delta-V	-09 mph.
Lat. Delta V	-15 mph.

COMMENTS:
Right front door latch damage. No hinge damage. No doors opened. Intruding components: side panels, A-, B-, C-pillars, roof side rail. Maximum intrusion: 28 inches (B-pillar). Driver contacted Steering Wheel, Instrument Panel and Windshield. Windshield broken and driver ejected through windshield. Intrusion not considered a factor in injury.

OCCUPANTS:

Driver, 22 years, far side, unrestrained, FATAL OAIS-6, fractured vertebrae (neck). Source coded external--more likely initial contact and interior of vehicle.

CASE # 6711098/A-3

1977 Ford Thunderbird 2-door with B-pillar slid into a ditch striking a culvert. The front fender area received direct damage. Body distortion produced a gap between the right A-pillar and the front edge of the window glass in the right front door.

CDC (Case vehicle)	02 RFEW 7 (Third impact)
Total Delta-V's	32 mph.
Long. Delta-V	-16 mph.
Lat. Delta-V	-28 mph.

COMMENTS:
Doors did not "open" as such--no latch or hinge separation. However, the gap between the A-pillar and the window glass (glass out of track) provided an ejection portal for the driver. No lateral intrusion.

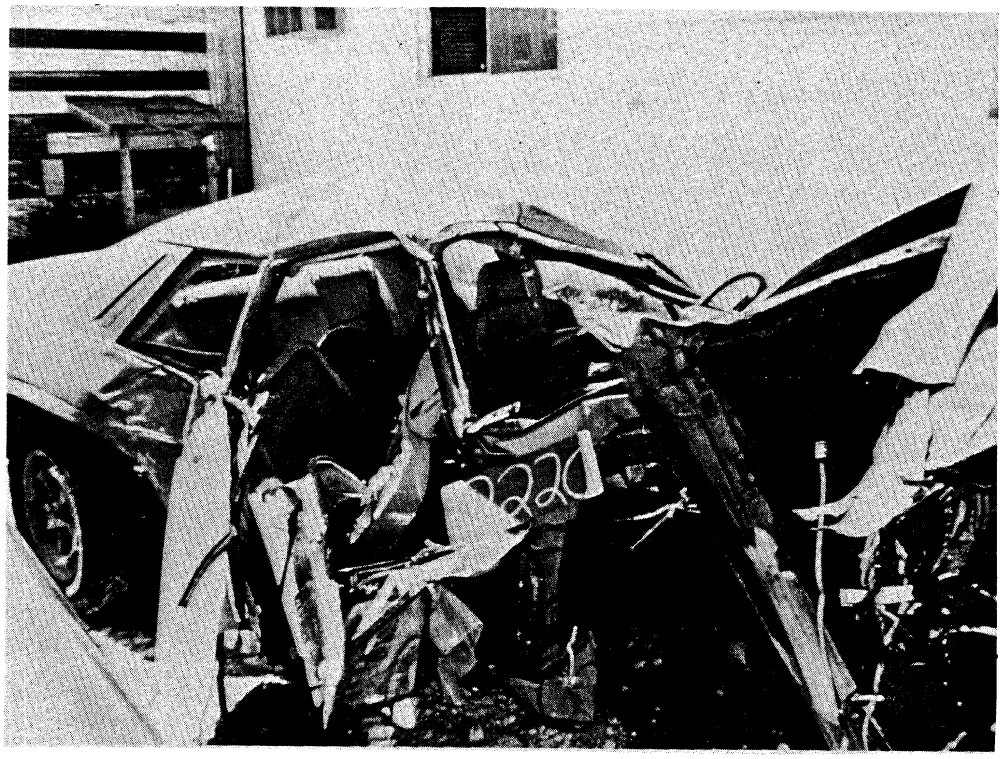
OCCUPANT(1):

Driver, 35 years, far side, unrestrained, FATAL OAIS-6, fractured neck vertebrae. Possible source: A-pillar, windshield or contact with the ground. Laceration, face--windshield or A-pillar. Laceration, back of head--windshield, A-pillar, or ground. Fracture of right arm--instrument panel, A-pillar, or ground. Fracture of right thigh from contact with instrument panel, or side panels.

CASE # 6709097/A-4

1976 Jaguar XJ-S 2-door with B-pillar slid into a large tree after striking several small posts and signs. The maximum penetration was less than 10 inches (right rear door area). Sill and rail engaged less than maximum. The impact caused the engine, front frame, and front wheels to separate at the firewall. These components burned.

CDC (Case Vehicle)	01 RYAW 4
Delta-V's	Not Computed



COMMENTS:
Doors did not open. Right front door latch damage. Driver ejected through windshield. Intruding components: Right rear door panel, window frame, and roof side rail. Maximum intrusion 8 inches (right rear door area panel). Intrusion not a factor in injury.

OCCUPANT(1)

Driver, 35 years, far side, unrestrained, FATAL OAIS-6, fractured neck vertebrae--interior of vehicle or contact with ground. Unspecified facial and internal injuries (per police report).

CASE # 7709038/A-5

1977 Datsun 280Z 2-door with B-pillar spun out striking two small "NO PARKING/NO STOPPING" signs before striking a utility pole with the right side. Both the sill and the roof rail were engaged the full amount. Maximum penetration was 43 inches (right rear door area).

CDC (Case Vehicle)	03 RPAN 5
Total Delta V	38 mph.
Long. Delta V	+07 mph.
Lat. Delta V	-38 mph.

COMMENTS:
Both front doors opened with latch damage and release. Both doors had hinge separation. The driver was not ejected. Unknown if the two passengers were ejected. Right side intrusion included the A-pillar, B-pillar, right rear door area panel, C-pillar, window frame and roof side rail. Maximum intrusion of 42 inches (side rail). Intrusion was a factor.

OCCUPANTS(3):

Driver, 24 years, unrestrained, OAIS-3. Fractured neck vertebrae--Impact force; Laceration, right shoulder--B-pillar; Contusion, thigh--Instrument panel; Abrasion, face--Instrument panel.

Right front, 17 years, unrestrained, OAIS-6 FATAL. Laceration, brain--unknown source; Laceration, heart--unknown source; Laceration, liver--Intruding pole; Laceration (Bilateral), lungs--unknown source; Laceration, neck (respiratory)--unknown source; Fractured skull--unknown source.

Right rear, 21 years, unrestrained, OAIS-4. Fractured skull--vehicle roof; Concussion, brain--vehicle roof; Contusion, brain--vehicle roof; Hemorrhage, brain--vehicle roof; Laceration, top of head --vehicle roof; Fractured right forearm--side surface.

CASE # 2708027/A-6

1976 Chevrolet Vega 2-door hatchback with B-pillar struck a utility pole with the left quarter panel and then slid broad side into a large tree. The maximum penetration was just ahead of the B-pillar at the belt line (32 inches). The roof rail was engaged the full amount, the sill less than maximum.

CDC (Case Vehicle, Second Impact)	03 RPAW 5
Total Delta V	34 mph.
Long. Delta-V	00 mph.
Lat. Delta-V	-34 mph.

COMMENTS:
Right door damaged by direct contact. No latch or hinge damage. Right door did not open. Left door opened at some time. Driver partial ejection through left door. Intruding components. (Right side). A-, B-, C-pillar, both right door area panels, window frame and roof side rail. Maximum intrusion of 14 inches (B-pillar).

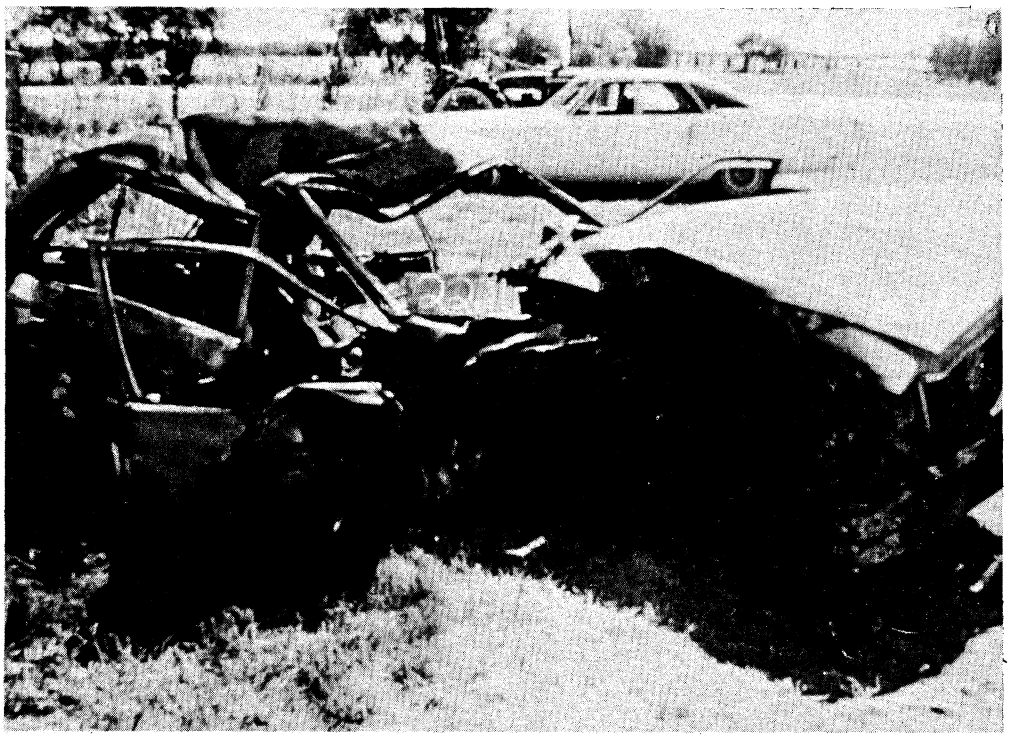
OCCUPANT(1):

Driver, 41 years, far side (second impact), unrestrained, OAIS-6 FATAL. Injury details unknown.

CASE # 6709096/A-7

1976 Buick Skylark 4-door with B-pillar struck a deer, lost control, and slid into a large tree. The right front fender and right front door were damaged. The maximum penetration (lateral) was less than 10 inches (right front door). There was considerable deformation to the windshield header and right roof side rail. This may be induced damage or it is possible that the deer became airborne and struck the superstructure. Fire reported as starting in engine compartment.

CDC (Case Vehicle)	01 RYAW 4
Total Delta-V	58 mph.
Long. Delta-V	-50 mph.
Lat. Delta-V	-29 mph.



COMMENTS:
Right front door impacted. Latch and hinge damage. Latch released and door opened. No ejection. The only obvious side intrusion was the roof side rail. The primary intrusion listed in the original report was longitudinal--involving the instrument panel, etc. Intrusion was not a factor.

OCCUPANTS(1):

Driver, 37 years, far side, unknown restraint usage, OAIS-6 FATAL. Burned feet--fire; Unknown injury--unknown source.

CASE # 3712057/A-8

1976 Ford Mustang 2-door with B-pillar went out of control, knocked down two wooden guard rail posts and then slid sideways into the end of a concrete bridge rail. The main area of impact was the right A-pillar and the right front door. The sill was engaged the full amount. The roof rail was not engaged. The maximum penetration was 36 inches (right front door).

CDC (Case Vehicle)	03 RYEW 4 (Bridge)
Total Delta-V	26 mph.
Long. Delta-V	00 mph.
Lat. Delta-V	-26 mph.

COMMENTS:
Right front door impacted. Latch damaged and released. Hinge separation. Door opened. Right front occupant ejected through door. Intrusion of 22 inches (A-pillar and right front door--before opening). Intrusion did not increase the severity of the injuries.

OCCUPANTS(3):

Driver, 22 years, far side, unrestrained, OAIS-1. Complaint of pain, neck--impact force; Contusion, top of head--unknown source; Contusion, right thigh--console; Abrasion, top of head--loose pieces of window glass.

Right front, 30 years, near side, unrestrained, OAIS-6 FATAL. Fractured neck vertebrae--probably contact with ground; Fracture of skull--probably contact with ground; Small lacerations of whole body--loose pieces of window glass.

Rear (probably sleeping on folded down seat), 2 years, far side, unrestrained, OAIS-2. Fractured right thigh--unknown source; Laceration, right thigh--loose glass; Laceration, right knee--loose glass.

CASE # 3703023/A-9

1974 Ford Mustang II 2-door no upper B-pillar, lost control after striking the rear of a 1969 Pontiac during an attempted passing maneuver. The case vehicle went off the left side of the road, traveled approximately 30 feet, came back on the road in a clockwise skid, crossed the road, went down an embankment and struck a wood utility pole with the left door. The vehicle rolled up into the pole causing extensive roof damage. The pole broke approximately 10 feet above the ground. It is possible that the vehicle was airborne when it struck the pole. The penetration at the left front door was 10-18 inches with the maximum point at the upper third near the rear edge. The sill was engaged less than the maximum. The roof rail was engaged fully.

CDC (Case Vehicle)	00 LPAW 7
Delta-V's	Not Computed

COMMENTS:
No latch or hinge damage and no ejection. (The door was removed for extrication.) Intrusion--A-, B-, and C-pillars, both left door area panels, and the roof rail. Maximum intrusion of 21 inches (roof rail).

OCCUPANTS(1):

Driver, 33 years, male, near side, lap and shoulder restraints, was trapped in vehicle, OAIS-6 FATAL Avulsion, brain (left side)--roof rail; Crushed chest--steering assembly; Fracture of pelvic area--interior side surface.

CASE # 6704090/A-10

1974 Lincoln Mark IV 4-door with B-pillar struck a bridge rail with the left side. The maximum penetration was over 18 at the left front door. Both the rocker panel and roof rail were engaged.

CDC (Case Vehicle)	11 LDEW 9
Delta V's	Not Computed

COMMENTS:
The damage to the vehicle was catastrophic. The left front door hinges and latch all separated. The left door, A-pillar, and bridge rail all intruded. The door panel intruded 40 inches. The body separated from the frame, which apparently broke into two parts. The floor pan separated from the body.

OCCUPANTS(4):
(Unknown if any were ejected)

Driver, 31 years, near side, unknown if restrained, OAIS-6 FATAL. Transection of lower torso by unknown mechanisms. Driver contacted steering wheel and A-pillar.

Right front, 30 years, far side, unknown if restrained, sustained AIS-3 injuries consisting of fracture of upper facial bones with avulsion of skin, and fracture of the right leg. The fatal injury is of unknown description and details.

Left rear,29 years, near side, unknown restraint, OAIS-6 FATAL. Fatality resulted from crushed chest of unknown source.

Right rear, 29 years, far side, unknown restraint, OAIS-6 FATAL. Fatality from unspecified injury to left chest. Source unknown.

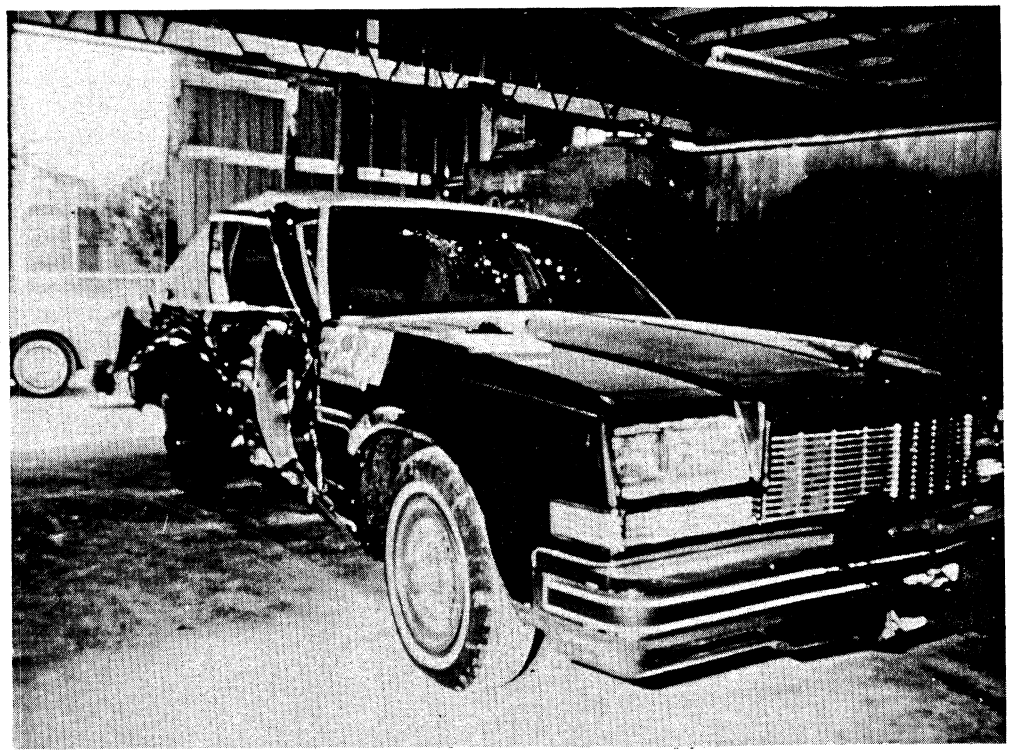
Photograph unavailable.

CASES A11 - A38
Car-Car or Car-Light Truck Crashes

CASE # 6710117/A-11

1977 Buick LeSabre, 4-door with B-pillar was struck in the right side by a Dodge Dart. A maximum penetration of 11 inches occurred at the right front door (low and center). The rear door and quarter panel also received some direct damage. The door sill was engaged less than the full amount. The roof rail was not engaged. Both doors had latch and hinge damage. No opening. No ejection.

	Case Vehicle	Other Vehicle
CDC	01 RZEW 3	10 FDEW 3
Delta V's	Not Computed	Not Computed



COMMENTS:
Intrusion - both door panels, window frame and B-pillar. Maximum intrusion of 11 inches (right front door).

OCCUPANTS(3):

Driver, 33 years, far side, unrestrained, OAIS-1. Laceration, face --unknown source; Laceration, knee--instrument panel.

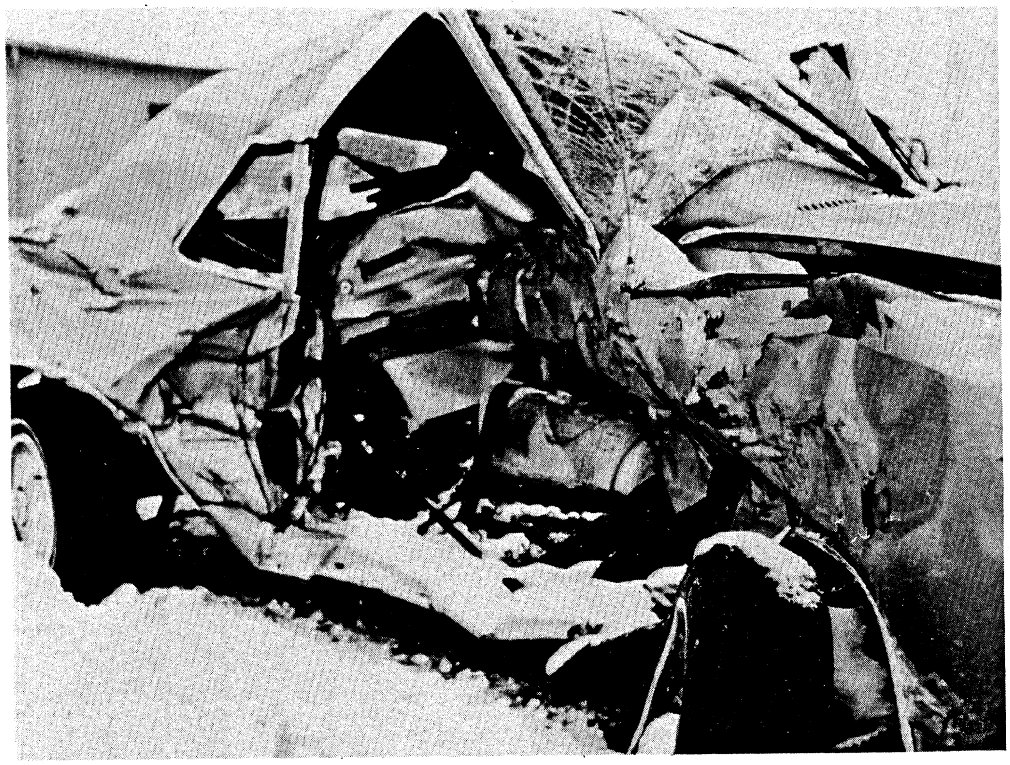
Right front, 72 years, near side, unrestrained, OAIS-6 FATAL. Pulmonary aneurism--Arm rest; Contusion, right lung--Arm rest.

Right rear, 70 years, near side, unrestrained, OAIS-4. Multiple fractures, face--B-pillar; Fractured thigh--arm rest; Laceration, face --B-pillar.

CASE # 2703025/A-12

1975 Ford Mustang II 2-door, no upper B-pillar, was struck in the right side by a Mercury Comet. The damaged area extended from the front wheel area to just behind the lower B-pillar. The sill was engaged less than the full amount. The roof rail was not engaged but had induced damage.

	Case Vehicle	Other Vehicle
CDC	02 RYEW 7	11 FDEW 3
Total Delta-V	27 mph.	31 mph.
Long. Delta-V	-23 mph.	-15 mph.
Lat. Delta-V	-13 mph.	-26 mph.



COMMENTS:
Right front door latch released. There was no ejection. Intruding components included the A-, B-, and C-pillars, the right rear door area. The worst intrusion was the right front door which pushed the right front seat into the driver's area and squeezed the driver between the seat and the left door panel (Remaining space was 14 inches wide). The intrusion of the right front door measured 30 inches.

OCCUPANTS(1):

Driver, 46 years, female, lap and shoulder restraints, was dead at scene. No autopsy. Probable cause of death--massive crushing of internal organs. It is known that the upper right arm was fractured.

CASE # 1707062/A-13

1973 Plymouth Duster 2-door with no upper B-pillar was struck in right side by a Pontiac Catalina. The damaged area extended from the right front door to just behind the right rear wheel. Sill engaged less than maximum. Roof rail engaged an unknown amount. The maximum penetration was 28 inches in the right rear door area.

	Case Vehicle	Other Vehicle
CDC	04 RZEW 4	12 FDEW 2
Total Delta-V	34 mph.	27 mph.
Long. Delta-V	+17 mph.	-30 mph.
Lat. Delta-V	-30 mph.	+00 mph.

COMMENTS:
The right front door latch was damaged. There was no release or separation. No ejections. Intruding components - right front and right rear door areas, A-, B-, and C-pillars, window frame and roof side rail. Maximum intrusion of 19 inches (door panel).

OCCUPANTS(5):

Driver, 17 years, no restraints, OAIS-3. Fractured right chest--steering assembly.

Center front, 16 years, no restraints, OAIS unknown. Concussion--severity unknown, source unknown; Fractured pelvis--unknown source.

Right front, 18 years, no restraints, OAIS-6 FATAL. Crushing of head--right rear window frame. Other injuries of AIS 3-4 to abdominal organs--unknown source.

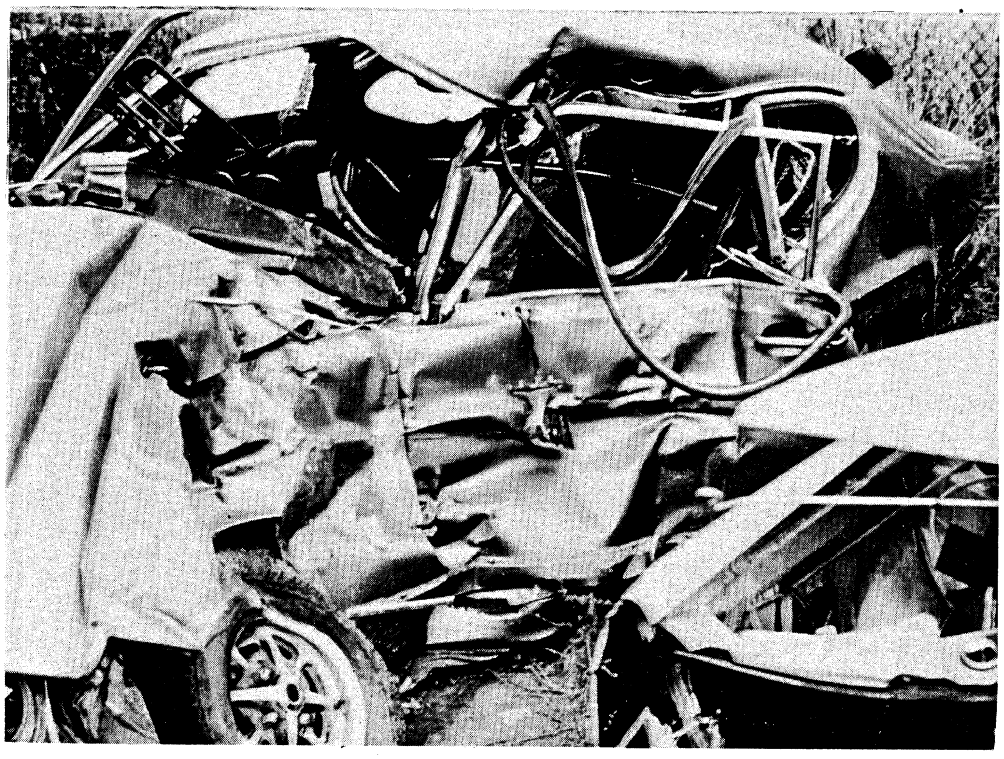
Left rear, 14 years, no restraints, OAIS-1. Complaint of pain in chest--front seat back. Contusion and pain, thigh and knee--other occupants.

Center rear occupant, 16 years, no restraint, OAIS-4. Ruptured spleen--other occupants. Laceration of liver--side panel; Contusion, rectum--side panel.

CASE # 2710032/A-14

1974 Mercury Capri 2-door with B-pillar, was struck in the left side by a Chevrolet pickup (1/2 ton, 4x4 with snow plow mount--no plow). The damaged area included the left front fender and the left front door. The sill was engaged the full amount. The roof rail was engaged less than the full amount. The maximum penetration was 22 inches (left front door).

	Case Vehicle	Other Vehicle
CDC	10 LYAW 4	12 FDEW 2
Total Delta-V	29	18 mph.
Long. Delta-V	-15 mph.	-18 mph.
Lat. Delta-V	+25 mph.	0 mph.



COMMENTS:
Left door did not open. Latch and hinge damage unknown. The right door opened. There were no ejections. Intruding components: Left front door panel, A-pillar, window frame, and roof side rail. Maximum intrusion - 15 inches (A-pillar).

OCCUPANTS(3):

Driver, 17 years, unrestrained, OAIS-6 FATAL, concussion, back of head--AIS-5, A-pillar.

Right front, 17 years, unrestrained, OAIS-6 FATAL. Injury and source unknown.

Right rear, 15 years, unrestrained, Injury and source unknown.

CASE # 2703038/A-15

1976 Chevrolet Camero, 2 door, B-pillar, was struck by a Buick Electra in the right side. The damaged area extended from the rear of the front wheel to the rear of the passenger area. The sill and rail were deformed less than maximum. Maximum penetration of "over 18 inches" halfway up the lower B-pillar.

	Case Vehicle	Other Vehicle
CDC	02 RYAW 4	11 FDEW 3
Total Delta-V	22 mph	18 mph.
Long. Delta-V	-11 mph.	-15 mph.
Lat. Delta-V	-19 mph.	+9 mph.

COMMENTS:
Right door latch damage. Door did not open. (Door removed by rescue squad by cutting hinges.) There was a possible partial ejection (unknown portal). Intrusion of right door, right rear door area, A-, B-, and C-pillars and roof rail. Maximum intrusion of 24 inches (right front door panel).

OCCUPANTS(3):

Driver, 19 years, unrestrained, OAIS-2. Numerous minor injuries to head, wrist, thigh and chest--unknown source.

Right front, 17 years, unrestrained, OAIS-5. Concussion, brain--Roof rail; Ruptured spleen and liver--Arm rest; Fractured hip--Arm rest; Contused lung--Door surface.

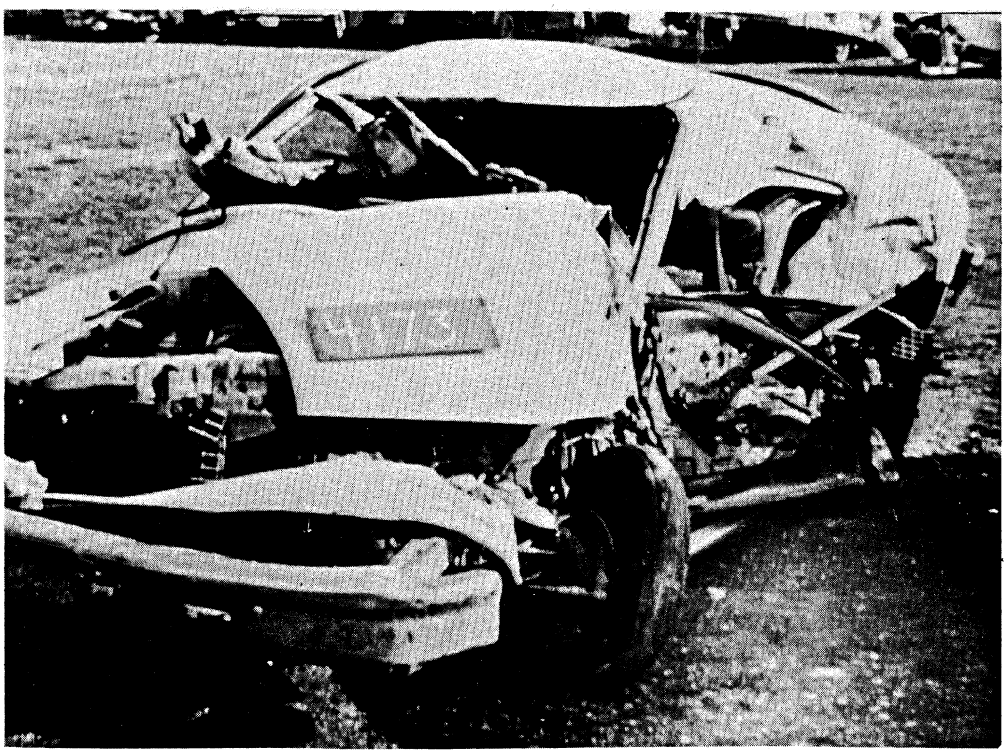
Right rear, 17 years, unrestrained, OAIS-6 FATAL. Dislocation, cervical spine--B-pillar; Contusion, brain (AIS-5)--B-pillar. Laceration, arteries (chest area)--side surface; Avulsion, arteries (abdomen)--Side surface; Rupture, urogenital tract--side surface; Fractured right leg (lower)--side surface.

NOTE: This occupant either partially ejected (unknown portal) and became trapped or was trapped.

CASE # 6703097/A-16

1976 Ford Pinto 2-door hatchback with B-pillar was struck in the left side by a Chevrolet pickup. The maximum penetration was 23 inches at the left front door. The door sill was engaged less than the full amount. The roof rail was not engaged.

	Case Vehicle	Other Vehicle
CDC	10 LDAW 4	02 FDEW 2
Total Delta-V	47 mph.	22 mph.
Long. Delta-V	-23 mph.	-11 mph.
Lat. Delta-V	+40 mph.	-19 mph.



COMMENTS:
Intrusion - A- and B-pillars, both door area panels, window frame and roof side rail. Maximum intrusion of 23 inches (B-pillar). Latch and hinge damage. No separation, no opening, no ejection. Unknown if driver was trapped. No interior slides--unknown if intrusion was a factor.

OCCUPANTS(1):

Driver, 22 years, near side, unrestrained, OAIS-6, FATAL. Unknown head injury--probable source is roof side rail.

CASE #2702039/A-17

1974 Pontiac Ventura 2-door with B-pillar was struck in the right side by a Lincoln Continental. Both right door areas and the quarter panel received direct damage. The door sill and the roof side rail were coded as "engaged less than the full amount." It is possible that this is induced damage. The maximum penetration was 20 inches at the leading edge of the rear door area.

	Case Vehicle	Other Vehicle
CDC	02 RZEW 4	11 FDEW 2
Total Delta-V	26 mph.	17 mph.
Long. Delta-V	-7 mph.	-16 mph.
Lat. Delta-V	-25 mph.	+4 mph.

COMMENTS:
Right front door latch and hinge damage. No opening, no ejection. Intrusion--both right door area panels, B- and C-pillars, window frame and roof side rail. Maximum intrusion of 20 inches (right rear panel). Role of intrusion unknown.

OCCUPANTS(2):

Driver, 64 years, far side, unrestrained, OAIS-3. Fracture and hemorrhage (right), chest--Unknown source.

Right front, 66 years, near side, unrestrained, OAIS-6 FATAL. Unknown injury and source. Right front occupant did contact right front door panel.

CASE #7802018/A-18

1977 Ford Granada 2-door with B-pillar was struck in the left side by a Ford Fairlane. The maximum penetration occurred at the left B-pillar (27 inches). The door sill and roof rail were deformed about 70 percent of the maximum. This was the first of two impacts.

	Case Vehicle	Other Vehicle
CDC	10 LPEW 4	01 FDEW 2
Total Delta-V	22 mph.	1 mph.
Long. Delta-V	-06 mph.	-21 mph.
Lat. Delta-V	+22 mph.	-05 mph.

COMMENTS:
Left door impacted. Door opened with hinge separation. No ejection. Intrusion--A-, B-, C-pillars, roof side rail, left front window frame, both left door area panels. Maximum intrusion of 22 inches. (B-pillar). Intrusion probably did not increase severity of injuries.

OCCUPANTS(2):

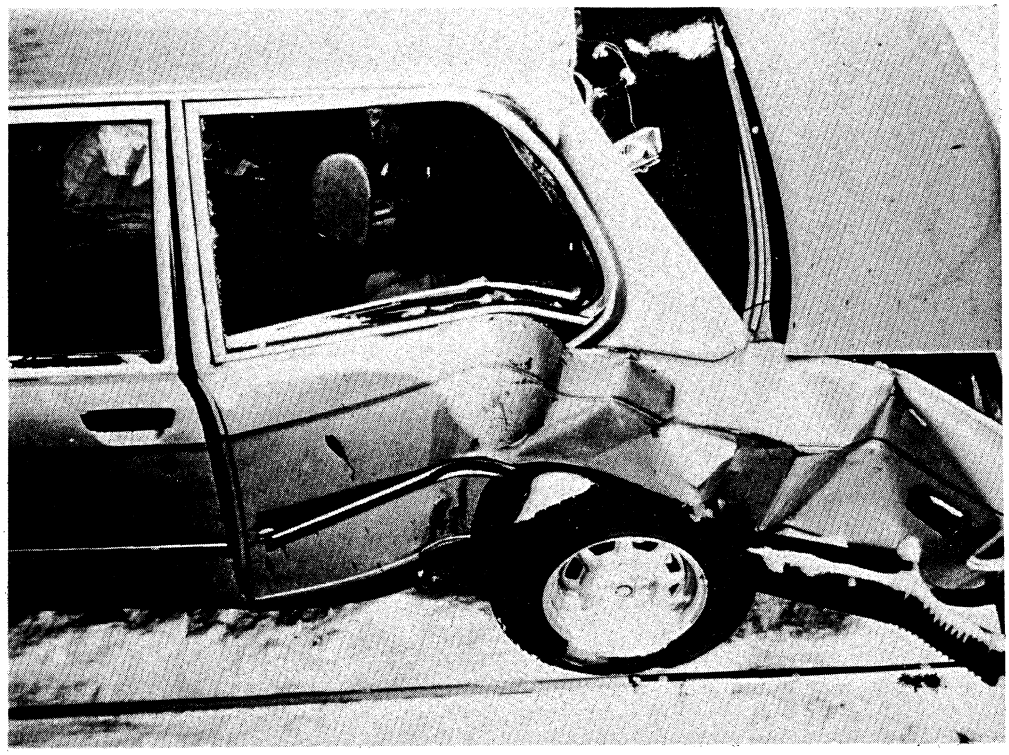
Driver, 55 years, near side, unrestrained, OAIS-6 FATAL Laceration and hemorrhage, brain--Roof side rail; Laceration, chest arteries--Hardware; Laceration, liver--Arm rest; Laceration, lungs and heart--side interior surface.

Right front, unknown age, far side, unrestrained, OAIS-6 FATAL Contusion and hemorrhage, brain--unknown source; Laceration, liver--Instrument panel; Fractured skull--unknown source; Contusion, lungs and hemorrhage, abdominal arteries--Instrument panel.

CASE #3701020/A-19

1976 BMW 320 2-door with B-pillar was initially struck by an Oldsmobile Cutlass in the right rear (04 RBEW 3). This impact apparently threw the driver backwards--with seat track separation. At this point, the case vehicle slid sideways into a pole making contact in the area of the left C-pillar. The maximum penetration was 12 inches. The roof side rail and door sill were engaged less than maximum.

CDC (Case Vehicle)	09 LPAN 3
Total Delta-V	05 mph.
Long. Delta-V	00 mph.
Lat. Delta-V	+05 mph.



COMMENTS:
Left front door not impacted and did not open. Intrusion--left rear door area panel, C-pillar and window frame. Maximum intrusion of 12 inches (rear panel).

OCCUPANTS(2):

Driver, 34 years, near side, lap and torso restraint, OAIS-6 FATAL. Laceration, brain--C-pillar; Fractured skull--C-pillar; Fractured chest area--front seat back.

Right front, 26 years, far side, unrestrained, OAIS-1. Laceration, left side of face--window glass; Contusion, shoulders--Front seat back; Contusion, lower back--Front seat back.

CASE # 2710007/A-20

1974 Ford Galaxie 500 2-door no upper B-pillar was struck in the right side by a Chevrolet Impala. The direct damage included the front and rear door areas. The maximum penetration was 18 inches at the rear of the front door. The door sill was engaged an unknown amount. The roof side rail may have had some induced damage.

	Case Vehicle	Other Vehicle
CDC	02 RPEW 3	11 FDEW 2
Total Delta-V	19 mph.	18 mph.
Long. Delta-V	-09 mph.	-16 mph.
Lat. Delta-V	-16 mph.	+09 mph.

COMMENTS:
No latch or hinge damage. Doors did not open. No ejection. Intrusion--right door panels, lower B-pillar, C-pillar, Maximum Intrusion of 9 inches (right front door panel). Intrusion did not increase severity of injury.

OCCUPANTS(4):

Driver, 30 years, unrestrained, OAIS-1. Contusion, right chest--steering assembly.

Front center, 3 years, far side, unrestrained, Unknown OAIS. Injury unknown.

Right front, 54 years, near side, unrestrained, OAIS-6 FATAL Fractured neck--window glass; Lacerated liver--Arm rest; Fractured chest area--window frame; Lacerated lung--Instrument panel.

Center rear, 2 years, near side, unrestrained, OAIS-1. Concussion --side interior surface; Lacerations, face--interior side surfaces.

CASE # 6803023/A-21

1975 Ford Granada 4-door with B-pillar was struck in the left side by a Ford F-100 pickup. Both left doors, the B-pillar, and the lower C-pillar were damaged. There was some direct damage to the trunk area--but mostly induced damage. The sill and rail appear to have been damaged. The amount was recorded as "unknown amount." The maximum penetration was 16 inches--centered in the left rear door.

	Case Vehicle	Other Vehicle
CDC	10 LZAW 3	01 FYEW 1
Delta-V's	Not Computed	Not Computed

COMMENTS:
Both left door latches were damaged. No release and none opened. No ejection. Intrusion--Both door panels, and B-pillar. Maximum intrusion of 8 inches (rear door panel). Intrusion did not increase the severity of the injuries.

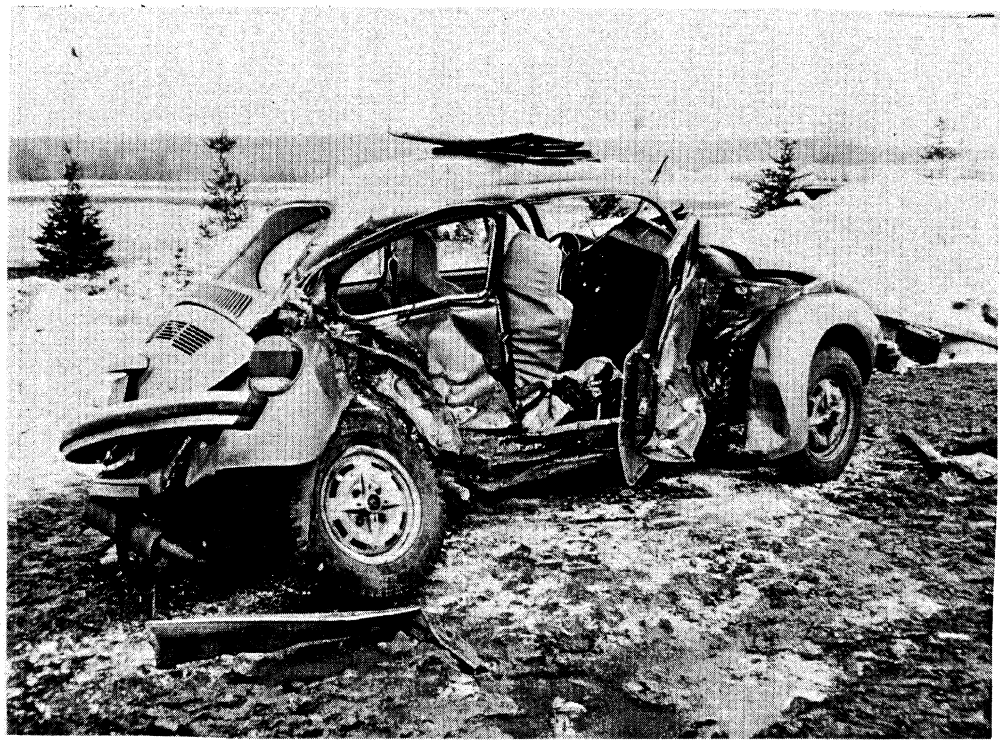
OCCUPANTS(1):

Driver, 70 years, near side, unrestrained, OAIS-6 FATAL. Fractured chest area (bilateral)--side interior surface. Laceration--Head (left side)--window glass. Death due to chronic, pre-existing heart and lung condition--aggrevated by impact with interior surface.

CASE # 1803071/A-22

1975 VW Super Beetle 2-door with B-pillar was struck in the right side by a Ford Thunderbird. The damaged area extended from just behind the front wheel to the rear of the rear wheel. The maximum penetration (18 inches) occurred just behind the B-pillar. The sill was engaged less than the full penetration. The roof side rail had some induced damage.

	Case Vehicle	Other Vehicle
CDC	04 RDEW 4	11 FDEW 2
Total Delta-V	33 mph.	16 mph.
Long. Delta-V	00 mph.	-14 mph.
Lat. Delta-V	-33 mph.	+08 mph.



COMMENTS:
Right front door impacted. Latch damaged. Door did not open. No ejection. Intrusion--right rear door area panel, B-pillar, C-pillar, Roof side rail. Maximum intrusion of 11 inches (panel). Intrusion not a factor.

OCCUPANTS(1):

Driver, 30 years, far side, unrestrained, OAIS-6 FATAL. Details of injury unknown. According to E.R. report, "Patient was bleeding profusely from both ears," suggesting severe head injury. Driver did contact roof and roof rail on right side.

CASE # 1703002/A-23

1973 Dodge Dart 2-door B-pillar was struck in the right side by a Chevrolet El Camino (pick-up car). The damaged area included the right front fender, A-pillar, and door. The sill was engaged the full amount. The roof rail had severe induced damage. The maximum penetration was 10-18 inches at the right A-pillar.

	Case Vehicle	Other Vehicle
CDC	02 RYAW 3	11 FDEW 3
Total Delta-V	42 mph.	31 mph.
Long. Delta-V	-21 mph.	-27 mph.
Lat. Delta-V	-36 mph.	+15 mph.

COMMENTS:
The right front door was jammed closed and was forced open after the accident. The latch was damaged. There were no ejections. Intruding components: A-pillar, right front door panel, B-pillar, right rear door area, window frame and roof rail. The maximum intrusion was 10 inches (A-pillar).

OCCUPANTS(4):

Driver, 44 years, male, lap restraint only, OAIS-5. Ruptured kidneys--steering assembly; Contusion, digestive system--Steering assembly; Concussion, brain--Unknown source; Fractured right shoulder--Instrument panel; Hemorrhage, abdominal arteries--steering assembly.

Right front, 44 years, female, lap restraint only, OAIS-6 FATAL. Lacerated brain--A-pillar; Fractured neck vertebrae--A-pillar; Laceration, heart--Side interior surface; Laceration, chest arteries--Side interior surface; Fractured pelvic/hip area--Side interior surface; Fractured chest area.

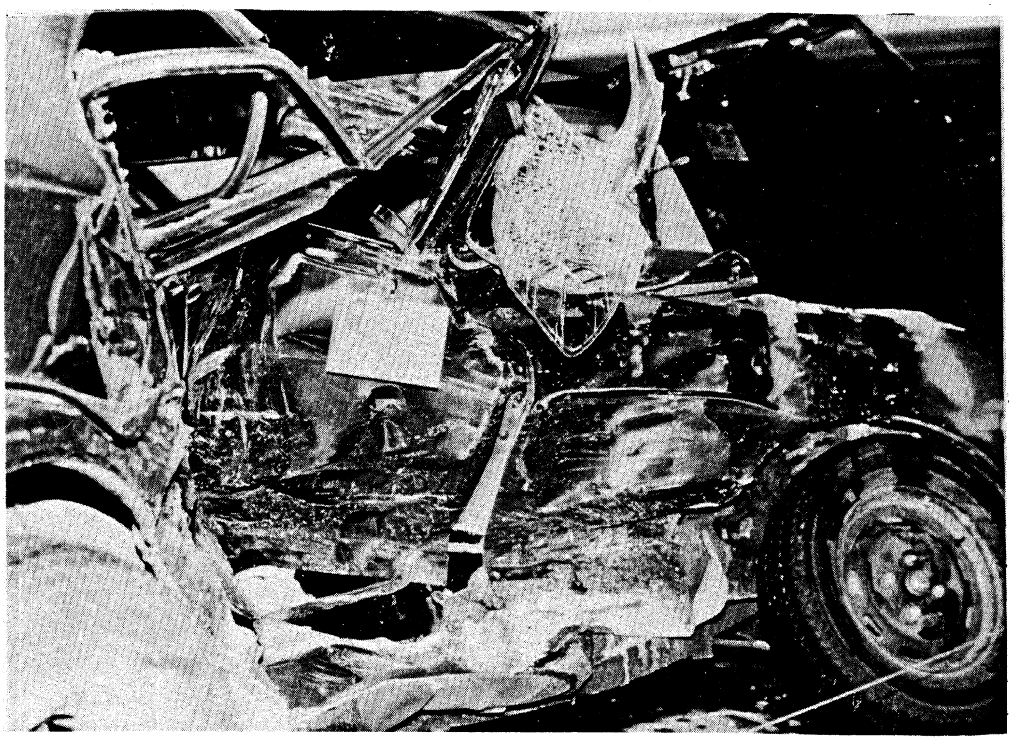
Left rear, 9 years, male, no restraints. Unknown severity. Concussion, brain--Head restraints; Fractured thigh--front seat back; Fractured wrist/hand--Front seat back.

Right rear, 17 years, female, no restraints, OAIS-5. Fractured neck vertebrae--Impact force; Concussion, brain--Side interior surface; Fractured pelvic/hip area--Side interior surface; Contusion, Urogenital area--Side interior surface; Fractured chest area--Unknown source; Contused lungs.

CASE # 5710018/A-24

1976 Datsun 280Z 2-door with B-pillar was struck in the right side by a Mercedes 450 S. Extreme collision damage plus, probable rescue team damage. Maximum penetration of 42 inches (right front door). The sill and rail were listed as "not engaged."

	Case Vehicle	Other Vehicle
CDC	02 RDEW 7	11 FDEW 2
Total Delta-V	33 mph.	22 mph.
Long. Delta-V	-17 mph.	-19 mph.
Lat. Delta-V	-30 mph.	+11 mph.



COMMENTS:
Right front door impact. Latch damaged and released. Hinge damage. Door did not open. No ejection. Intrusion--right front and right rear door areas A- and B-pillars. Maximum intrusion 35 inches (right front door panel). Incomplete data. No contacts noted due to severe internal damage. It seems likely that the driver contacted passenger door area. Intrusion probably not a factor.

OCCUPANTS(1):

Driver, 29 years, far side, unrestrained, OAIS-6 FATAL Concussion, brain--Unknown source; Ruptured liver--Unknown source; Fractured chest area (right side)--Unknown source; Fractured skull--Unknown source; Laceration, face--Unknown source; Abrasion, hand--Unknown source.

CASE # 6701106/A-25

1973 Chevrolet Impala, 2-door, No B-pillar was struck in the left side by a Chevrolet C-10 truck. The distributed side damage extended from the rear of the front wheel to the back of the vehicle. The maximum penetration was just in front of the C-pillar. The sill and rail were engaged less than the maximum.

	Case Vehicle	Other Vehicle
CDC	11 LDAW 3	01 FDEW 3
Delta-V's	Not Computed	Not Computed

COMMENTS:
Both left door areas damaged by direct contact. The left front opened with latch damage and release. Hinges were damaged--no separation. The driver was trapped. The ejection--entrapment situation for the remaining occupants is unknown. Intruding components--B-pillar, left rear door area, C-pillar and roof side rail. Maximum intrusion of 18 inches (C-pillar). Intrusion not a factor.

OCCUPANTS(5):

Driver, 20 years, near side, unrestrained, OAIS unknown, injury unknown.

Front center, 55 years, far side, unrestrained, OAIS-1, Strain, left ankle--unknown source.

Front right, 14 years, far side, unrestrained, OAIS-6 FATAL Injury to head--probably from roof.

Rear right, 49 years, far side, unrestrained, OAIS unknown, injury unknown.

Fifth occupant position unknown, restraint usage unknown, OAIS unknown, injury to left foot.

CASE # 6708052/A-26

1975 VW Rabbit, 2-door with B-pillar was struck in the left side by a small Ford dump truck (pickup chassis). The distributed side damage extended from the front of the vehicle to the C-pillar. The maximum penetration was 21 inches (left front door--center at beltline). The sill and rail were engaged less than the maximum. After the first impact, the case vehicle went off the right side of the road and rolled onto its right side.

	Case Vehicle	Other Vehicle
CDC	11 LDAW 4	01 FYEW 1
Total Delta-V	39 mph.	13 mph.
Long. Delta-V	-34 mph.	-11 mph.
Lat. Delta-V	+19 mph.	-06 mph.

COMMENTS:
Left front door impacted. Latch and hinge damage. Door did not open. No ejection. Intruding components--A- and B-pillar, left front and left rear door area panels. Maximum intrusion of 21 inches (B-pillar). Intrusion probably not a factor.

OCCUPANTS(3):

Driver, 18 years, near side, unrestrained, OAIS-6 FATAL. Unknown injury to brain--A-pillar; Fracture (bilateral), chest area and unknown injury to left lung--Side interior surface.

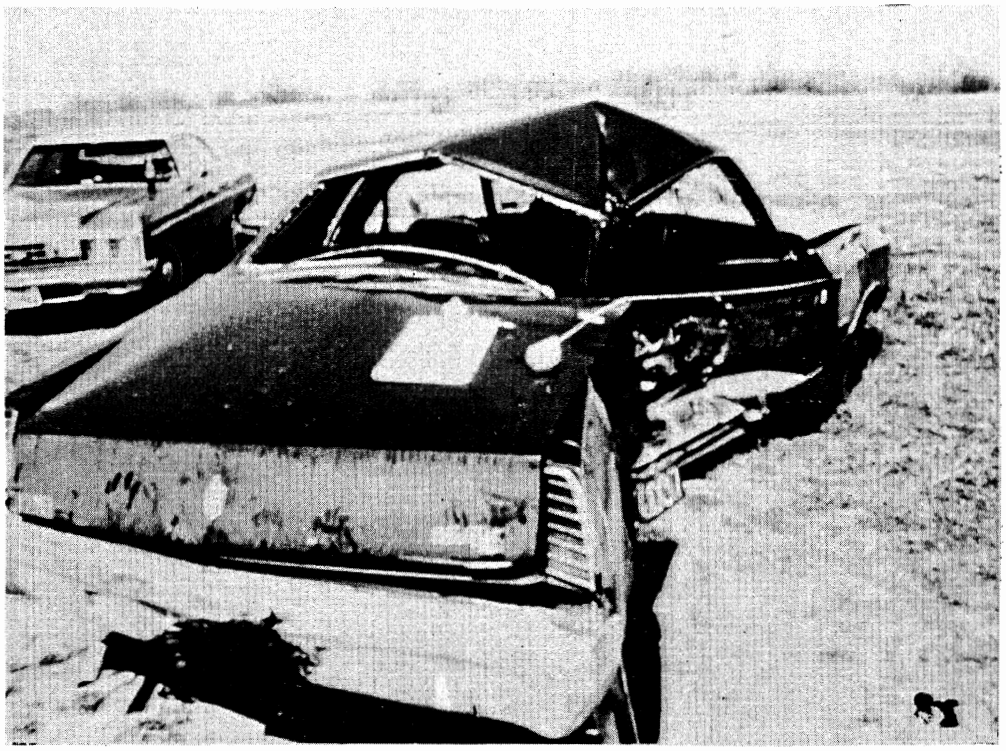
Right front, 19 years, far side, unrestrained, OAIS-1. Lacerations, face, head and forearm--Unknown source; Pain, neck and back--Impact force.

Right rear, 19 years, far side, unrestrained, OAIS-4. Fractures of left chest area, left area of face; Abrasion of left arm--All unknown source.

CASE # 6802055/A-27

1973 Chevrolet Monte Carlo struck in right side by Ford LTD. Major damage: Both right door areas Induced damage: Sill and roof side rail. Maximum penetration: 29 inches at right front door edge.

	Case Vehicle	Other Vehicle
CDC	02 RZEW 5	12 FDEW 3
Total Delta-V	31 mph.	+31 mph.
Long. Delta-V	-08 mph.	-30 mph.
Lat. Delta-V	-29 mph.	+08 mph.



COMMENTS:
Right front door impacted, latch and hinge damage. Right door did not open. Left front door opened due to body distortion. No ejection. Intrusion--Both right side door area panels, B-pillar and roof side rail. Maximum intrusion--25 inches (B-pillar). Intrusion probably not a factor in injury.

OCCUPANTS(2):

Driver, 17 years, unrestrained--OAIS-5 Contusion, brain--Windshield Fracture and laceration of jaw--Instrument Panel

Right front, 15 years, unrestrained, OAIS-6, FATAL Unknown injury, brain--A-pillar Contusion, right side chest--Side surface Abrasion, upper face --A-pillar

CASE # 6706057/A-28

1973 Toyota Corona 4-door with B-pillar was struck in the right side by a Plymouth. The damaged area extended from the front wheel to the C-pillar. The maximum door penetration was 18 inches (right rear--low and center). There was induced damage to the roof rail and door sill.

	Case Vehicle	Other Vehicle
CDC	02 RYEW 3	11 FDEW 3
Total Delta-V	38 mph.	23 mph.
Long. Delta-V	-19 mph.	-20 mph.
Lat. Delta-V	-32 mph.	+12 mph.

COMMENTS:
Both right doors impacted. Latch and hinge damage. Neither door on right side opened. Left front door opened due to body distortion. Unknown if driver was ejected at some time. Probably not at first impact. Driver struck and bent floor-mounted shift lever, contacted right A-pillar and general area in right front. There were two impacts. Intrusion--both right door panels, A- and B-pillars. Maximum intrusion of 20 inches (right rear door panel). Intrusion not a factor in injury.

OCCUPANTS(1):

Driver, 78 years, far side, unrestrained, OAIS-6 FATAL Contusion, brain--A-pillar; Fracture,, right chest area--Side interior surface; Contusion, right lung--Side interior surface; Other unspecified injuries--Unknown source.

CASE # 1708046/A-29

1977 Ford Mustang 2-door with B-pillar was struck in the left side by a Dodge Coronet. The damaged area extended from the A-pillar to the C-pillar. The sill was engaged less than maximum. The roof side rail had induced damage. Maximum penetration of 20 inches (left rear door area).

	Case Vehicle	Other Vehicle
CDC	10 LPEW 4	01 FDEW 2
Total Delta-V	24 mph.	19 mph.
Long. Delta-V	-17 mph.	-15 mph.
Lat. Delta-V	+17 mph.	12 mph.

COMMENTS:
Left front door impacted. Latch damage. Door did not open. Driver ejected through unknown portal. Intrusion--B-pillar, left rear door area panel and window frame. Maximum intrusion of 15 inches (door area panel).

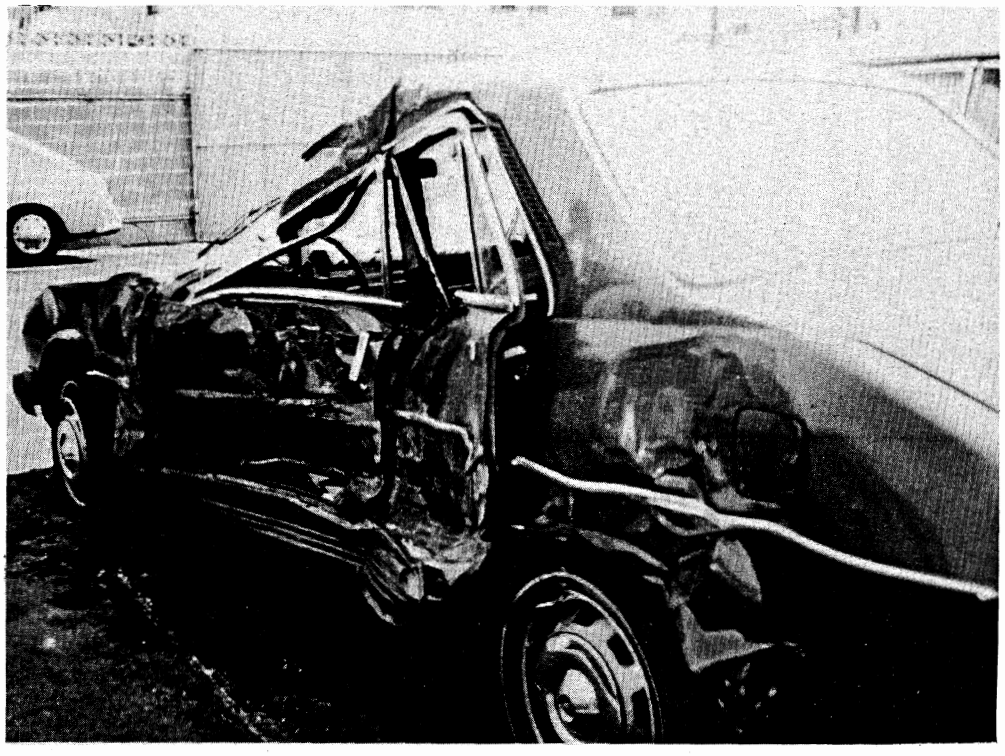
OCCUPANTS(1):

Driver, 29 years, near side, unrestrained, OAIS-6 FATAL Lacerated aorta--Side interior surface; Other unspecified injuries.

CASE #7709021/A-30

1975 Peugot 504, 4-door with B-pillar was struck in the left side by a Ford 600 truck. The damaged area extended from the front wheel to just behind the rear wheel with the greatest penetrating (12 inches) at the left front door (low at the rear edge). The sill was engaged less than the full amount. The roof side rail was engaged an unknown amount.

	Case Vehicle	Other Vehicle
CDC	10 LDAW 3	01 FDEW 1
Total Delta-V	16 mph.	10 mph.
Long. Delta-V	-6 mph.	-10 mph.
Lat. Delta-V	+15 mph.	-03 mph.



COMMENTS:
Both doors impacted. Both with latch and hinge damage. Neither latch released. Doors did not open. No ejection. Intrusion--both door panels, A- and B-pillars, window frame, and roof side rail. Maximum intrusion of 7 inches (left front door panel). Intrusion probably not a factor.

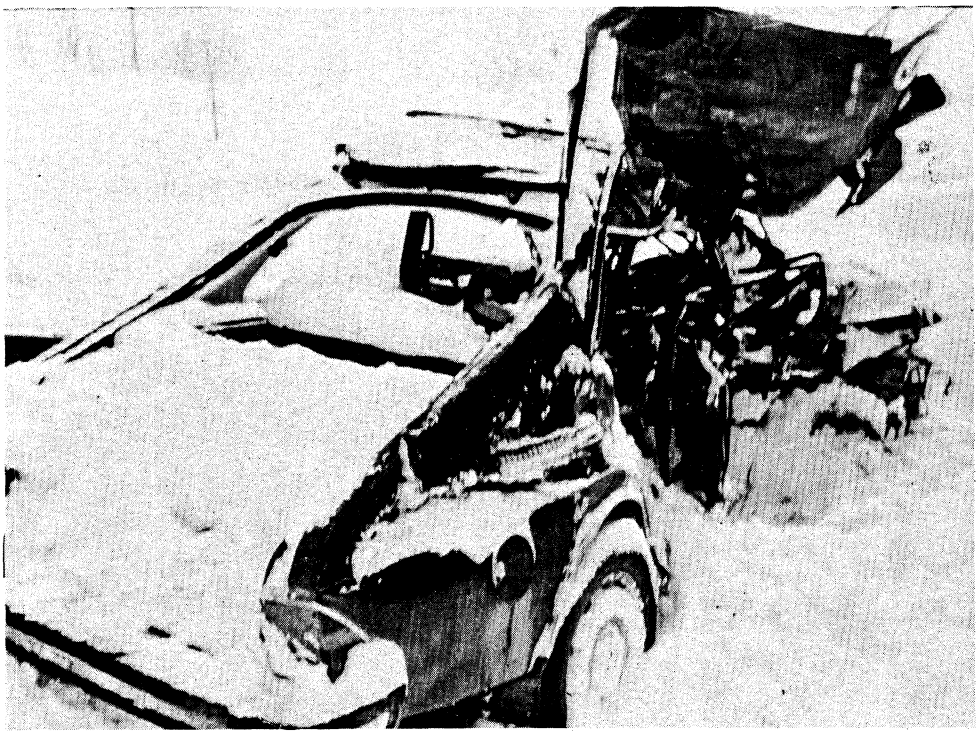
OCCUPANTS(1):

Driver, 54 years, near side, unrestrained, OAIS-6 FATAL Lacerated heart, chest area arteries, hemorrhage of lungs. Fractured spine and lacerations, urogenital area. Source of injuries--Side interior surface. Fractured pelvic area--unknown source.

CASE #1701059/A-31

1974 Saab 99 2-door with B-pillar was struck in the right side by a Chevrolet Malibu. The damaged area included the right front fender and the passenger compartment. The maximum door penetration was 33 inches (entire vertical section near hinge). The sill was engaged less than the full amount. The roof side rail was engaged the full amount.

	Case Vehicle	Other Vehicle
CDC	02 RYAW 5	11 FDEW 2
Total Delta-V	29 mph.	20 mph.
Long. Delta-V	-14 mph.	-18 mph.
Lat. Delta-V	-25 mph.	+10 mph.



COMMENTS:
Direct damage to right front door. Latch damaged and released. Door opened. No ejection. Hinge damage--no separation. Intrusion--A-, B-, and C-pillars, right front and right rear door area panels, both window frames, and right front roof side rail. Maximum intrusion of 30 inches (right front door panel). Intrusion may have been a factor.

OCCUPANTS(1):

Driver, 23 years, far side, unrestrained, OAIS FATAL Fractured vertebrae (neck)--Impact force; Laceration, right lung, liver, respiratory system, fracture right chest area, fracture pelvic area--Side interior surface.

CASE # 6701081/A-32

1975 Toyota Corolla 2-door with B-pillar was struck in the right side by a Buick Riviera. The damage extended from the A-pillar to the rear of the vehicle. The sill and roof rail were not engaged. The maximum penetration (17 inches) was in the right rear door area (beltline, near the B-pillar).

	Case Vehicle	Other Vehicle
CDC	02 RZMW 4	11 FDEW 1
Total Delta-V	26 mph.	15 mph.
Long. Delta-V	-18 mph.	-9 mph.
Lat. Delta-V	-19 mph.	11 mph.

COMMENTS:
Latch and hinge damage. No release or separation. Door did not open; no ejection. Intrusion--right front and right rear door area panels, B- and C-pillars. Maximum intrusion--11 inches (B-pillar).

OCCUPANTS(3):

Driver, 30 years, far side, unrestrained, OAIS-1. Abrasion, face--Steering assembly. Complaint of pain, shoulder--Other occupant.

Front center, 4 years, far side, no restraint available, OAIS-2. Laceration, face--mirror.

Front right, 5 years, near side, unrestrained, OAIS-6 FATAL. Fractured skull and unknown injury to brain--Interior side surface.

CASE # 5709027/A-33

1976 Chevrolet Chevette 2-door with B-pillar was struck in the left side by an Oldsmobile 98. Direct damage to entire left side with greatest penetration (38 inches) in the left rear door area. The sill was engaged less than the maximum. The roof side rail was not engaged but was subject to induced damage.

	Case Vehicle	Other Vehicle
CDC	10 LDEW 6	Unknown
Delta-V's	Not Computed	Not Computed

COMMENTS:
Left front door latch and hinge damage. No release or separation. Door did not open. Door had to be removed by rescue team to extricate driver. No ejection. Intrusion--both left door areas, A- and B-pillars, roof side rail and left front door window frame. Maximum intrusion--32 inches (left rear door area panel).

OCCUPANTS(2):

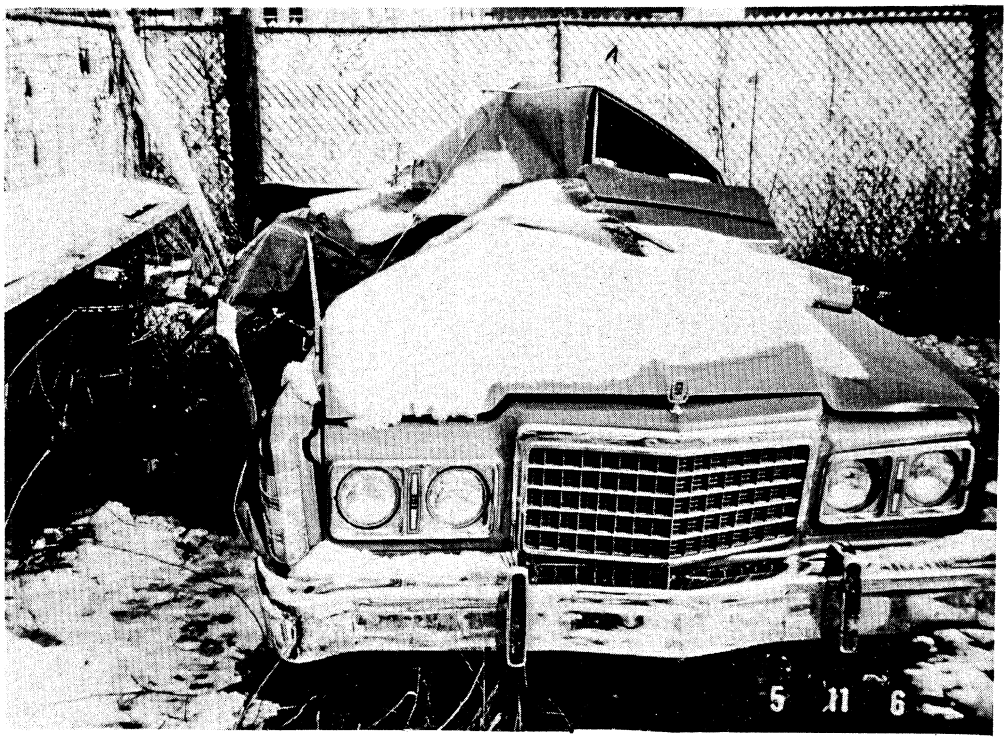
Driver, 57 years, near side, unrestrained, OAIS-6 FATAL Ruptured heart--side interior surface; Fractured vertebrae--upper back--side interior surface; Contusion, brain--interior side surface; Fractured chest area (Bilateral)--side interior surface; Fractured skull--side interior surface.

Right front, 23 years, far side, unrestrained, OAIS-3. Fractured jaw--Instrument panel; Fractured left forearm.

CASE #3711056/A-34

1975 Ford LD 4-door with B-pillar was struck in the right side by a Ford Walk-in Van. The right side of the passenger compartment, the roof side rail, and the roof were damaged by direct contact. A maximum of 46 inches penetration occurred just forward of the B-pillar at the beltline. The sill and roof rail were engaged less than maximum.

	Case Vehicle	Other Vehicle
CDC	03 RDAW 6	12 FDEW 5
Total Delta-V	33 mph.	25 mph.
Long. Delta-V	00 mph	-25 mph.
Lat. Delta-V	-33 mph.	00 mph.



COMMENTS:
Both right doors impacted. Right front latch and hinge damage. No release, no separation. Doors did not open. No ejection. Intrusion--both door panels, A-, B-, and C-pillars, and roof rail. Maximum intrusion of 40 inches (B-pillar). Intrusion probably not a factor.

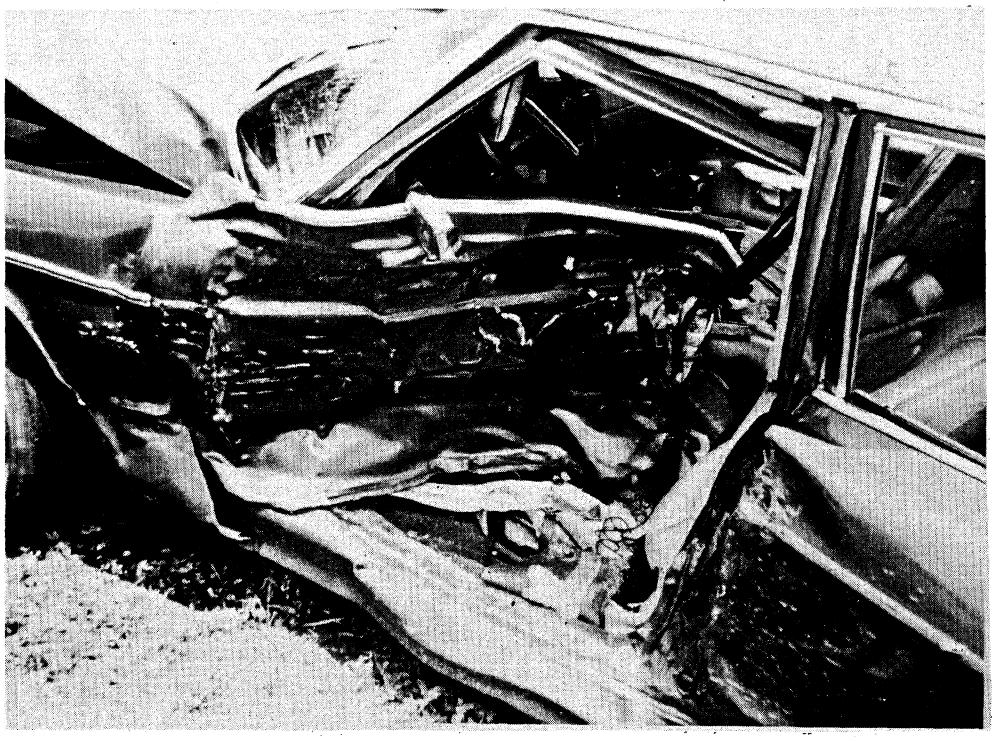
OCCUPANTS(1):

Driver, 20 years, far side, unrestrained, OAIS-6 FATAL Fractured neck vertebrae--roof side rail; fractured skull--roof side rail; Fractured back vertebrae--Unknown source; Unspecified internal injuries.

CASE #4706047/A-35

1974 Dodge Monaco 4-door with B-pillar was struck in the left side by a Ford Custom 500. The damaged area was primarily confined to the left front door with some direct damage to the A- and B-pillars. The sill was engaged less than maximum. The roof side rail was not engaged. Maximum penetration of 22 inches (left front door).

	Case Vehicle	Other Vehicle
CDC	08 LYEW 3	12 FZEW 1
Total Delta-V	16 mph.	16 mph.
Long. Delta-V	+08 mph.	-16 mph.
Lat. Delta-V	+14 mph.	-04 mph.



COMMENTS:
Both left doors impacted. Both with latch damage. Left front door latch released but neither door opened. Ejection--entrapment unknown. Intrusion included left front door panel, B-pillar, and window frame. Maximum intrusion was 23 inches (left front door panel). Intrusion probably a factor.

OCCUPANTS(2):

Driver, 75 years, near side, restraint usage unknown, OAIS-6 FATAL. Crushed chest (all systems)--side interior surface; Lacerated liver--side interior surface; Fractured thigh, lacerated diaphragm, fractured pelvis--Side interior surface; face laceration--window glass.

Right front, 71 years, far side, restraint usage unknown, OAIS-1. Contusion, right eye--Unknown source; Contusion, left face--Unknown source; Contusion, left wrist/hand--Unknown source.

CASE #5802036/A-36

1975 Buick Skylark 2-door with B-pillar was struck in the left side by a Dodge. Damaged area included the left front fender, left front door, and left rear door area. Sill was engaged less than maximum. The roof rail was not engaged. The maximum penetration (26 inches) occurred at the lower right corner of the left front door.

	Case Vehicle	Other Vehicle
CDC	10 LYEW 4	Unknown
Delta-V's	Not Computed	Not Computed

COMMENTS:
Left front door impacted. Latch and hinge damage. No release. No separation. Door did not open. No ejection. Intrusion--Left front and left rear door area panels, A- and B-pillars and window frame. Maximum intrusion of 11 inches (left front panel). Intrusion probably not a factor.

OCCUPANTS(1):

Driver, 74 years, near side, unrestrained, OAIS-6 FATAL Lacerated artery (chest)--side interior surface; Fracture (left) chest; Fracture (center) chest; Fracture (left) thigh; contusion, hip--Side interior surface.

CASE # 270643/A-37

1974 Chevrolet Vega 2-door with B-pillar struck in left side by a 1973 Pontiac LeMans. The left rear passenger compartment area and rear quarter panel area were struck. The crash was catastrophic with well over 18 inches of intrusion of the left rear side panel. Both rocker panel "area" and roof rail were engaged.

	Case Vehicle	Other Vehicle
CDC	10 LZEW 9	12 FYEW 3
Delta-V's	Not Computed	Not Computed

COMMENTS:
The left rear side panel, floor pan, and drive train sheared off. These components were found "several hundred feet from final resting place." Considerable intrusion of the side panel occurred before complete separation.

OCCUPANTS(3):

Driver, 28 years, near side, unknown restraint, OAIS-1. Contusion of right side of the head (source unknown) and left side of chest from door panel. Not ejected.

Right front, 23 years, far side, unknown restraint, OAIS-1. Contusion of left side of face from windshield, right side of chest and left side of abdomen from instrument panel. Unknown if ejected.

Left rear, 3 years, near side, unknown if restrained, OAIS-6 FATAL. Laceration of brain with avulsion of right side, contact unknown. Unknown if ejected.

No photographs available.

CASE # 2710029/A-38

1977 Plymouth Volare 4-door with B-pillar was struck in right side by a F-250 Ford pickup. The catastrophic damage was to the passenger compartment and forward. Intrusion by the hood of the truck into the right front passenger compartment was 15 inches. The rocker panel was engaged for penetration (15 inches), and the roof rail was engaged with less intrusion.

	Case Vehicle	Other Vehicle
CDC	04 RYAW 4	12 FDEW 4
Delta-V's	Not Computed	Not Computed

COMMENTS:
The front end of the Plymouth was sheared off at the rear of the instrument panel, exposing the passenger compartment. The right front door opened as a result of the front end removal and latch separation. Not ejected.

OCCUPANTS(2):

Driver, 40 years, far side, lap-belted, OAIS-3. Bilateral contused lungs from contact with instrument panel. Other minor and moderate injuries from the instrument panel, steering wheel, windshield, and glove box area. Not ejected.

Right front, 47 years, near side, unrestrained, OAIS-6 FATAL. Fatal injury was left side brain hemorrhage. Also skull fracture AIS-4. Both from the hood of the pickup which intruded through the right front window. Not ejected.

No photographs available.

CASES A39 - A46
Car-Truck Crashes

CASE # 6711107/A-39

1978 Datsun 280Z, 2-door with B-pillar was entering a rest area (at high speed) and slid into the right rear corner of a parked Semi-trailer. The initial impact was in the left front door. The sill was engaged less than the full amount. The roof rail was engaged fully. The maximum penetration was 35 inches (left front door).

	Case Vehicle	Other Vehicle
CDC	10 LZAW 5	Unknown
Total Delta-V	38 mph.	Unknown
Long. Delta-V	+05 mph.	Unknown
Lat. Delta-V	+38 mph.	Unknown

COMMENTS:
Latch and hinge damage. Latch released, no hinge separation. Doors did not open, no ejection. Intruding components: A- and B-pillar, left front door, window frame and roof side rail. Maximum intrusion of 23 inches (rail). Intrusion was a factor.

OCCUPANTS(1):

Driver, 31 years, near side, unrestrained, OAIS-6 FATAL Fractured neck vertebrae--Unknown source; Unspecified head injuries--Unknown source.

CASE # 1803008/A-40

1973 AMC Hornet 4-door with B-pillar was struck by a White Freightliner. The tractor-trailer had jackknifed in such a manner that the trailer was still aligned with the roadway and the tractor was at right angles to the on-coming traffic. The unit was still sliding in the original direction of travel when it struck the case vehicle in the left side. The case vehicle was pushed backwards approximately 60 feet where it struck a guard rail with the right rear corner. The case vehicle then rolled over.

	Case Vehicle	Other Vehicle
CDC	11 LYAW 4	03 RFEW 4
Delta-V's	Not Computed	Not Computed

COMMENTS:
Both left doors damaged by direct contact. Left front door--latch damage and release, hinge separation. Left front door ripped off. Left rear door--latch damage and release. Ejection through left front door. Intrusion--A- and B-pillars, both door panels, both window frames, and roof side rail (left front door panel). Maximum intrusion of 20 inches (left front door panel). In the initial impact, the roof side rail and the door sill were engaged less than the full amount. Intrusion probably a factor.

OCCUPANT(1):

Driver, 24 years, near side, unrestrained, OAIS-6 FATAL Lacerated artery in chest--A-pillar; Lacerated liver--steering assembly; Lacerated arteries--ruptured diaphragm in abdomen--steering assembly; Fractured sternum--steering assembly.

CASE # 1803054/A-41

1975 Plymouth Volare 4-door with B-pillar was struck in the left side by a Ford Tractor-Semitrailer. Both left doors received direct damage. The door sill and the roof side rail were engaged less than the full amount.

	Case Vehicle	Other Vehicle
CDC	09 LDAW 4	12 FDEW 1
Delta-V's	Not Computed	Not Computed

COMMENTS:
Both left doors impacted. Both with latch and hinge damage. None opened. Maximum penetration of 33 inches (upper right corner, left front door). Intrusion A-, B-, and C-pillars, both door panels, window frames and roof side rail. Maximum intrusion--13 inches (B-pillar). No ejection. Intrusion probably did not increase severity of injuries.

OCCUPANTS(1):

Driver, 42 years, near side, unrestrained, OAIS-6 FATAL Lacerated chest arteries--side interior surface; Ruptured spleen--Arm rest; Ruptured digestive system--hardware.

CASE #2701050/A-42

1974 Ford Maverick 2-door with B-pillar was struck in the left side by a Ford Tractor-Semitrailer. The case vehicle received distributed side damage. The maximum penetration is unknown.

	Case Vehicle	Other Vehicle
CDC	08 LDAW 4	12 FDEW 3
Delta-V's	Not Computed	Not Computed

COMMENTS:
Left front door impacted. Latch damaged and released. Hinge damage--no separation. Door opened, ejection through open door. Intrusion--Left front door panel, B-pillar and roof side rail. Maximum intrusion of 20 inches (side rail). Role of intrusion unknown.

OCCUPANTS(2):

Driver, 18 years, near side, unrestrained, OAIS-6 FATAL

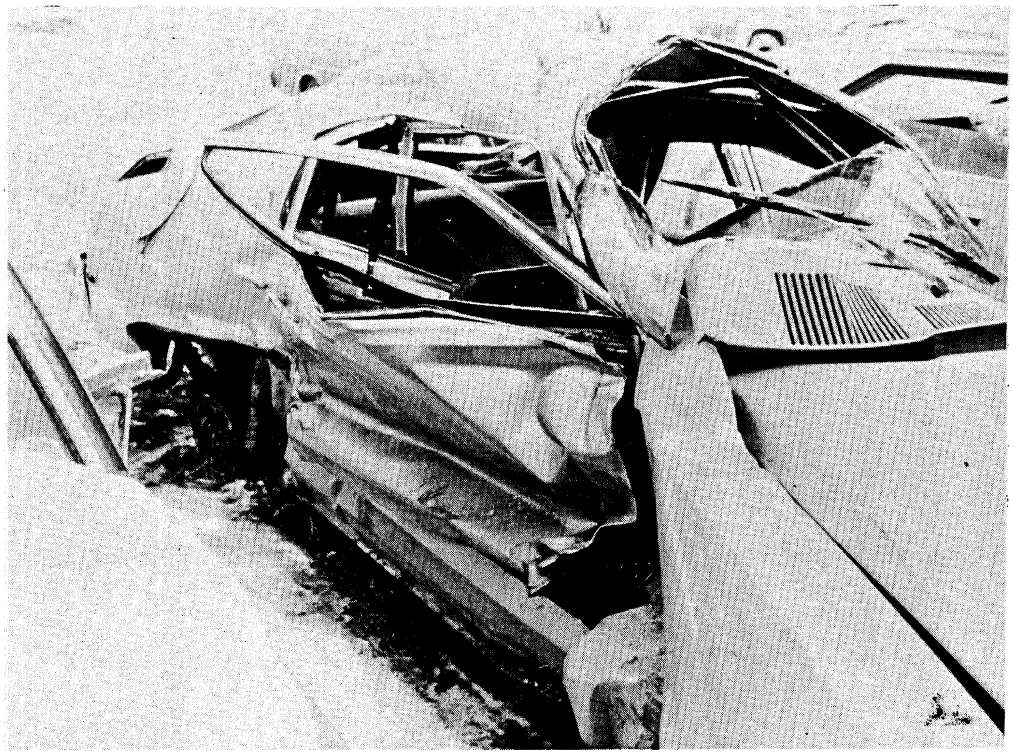
Right front, 6 years,far side, unrestrained, OAIS-4. Lacerated spleen, Contused kidney, Contused left lung, Fractured lower head, Fracture of pelvic area, Fracture of left shoulder--Unknown source.

No photographs available.

CASE #1703020/A-43

1973 Pontiac Ventura 2-door with B-pillar was struck in the right side by an International Transtar II Tractor. While the damage, by definition (CDC), was "distributed" the maximum deformation was confined to the passenger compartment. A penetration of "over 18" was recorded for the right rear door area. The door sill was not engaged. The roof rail was engaged--full penetration.

	Case Vehicle	Other Vehicle
CDC	02 RDAW 4	12 FDEW 6
Delta-V's	Not Computed	Not Computed



COMMENTS:
Right front door impact. Latch damaged and released. Door opened. No ejection. Intrusion--A- and B-pillars, both right door area panels, window frame and roof side rail. Maximum intrusion of 24 inches (B-pillar). Intrusion probably a factor.

OCCUPANTS(2):

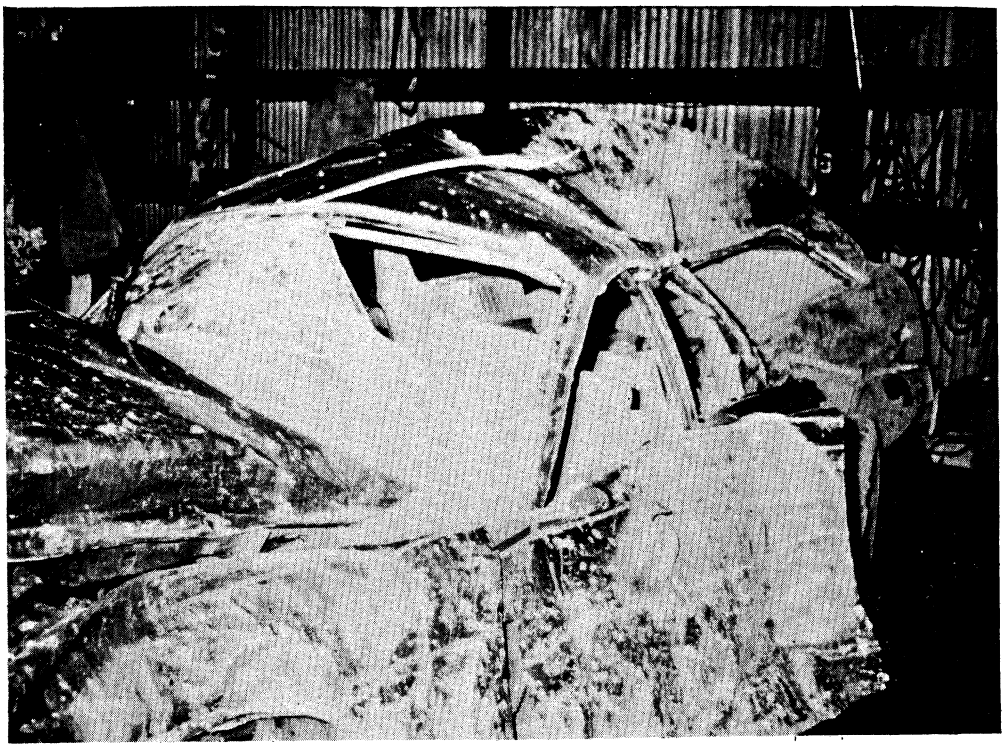
Driver, 65 years, far side, unrestrained, OAIS-6 FATAL Laceration--brain, liver, right lung, heart, spleen--Source-side interior surfaces.

Right front, 70 years, near side, unrestrained, OAIS-6 FATAL. Laceration--chest arteries, left lung, stomach, side interior surfaces. Laceration, liver--arm rest; Fracture (bilateral) chest area --side interior surface.

CASE # 1711040/A-44

1975 Ford LTD 4-door s/w B-pillar was struck initially in the left front by an International dump truck. The vehicles then came together side to side. The truck caught fire and burned out the cab completely. The case vehicle also caught fire but the fire was quickly extinguished. At some point in the sequence of events, the truck's dump box came off the chassis. Damage to the case vehicle involved the left fender and both left doors. The door sill was engaged less than the full amount, the roof rail an unknown amount. The maximum penetration was given as "over 18 inches" at the left rear door.

	Case Vehicle	Other Vehicle
CDC (1st impact)	10 LFEW 4	01 FZEW 6
CDC (2nd impact)	09 LZAW 5	03 RZEW 1
Total Delta-V (1st)	42 mph.	35 mph.
Long. Delta-V (1st)	-21 mph.	-30 mph.
Lat. Delta-V (1st)	+36 mph.	-17 mph.



COMMENTS:
Both left doors impacted with latch and hinge damage. Left front latch released and door opened. No ejection. Intrusion--A-, B-,and C-pillars, both door panels and roof side rail. Maximum intrusion of 18 inches (rear door panel).

OCCUPANTS(1):

Driver, 71 years, near side, unrestrained, OAIS-6 FATAL Unknown injury and source.

CASE # 1803044/A-45

1975 Buick Skyhawk 2-door with B-pillar was struck in the left side by a GMC Tractor. Severe damage to left side. Extent as sketched (no photographs), shows at least 50 percent of vehicle crushed. Crush listed as "over 18 inches)." Sill and rail probably less than maximum.

	Case Vehicle	Other Vehicle
CDC	09 LZAW 7	12 FDEW 7
Delta-V's	Not Computed	Not Computed

COMMENTS:
Left front door and latch damage. Latch did not release, door did not open. Ejection of driver through unknown portal. Intrusion--A-, B-, C-pillars, both door panels, and roof side rail. Probably A-pillar had most intrusion. Intrusion extend unknown. It is probable that the injuries were caused by the intrusion of the side of the vehicle followed by the intrusion of the truck.

OCCUPANTS(1):

Driver, 21 years, near side, unrestrained,OAIS-6 FATAL Laceration, brain, chest arteries, liver, lungs (right), spleen--unknown source; Fractured skull--unknown source.

No photographs available.

CASE # 1705004/A-46

1973 Mercury Montego,4-door with B-pillar struck in left side by a F-700 Mack truck. The crash was catastrophic with 23 inches of intrusion of the left front door in the center at the beltline. The roof rail intruded 40 inches. The rocker panel/sill area was not engaged.

	Case Vehicle	Other Vehicle
CDC	10 LZAW 4	01 FDEW 6
Delta V's	Not Computed	Not Computed

COMMENTS:
The damage to the left side at the passenger compartment was massive. Direct damage also resulted in intrusion of the left rear door. Both doors opened because of hinge and lap separation. Evidence of occupant contact was destroyed by fire. Two occupants were ejected through unknown portals. Although the occupant contacts were not given by the investigators, it appears that many of the fatal injuries are from the intruding truck.

OCCUPANTS(6):

Driver, 29 years, near side, unknown restraint, OAIS-6 FATAL. Fatal injuries were laceration of the brain and cervical spinal cord, and bilateral crushed chest. Also received AIS-5 laceration of the liver and kidney. Ejected. Injury associated with ejection was not identified, nor was the portal.

Unknown position, 20 years, ejected from unknown portal, OAIS-6 FATAL. Fatal injuries were crushed head and chest. Also received AIS-5 lacerations of the liver and kidney.

Unknown position, 19 years, OAIS-6 FATAL. Fatal injuries were laceration of the brain and cervical spinal cord, from the back. Also received lacerated kidney (AIS-5), fractured skull (AIS-4), and contusion of the lungs with hemothorax (AIS-3). Occupant not ejected.

Unknown position, 20 years, OAIS-6 FATAL. Fatal injuries were laceration of the brain and heart. Also received laceration of lungs, liver, and kidney. Not ejected.

Unknown position,19 years, OAIS-6 FATAL. Fatal injuries were complete transection at upper back, fracture of cervical spine, laceration of brain, and laceration of heart. Not ejected.

Unknown position, 19 years, OAIS-6 FATAL. Fatal injuries were laceration of brain, cervical spinal cord, heart, and lungs. Not ejected.

No photographs available.

CASES A47 - A53
Car-Train Crashes

CASE # 3706052/A-47

1976 Buick Le Sabre 4-door with B-pillar was struck in the left side by a GM locomotive. The damage extended from the front fender to the rear door. The maximum penetration was 37 inches (center at front door).

	Case Vehicle	Other Vehicle
CDC	9 LDAW 4	Unknown
Delta-V's	Not Computed	Not Computed

COMMENTS:
The hinges and latches on both left doors were damaged. There was no separation. The doors did not open. No ejection. Left front door intruded 37 inches. Driver's legs pinned between door and seat. Driver's feet pinned against foot controls. Other intrusion--left rear door, A-, B-, and C-pillars, window frame, roof rail. Intrusion a factor.

OCCUPANT(1):

Driver, 34 years, male, unrestrained, near side, OAIS-6 FATAL Avulsion of liver and arteries, laceration of left mediastinum, --train coupler.

CASE # 3705077/A-48

1973 Ford Mustang without B-pillar ran into the side of a moving train. The vehicle was thrown 35 feet to the left. The right rear of the vehicle struck the train. There was very little damage to the passenger compartment. The sill and rail were not engaged.

	Case Vehicle	Other Vehicle
CDC	03 RFEW 8	Unknown

COMMENTS:
No latch or hinge damage. Right front occupant ejected through right front window--unknown if open. No intrusion.

OCCUPANTS(2):

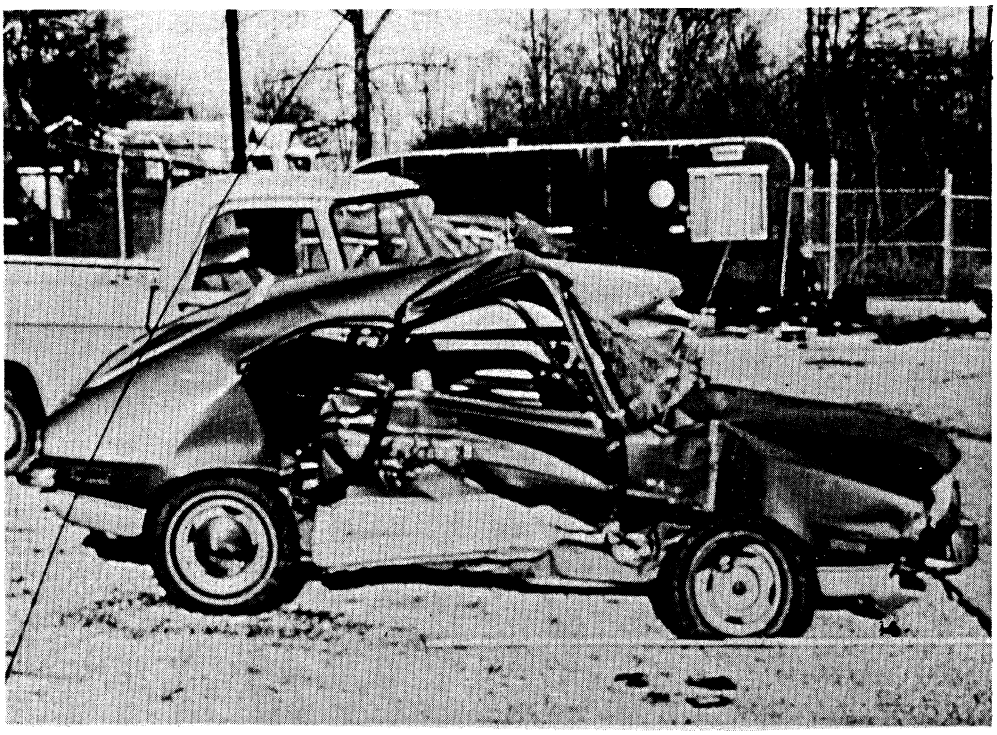
Driver, 16 years, far side, unrestrained, OAIS-1. Abrasions, face --steering assembly. Contusions, head--steering assembly. Contusion, knee--Instrument panel.

Right front, 17 years, near side, unrestrained, OAIS-6 FATAL Unknown injury detail. Police report--Skull fracture and extensive cuts and abrasion.

CASE # 3703013/A-49

1973 Ford Pinto, 2-door hatchback with B-pillar was struck on the right side by a locomotive. The damage extended from the front of the vehicle to the rear window. Maximum penetration of 30 inches (just above sill at the front edge of the door). The sill was engaged less than maximum. The roof rail was not engaged.

	Case Vehicle	Other Vehicle
CDC	02 RYEW 4	Unknown
Delta-V's	Not Computed	Not Computed



COMMENTS:
Right front door impacted. Latch and hinge damage. Door did not open. No ejection. Intrusion--Both right door area panels, A-, B-, C-pillars, front window frame, roof side rail (induced). Maximum intrusion of 26 inches (right rear door area). Intrusion may have been a factor.

OCCUPANTS(2):

Driver, 69 years, far side, unrestrained, OAIS-2. Fracture, pelvic area--console; Contusions, chest and abdomen areas (external)--Unknown source; Abrasion, thigh, wrist/hand, face--Unknown source.

Right front, 84 years, near side, unrestrained, OAIS-6 FATAL Crushed chest and lacerated liver--Side interior surfaces; Fractured skull and lacerated brain--Locomotive.

CASE #6703034/A-50

1975 Oldsmobile 98 4-door was struck in the left side by a locomotive. The entire left side was damaged. The sill and rail were engaged an unknown amount. The maximum penetration was 38 inches (left rear door).

	Case Vehicle	Other Vehicle
CDC	10 LDAW 5	Unknown
Delta-V's	Not Computed	Not Computed

COMMENTS:
Both left doors impacted. Left door latch damaged and released. Door opened. Left rear door latch damaged--did not "release." Left rear hinge separation and door torn off. Driver ejected--unknown portal. Unknown amount of intrusion--probably all elements on left side.

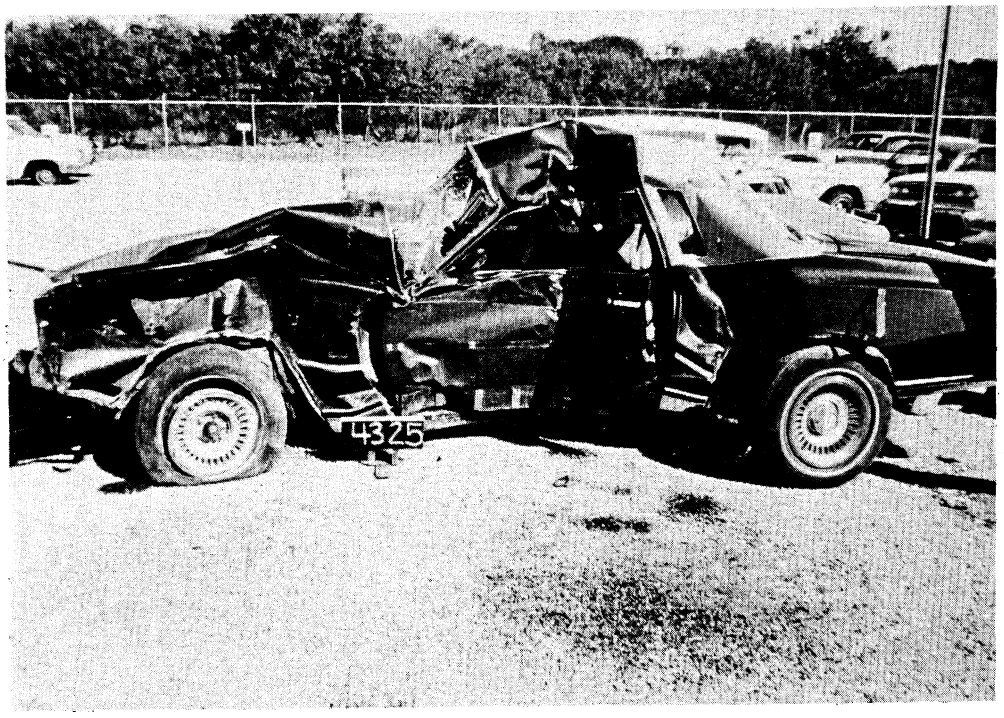
OCCUPANT(1):

Driver, 48 years, near side, unknown, restraint usage. OAIS-6 FATAL Crushed head--A-pillar; Fractured pelvic area--side interior surfaces; Laceration, shoulder--side interior surfaces; Fractured wrist and hand, abrasion,thigh and abrasion, knee--Exterior objects.

CASE #6709054/A-51

1977 Chevrolet Monte Carlo 2-door with B-pillar was struck by a locomotive. The damaged area included the right front fender, left front and left rear door areas. The sill was engaged less than the full amount. The roof rail was engaged the full amount. The maximum penetration was 31 inches (left front door).

CDC (Case Vehicle) 09 LYAW 5
Delta-V's Not Computed



COMMENTS:
There was latch and hinge damage. The door did not open. No ejection. The driver was trapped. Both left door areas intruded as did the roof rail. The maximum intrusion was 34 inches (left front door panel).

OCCUPANT(1):

Driver, 53 years, female, near side, lap restraint only, OAIS-6 FATAL Unknown injury to brain--Intruding locomotive; Fracture, upper arm--Side interior surface; Laceration, leftside of head--Intruding locomotive; Contusion, chest--Steering assembly; Contusion, lower leg--Unknown source.

CASE # 6711094/A-52

1973 AMC Ambassador 4-door with B-pillar was struck in the left side by a locomotive. The damaged area extended from the front of the vehicle to approximately the rear wheel. Both sill and roof rail were engaged less than the full amount. The maximum penetration was 37 inches at the left front door.

CDC (Case Vehicle)	09 LDAW 6
Delta-V's	Not Computed

COMMENTS:
Both left doors had latch and hinge damage. No hinge separation. None opened. No ejection. Intrusion included, left front door panel, A- and B-pillar, window frame, roof side rail. Maximum intrusion of 31 inches (left front door panel) (No information on intrusion of left rear door panel.)

OCCUPANT(1):

Driver, 73 years, unrestrained, OAIS-6 FATAL. Unknown injury to brain--intruding locomotive; Unknown injury to chest--side interior surface; Unknown injury to abdomen--side interior surface.

CASE # 4701002/A-53

1976 Toyota Corolla 2-door with B-pillar struck in left side by a railroad train. Both the roof rail and rocker panel/sill area were engaged. Penetration and intrusion are undefined because the catastrophic crash severed the car at the fire wall, with the instrument panel remaining with the front section.

	Case Vehicle	Other Vehicle
CDC	10 LYAW 9	Unclassifiable
Delta V's	Not Computed	Not Computed

COMMENTS:
The damage was catastrophic. In spite of this, the doors did not open. Although both latches and hinges were damaged, they did not separate. Both the rocker panel and roof rail on the left side were engaged.

OCCUPANT:

Driver, 28 years, near side, unrestrained, OAIS-6 FATAL. Fatal injury was fractured cervical vertebrae (AIS-60. Source of injury was coded as "other" exterior to passenger compartment. Ejected.

No photographs available.