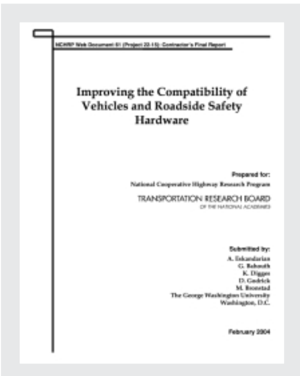
Improving the Compatibility of Vehicles and Roadside Safety Hardware

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DETAILS

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AUTHORS

K Digges; M Bronstad; A Eskandarian; G Bahouth; D Godrick; Transportation Research Board

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Improving the Compatibility of Vehicles and Roadside Safety Hardware

Prepared for:

National Cooperative Highway Research Program

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Submitted by:

A. Eskandarian
G. Bahouth
K. Digges
D. Godrick
M. Bronstad
The George Washington University
Washington, D.C.

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Summary of Findings

The objectives of this study, "Improving the Compatibility of Vehicles and Roadside Safety Hardware", are to 1) Identify current and future vehicle characteristics that are potentially incompatible with existing roadside safety hardware, 2) assess opportunities for and barriers to improved compatibility, and 3) increase the vehicle and hardware manufacturer's awareness of compatibility problems.

Since the early 1990's, the United States vehicle fleet has shown drastic changes in its characteristics. Overall, vehicle size and mass have increased while a large population of drivers have shifted from passenger cars to Sport Utility Vehicles (SUVs) and pickup trucks. The magnitude and implication of these changes as they affect roadside hardware crash outcomes was one area of concentration during this research.

Based on early studies, the 820 kg small car and the 2000 kg pickup truck were considered to be representative of the worst cases or extremes of the passenger vehicle population during impacts with roadside devices. Based on vehicle population profiles, this assumption was valid during the early 1980's. However, a steady increase in vehicle size for the compact and small car categories as well as the emergence of SUVs has lead to a significantly different vehicle fleet today.

Pickup trucks were found to inadequately represent the crash behavior of SUVs. Also, analysis of fatal crashes involving longitudinal barriers (guardrails and concrete median barriers) indicated that midsize SUVs have nearly 8.6 fatal crashes per million vehicles per year registered during barrier impacts; compared to 4.6 for full size pickup trucks. In addition, it was found that rollover involvement is 10-14% higher for compact and midsize SUVs verses compact and full size pickup trucks. An evaluation of the dynamic characteristics of pickup trucks and SUVs indicated significant differences in the center of gravity location (CG) and vehicle weight distribution. Further, SUVs were found to have a 10% higher rollover risk than pickups of similar wheelbase and track width.

A methodology to review real world crash cases from the National Automobile Sampling System/Crashworthiness Data System (NASS/CDS) database was developed to identify patterns and occurrences of incompatibility. In all, 247 crash cases were reviewed thoroughly. These cases involved passenger vehicle impacts with guardrails, concrete median barriers and end terminals. Based on this review, the following observations were made.

1. Under typical impact conditions (i.e. impact angles $\leq$ 25 deg), small and midsize cars involved in guardrail crashes are usually safely redirected with minimal injury to the occupants. This

indicates that there are no major compatibility issues between guardrails and these types of vehicles.

2. Impacts with concrete median barriers were found to be more serious. Even at moderate impact angles, significant numbers of car occupants sustained serious injuries.

3. Under normal impact conditions into guardrails and concrete median barriers, significantly higher counts of rollovers were found among SUVs than compact and full-size pickup trucks.

4. A significant number of end terminals intruding into the occupant compartment during side impact collisions with passenger cars were found.

5. Side impact crashes of SUVs involving guardrail end terminals often resulted in severe barrier deformation and a lack of vehicle containment. Often this lack of containment lead to additional harmful impacts with natural features behind the barrier.

Passenger vehicle crashes with roadside devices often involve other harmful events or impact characteristics which contribute to the likelihood of serious injury. Data contained in the NASS/CDS system provides good documentation of vehicle behavior and occupant protection; however, several factors that are important for roadside hardware safety analysis are missing. To provide this additional information, supplemental data collection sheets have been created (Section 4.2 Figures 4.2-4.5). These proposed sheets are intended to help accident investigators collect pertinent device and crash characteristics. In addition, supplemental instructions are given to document impacted devices using more detailed scene photographs.

In order to identify the vehicle structural characteristics that affected the outcome of roadside hardware crashes, several databases were examined to determine the vehicle dimensions. Upon examination of the structural characteristics of the vehicles contained in the databases, some correlation was found between vehicle global attributes and crash outcomes. Specifically an evaluation of track width and height, overall height, and mass indicated good correlation with crash outcomes and severe injuries. However, more detailed characteristics, such as frame rail spread, frontal overhang and center of force did not show a significant correlation.

Further, to identify the most appropriate vehicles for testing roadside hardware devices, vehicle registration data as well as vehicle characteristics were examined. A new vehicle classification method was established using this data. An average vehicle from within each of these classes would be a logical choice as a test vehicle.

To solicit ideas from a group of safety experts and to raise awareness to communities who are not exposed to roadside safety issues, a one day workshop was organized. Representatives from the automotive industry, roadside hardware manufacturers and a series of government agencies attended a one day workshop for this purpose. Specific workshop findings include:

1. The automotive industry was not aware of the magnitude and frequency of incompatibilities between roadside hardware and vehicles. Because of this, their current vehicle design strategies do not specifically address these issues.

2. Future roadside hardware testing criteria must take emerging vehicle platforms and design trends into account. The vehicles chosen for testing must be representative of the current vehicle population.

3. Automotive manufacturers are willing to explore the use of finite element methods to evaluate their emerging vehicle designs. Vehicle finite element models can be used to simulate a series of impact conditions with prominent roadside devices.

4. Improved data collection and analysis techniques are necessary to evaluate on-the-road systems and aid in identifying vehicle to roadside hardware incompatibilities.

Chapter 1
Introduction and Background

Between 1995 and 2000, over 2,000,000 people were injured during single vehicle crashes involving roadside structures. More than 280,000 sustained serious injuries. Single vehicle crashes involving roadside objects accounted for over 1/4 of all serious and fatal injuries that occurred on the roadways. The societal costs associated with these impacts consistently exceeded $70 billion annually during this time period.

The function of roadside safety features, as stated by NCHRP Report 350, is:

> to provide a forgiving roadway and roadside for an errant motorist. The safety goal is met when the feature either contains and redirects the vehicle away from a hazardous area, decelerates the vehicle to a stop over a relatively short distance, readily breaks away or fractures or yields, allows a controlled penetration, or is traversable, without causing serious injuries to the vehicle's occupants or to other motorists, pedestrians, or work zone personnel. [38]

As these devices contain, redirect or decelerate vehicles in a safe manner, the risk of impact with non-crashworthy objects at the roadside is reduced.

In many cases, the roadside hardware safety systems were designed and installed over 20 years ago. These systems are based on attributes of a now outdated vehicle fleet. The current crash testing criteria utilizes more modern impacting vehicles but only two vehicle classes are required for testing. These two classes, specified in Report 350, are the small passenger car class (820 kg) and the large pickup truck class (2000 kg). These platforms adequately represent the extremes of the passenger vehicle fleet, but it remains unclear if intermediate vehicle platforms exhibit the same impact behavior as these tested vehicles.

Changes in vehicle attributes over the past two decades; including size, mass and geometry; have been drastic while design criteria for roadside hardware systems have evolved at a lower rate. Those safety systems designed to perform adequately with older vehicles cannot be expected to perform similarly with more modern vehicle structures. In addition, the populations of today's vehicle classes are drastically different than those of only 5 years ago due to the increased popularity of light trucks and sport utility vehicles. These vehicles have gained popularity recently, and their market share will continue to grow based on recent projections. Due to higher CG, larger mass and varied structural geometry, this vehicle class will not interact with roadside structures like passenger cars. Conversely, small cars have decreased in popularity and their vehicle structures have become larger in recent years. As a consequence, current test procedures using the 820 kg body structure may not adequately represent the current and future vehicle fleet.

This study investigates these changes in vehicle attributes and the vehicle's compatibility with roadside hardware devices. A summary of this investigation is included in the next three sections of this report. First, in Chapter 2, real world crash data and case studies from the NASS/CDS and FARS databases are examined. Next, Chapter 3, the vehicle characteristics and registrations are presented to identify changes in the vehicle fleet over the past ten years. Following this, strategies to improve vehicle to roadside hardware compatibility are included in Chapter 4. In chapter 5, conclusions and suggestions for future research are given for the benefit of subsequent work in this area.

Chapter 2
Analysis of Real World Crash Information

An investigation of cases in the National Automotive Sampling System Crashworthiness Data Systems (NASS/CDS) [13] and the Fatal Accident Reporting System (FARS) [28] databases unearthed many accidents involving vehicles and roadside hardware systems. It was found that the different classes of vehicles had different compatibility issues with roadside hardware systems. These issues were investigated using two different approaches. The first approach used statistical analysis to find correlations between vehicle characteristics and roadside hardware compatibility. The second approach examined individual accident cases to gain further insight into compatibility issues.

2.1 Statistical Analysis

A detailed investigation of NASS/CDS and FARS databases was conducted to understand the impact performance of vehicle body types during crashes with roadside objects. The vehicle body types surveyed included different sizes of cars, SUVs, pickup trucks and vans. Roadside hardware objects were categorized as guardrails, concrete median barriers and small to midsized poles and posts.

New vehicle classifications were derived based on vehicle mass, wheelbase and body style. This classification was adopted in this study due to limitations found in the classification schemes currently used in NASS and FARS databases. The absence of a midsize SUV category and outdated mass cutoffs for the small car category prompted this reclassification. These new vehicle classes are listed in Table 2.1.

Cars	**Classification**
Compact	Weight < 2000 lb. OR Length < 165 in. OR (Weight < 2900 lb. AND Length < 183 in.)
Midsized	If vehicle is not compact AND (Weight ≤ 3400 lb. AND Length ≤ 200 in.)
Large	Weight > 3400 lb. OR Length > 200 in.
SUVs	
Compact	Weight < 3500 lb.

Midsized	3500 lb. ≤ Weight ≤ 4850 lb. AND Length < 190 in. AND Height < 75 in.
Large	Length ≥ 190 in. OR Weight > 4850 lb. OR Height > 75 in.
Pickup Trucks	
Compact	Weight < 3500 lb. AND Height < 70 in.
Large	Weight ≥ 3500 lb. OR Height ≥ 70 in.
Vans	
Midsized	Height ≤ 70 in. OR (Height < 75 in. AND Weight < 4000 lb.)
Large	Height ≥ 70 in. OR Weight > 4000 lb.

Table 2.01 Reclassification criteria for new vehicle categories

Over 90% of all passenger vehicles listed in the 2000 registration database were classified using this new scheme. Low volume models, pre-1980 models, and vehicles with missing dimensional information could not be classified. All statistical analysis includes only those vehicles where the key dimensional attributes are known.

Figure 2.1 shows crash mode distribution by body type for these vehicle classes listed above. The figure includes frontal, near side, far side, rear and rollover crashes. Frontal crashes are defined as impacts where the Principal Direction of Force (PDOF) is 10 o'clock through 2 o'clock and the General Area of Damage (GAD) is "front." Nearside crashes occur when the GAD is side and the occupant in question is seated on this side of the vehicle. Far side crashes are side impacts where the occupant is seated on the non-struck side of the vehicle. Rear crashes involve a PDOF of 5 through 7 o'clock and a "rear" GAD. A crash is classified as a rollover if a vehicle undergoes at least one quarter-turn. In addition to the percent of total, included in the figure is the percent involvement of frontal and rollover crashes for each class. It can be observed from the figure that compact and midsize SUV's are nearly six times more likely to be involved in rollover events than midsize cars.

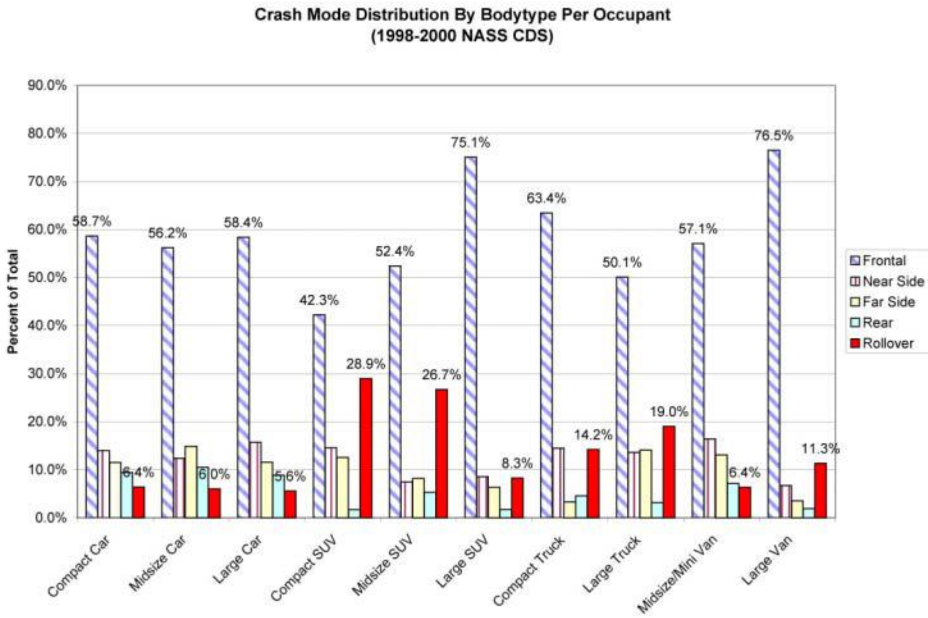


Figure 2.01 Crash involvement of passenger vehicles by impact mode (1998-2000 NASS/CDS)

Fatality rates for each vehicle class were also investigated. These rates, shown in Table 2.3, are presented in deaths per million vehicles registered. The four columns in the table display: fatality rates for all occurring crashes, crashes where guardrail impact was the most harmful event, crashes where concrete barriers were the most harmful event and crashes where posts and poles were the most harmful event. Each set of data has been ranked by fatality rate. The highest rates were placed at the top and the lowest at the bottom. A similar analysis was performed with rollover crashes excluded from the data, these results are listed in Table 2.4. In the table of all crashes (including rollover), fatality rates for compact cars are higher than fatality rates for other vehicle classes. However midsize and large SUVs have the highest fatality rates during Guardrail and Concrete Median Barrier impacts. Table 2.4, where rollover events are not considered, shows that fatality rates for SUV impacts with longitudinal barriers drop below the fatality rates of small and midsize cars.

During this analysis, adjustment for vehicle occupancy was considered. Table 2.2 shows the average number of vehicle occupants per vehicle class. Figure 2.2 shows these values in terms of occupant count for each vehicle body type. These occupancy values are normalized as a percent of the total number of crashes for each vehicle category. Further normalization by crash involvement reveals that SUV's are involved in slightly more crashes per vehicle registered than pickup trucks so that the fatality rates may be influenced by driver behavior in addition to the crash performance of each vehicle class. This trend is recognized however no adjustment for this trend has been made during this analysis.

Body Type	Ave. Occupants Per Vehicle	Percent Difference vs. Passenger Cars
Cars	1.46	Baseline
Small SUV's	1.49	1.9%
Large SUV's	1.64	11.7%
Small Pickups	1.28	-12.6%
Large Pickups	1.41	-3.6%
Minivans	1.83	25.0%

Table 2.02 Occupancy rates for each vehicle class relative to passenger car occupancy

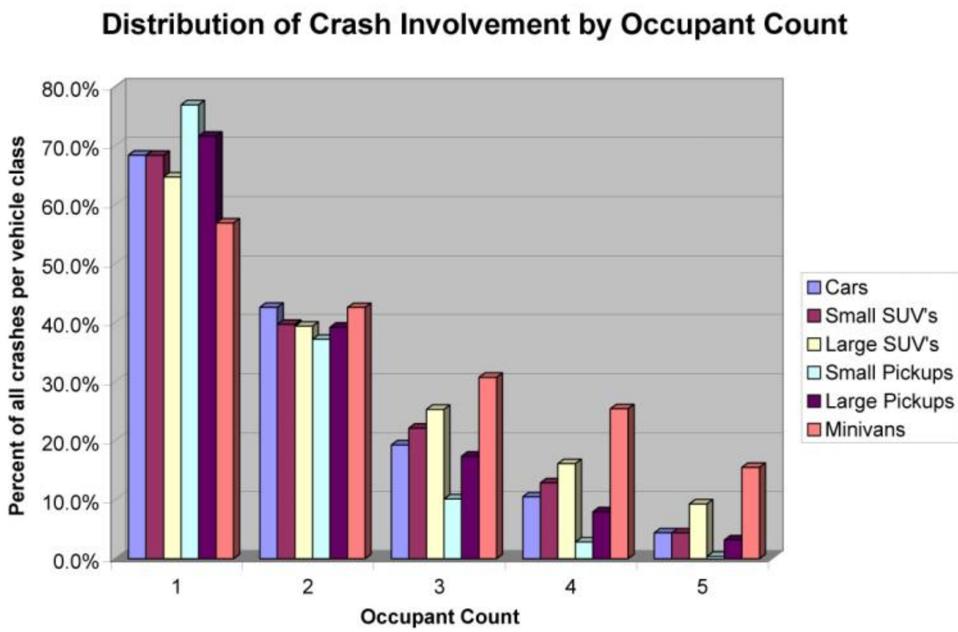


Figure 2.02: Occupancy counts normalized by total crash count per vehicle class

Another observation is that compact cars have the highest fatality rates during impacts with poles and posts.

Rollover Cases Included							
All Crashes		**Guardrails**		**Concrete Barriers**		**Posts/Poles**	
Comp Car	192.2	**Mid SUV**	8.6	**Lrg SUV**	2.3	**Comp Car**	14.3
Comp Trk	189.4	**Lrg SUV**	7.5	**Comp SUV**	1.9	**Mid Car**	13.4
Lrg SUV	189.1	**Comp Car**	5.8	**Mid SUV**	1.8	**Comp Trk**	12.9
Mid SUV	176.6	**Mid Car**	5.7	**Comp Car**	1.4	**Lrg SUV**	11.9
Mid Car	168.5	**Comp SUV**	5.6	**Mid Car**	1.2	**Lrg Car**	10.1
Comp SUV	156.9	**Comp Trk**	4.9	**Lrg Van**	0.9	**Mid SUV**	9.9
Lrg Car	133.6	**Lrg Trk**	4.6	**Mid Van**	0.9	**Comp SUV**	9.6
Mid Van	117.1	**Lrg Car**	4.3	**Lrg Car**	0.9	**Lrg Trk**	7.2
Lrg Trk	111.3	**Mid Van**	4.2	**Comp Trk**	0.9	**Lrg Van**	5.7
Lrg Van	87.5	**Lrg Van**	3.9	**Lrg Trk**	0.6	**Mid Van**	4.8

Table 2.03 Fatality rates for each vehicle class ranked from highest to lowest

Rollover Cases Excluded							
All Crashes		**Guardrails**		**Concrete Barriers**		**Posts/Poles**	
Comp Car	147.6	**Mid Car**	3.4	**Comp Car**	0.9	**Comp Car**	10.5
Mid Car	130.4	**Comp Car**	3.3	**Mid Car**	0.8	**Mid Car**	9.7
Comp Trk	112.7	**Lrg Car**	2.8	**Lrg SUV**	0.7	**Lrg Car**	7.8
Lrg Car	110.9	**Mid SUV**	2.5	**Lrg Car**	0.7	**Comp Trk**	7.8
Lrg SUV	78.9	**Comp SUV**	2.2	**Mid Van**	0.5	**Lrg SUV**	5.5
Mid Van	74.1	**Comp Trk**	2.0	**Comp SUV**	0.4	**Lrg Trk**	3.9
Lrg Trk	62.3	**Lrg Trk**	1.9	**Lrg Van**	0.4	**Mid SUV**	3.7
Mid SUV	59.5	**Mid Van**	1.9	**Comp Trk**	0.3	**Lrg Van**	3.6
Comp SUV	58.8	**Lrg SUV**	1.4	**Mid SUV**	0.3	**Comp SUV**	3.5
Lrg Van	48.9	**Lrg Van**	1.4	**Lrg Trk**	0.3	**Mid Van**	2.9

Table 2.04 Fatality rates excluding rollover-involved fatalities for each vehicle class ranked from highest to lowest

The NASS/CDS database was also used to assess fatality counts for impacts where the most harmful event was contact with a roadside hardware object. Fatality trends in impacts involving these objects were found per vehicle class based on the population of those vehicles on the road from 1990-2000. The analysis did not show significant differences in crash performance as vehicle design changed over this ten year period. It should be noted the frequency of roadside device installations was not included in the analysis therefore exposure was not well accounted for.

2.2 Single Vehicle Crash Case Reviews

In order to examine the vehicle to guardrail interaction more closely and identify compatibility issues, a thorough investigation of individual crash cases from the NASS/CDS database was performed. A web-based query tool was developed to facilitate access to complete NASS/CDS case information. The tool was used to query the NASS/CDS database with a user defined set of crash attributes. Once the cases were chosen, the tool allowed the individual cases to be reviewed in a simple and easy to read format. In these summaries, all data points recorded by NASS/CDS investigators were available, including the scene diagrams and post-crash photographs. Key variables from the NASS/CDS database have been selected for this study and displayed for each individual case. These variables gave a concise overview of the following accident attributes:

1. Crash Severity
2. Pre-Crash Environment
3. Vehicle Factors
4. Pre-Crash Driver Data
5. Driver Factors
6. Severe Injuries Sustained Per Occupant

This format was chosen to understand crash causation, vehicle behavior and injuries for individual roadside hardware crashes. Due to the limited amount of information concerning the roadside hardware systems in the NASS/CDS database, the crash photos were carefully examined to determine the type of guardrail involved in the collision. Upon completion of review for each case, the four photographs that best represent the case were chosen. The summary sheets were created, which include these photographs, the relevant case information, the scene diagram and the case summary to highlight the nature of the crash event.

Note: In some cases, certain data points could not obtained by NASS crash investigators and are therefore unavailable for this analysis. These data points, including some deltaV values and impact speeds, are alternatively coded as <5 km/h or 998 to indicate unknowns. This occurs in some cases because current methods used to retrospectively calculate deltaV based on vehicle crush are not valid for underride or override situations seen during some roadside hardware impacts. Similarly, impact speed is difficult to discern if final rest position and impact trajectory is unavailable. The data presented here is based on the best available crash information available within the NASS/CDS database.

The case review revealed different levels of vehicle to roadside hardware compatibility. Guardrails performed well when impacted by cars. Very few injuries were found in car to guardrail collisions involving a belted occupant. Un-belted occupants suffered more injuries than belted occupants, however many of these injuries were caused by partial or full ejection upon impact. Therefore it was hypothesized that the installation of a side curtain airbag would help reduce these injuries. More injuries were found in impacts involving cars and concrete barriers. Side curtain airbags would also help to reduce these injuries. Airbags can also be used to minimize the acceleration during automobile impacts with end terminals, however the timing of the airbag deployment could be critical.

Pick-up trucks and SUVs suffered from different types of incompatibilities with roadside hardware systems. The higher CG of these vehicles led to the vaulting of roadside barriers more frequently than cars. In addition, many of the injuries found in impacts between these vehicles and roadside hardware systems were the result of a rollover. In several cases, the hardware itself tripped the vehicle inducing a roll. A second mechanism of roll occurred due to an instability introduced by the collision with a barrier. Even though the barrier redirected the vehicle, this added instability caused the vehicle to roll later in the crash event.

The following 13 cases have been selected as examples of typical behavior during passenger vehicle impacts with roadside devices. In all of these cases the roadside device was the first or second most harmful event, and a serious injury (Maximum Abbreviated Injury Severity [MAIS] level 3+) occurred. Additionally, Appendix A contains a further selection of NASS/CDS cases meeting these criteria.

Case 1: 1998-75-154

In this case, a driver of a Toyota 4-Runner lost control while attempting a right-hand turn. Once out of control, the vehicle impacted a guardrail, climbed over the rail and subsequently rolled over. The rollover was a climb over initiated event with a tripping force applied to the undercarriage of the vehicle as indicated by the NASS investigator. The vehicle completed 5-quarter turns, and the occupant was ejected and killed.

This case is an example of poor interaction between the vehicle and barrier system where the guardrail failed to contain an SUV. Investigation into the scene and vehicle post crash pictures showed that the SUV hit the guardrail at a modest angle; however the SUV vaulted the barrier. It is hypothesized that impact severity (impact speed) may have exceeded the design capacity of this barrier; however, the post impact trajectory, as indicated by the scaled scene diagram, does not suggest excessive impact energy where multiple vehicle rolls occurred over a large distance. Current NCHRP 350 guidelines test these barrier systems at 100 km/h, 80 km/h and 60 km/h. This impact appears to have been at a lower severity than those required by NCHRP 350.

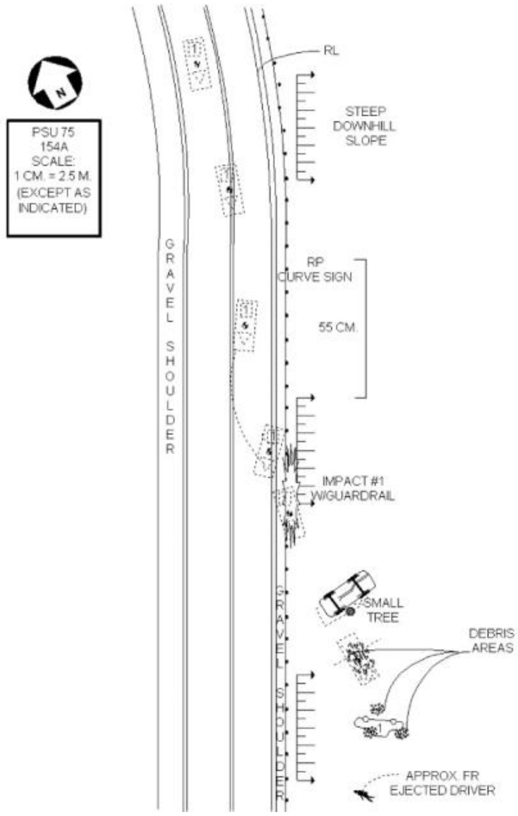
Pictures of the scene showed the guardrail to be a W-beam rail with wood posts and wood blockouts. It appears the guardrail was installed down a backslope. The high ground clearance, short overhang and exposed front tires of the 4-Runner led to interaction of the tires and barrier climbing by the vehicle. Additionally, the high CG and low static stability factor of this vehicle raised the risk of subsequent rollover once the vehicle climbed over the barrier system.

Important Factors

- Height of Treatment Relative to Roadway
- Installation Height of Treatment
- Distance of Treatment Relative to Roadway
- Downward Slope of Roadside before Impact Point
- CG Height of Toyota 4-Runner
- Average CG Height of Mid-Size SUVs
- Average CG Height of Full Size Pickup Trucks
- Researcher Determined Impact Angle

1 Case 1998-75-154

Summary:
V1 WAS TRAVELING WESTBOUND ON A TWO LANE TWO-WAY ROADWAY. V1 HAD JUST NEGOTIATED A SLIGHT RIGHT CURVE IN THE ROADWAY WHEN CONTROL OF THE VEHICLE WAS LOST. THE VEHICLE TRAVELED TO THE LEFT ACROSS THE CENTER LANE LINE, YAWED COUNTER CLOCKWISE ACROSS THE EASTBOUND TRAVEL LANE AND IMPACTED A GUARDRAIL WITH ITS FRONT. THE VEHICLE CONTINUED WESTBOUND, CLIMBING OVER THE GUARDRAIL AND BECAME AIRBORNE. THE VEHICLE HIT THE GROUND, ROTATED SLIGHTLY CLOCKWISE HIT A SMALL TREE AND ROLLED 5 QUARTER TURNS LEADING WITH ITS LEFT SIDE. DURING THE ROLLOVER, THE RIGHT FRONT DOOR OPENED. THE DRIVER WAS EJECTED THROUGH THE WINDSHIELD. THE DRIVER CAME TO REST APPROXIMATELY 13 METERS FROM V1'S FINAL REST. V1 CAME TO REST ON ITS LEFT SIDE FACING NORTHWEST. THE VEHICLE WAS TOWED FROM THE SCENE. THE DRIVER WAS TRANSPORTED AND DIED APPROXIMATELY 5 HOURS AFTER THE ACIDENT.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Toyota	4-Runner	1997	1	48	MALE	5 = CRITICAL INJURY

Figure 2.03: Case 1: Summary

Occupant: 1998-75-154-1-1




Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	CLIMB-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	OTHER BARRIER
Location on Vehicle where Principal Tripping Force was Applied	UNDERCARRIAGE
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	5 QUARTER TURNS
Impact Speed	< 0.5 KMPH
Total, Longitudinal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with Sequence number	SEVERE 3
CDC	0 T Z D O 6
Run off Road Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	NOT DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE RIGHT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	26

Vehicle Factors

Make-Model	Toyota 4-Runner
Year	1997
Class	PASSENGER CAR
Body Type	COMPACT UTILITY
Weight	183

NASS Weighting Factor

Weighting factor	60.957641664

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	BRAKE W/O LOCKUP
Pre-impact Stability	LATERAL SKID-CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age 48 Height 178 Weight 77

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NONDEPLOYED
Ejection	COMPLETE EJECT
Ejection Area	WINDSHIELD
Entrapment	NOT ENTRAPPED
Airbag Deployment – 1st Seat	NONDEPLOYED
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	1
MAIS	5 = CRITICAL INJURY
Seat Position	FRONT LEFT SIDE

Figure 2.04: Case 1: Crash Information

Case 2: 2000-12-4

In this case a Pontiac Grand Prix was traveling on a snowy road when it lost control. A clockwise rotation was induced and the vehicle went off of the road to the right. The vehicle engaged a guardrail end terminal, but due to the direction of the velocity vector only a short portion of the beam was deformed as designed. Buckling downstream of the impact point due to bending loads lead to redirection of the vehicle down the backslope. As the vehicle initiated a rollover down the hill, the driver was severely injured due to multiple contacts inside the vehicle compartment.

Initially, the guardrail terminal performed as designed. An examination of the car showed some damage, but there was little barrier penetration into the occupant compartment as seen in other end terminal cases. Due to the compatible heights of the door sill and the lowest point on the end terminal, the stiff vehicle side structure adequately transferred energy to the barrier.

An examination of the accident scene showed that the guardrail absorbed some energy and deflected adequately, however the distance between this installation and the backslope may have been too small. Had the terminal been installed slightly upstream, the system may decelerate the vehicle sufficiently before the backslope to avoid the rollover. Similar cases were seen where a guardrail terminal decelerated the vehicle, but the vehicle still subsequently impacted trees, poles and bridge posts with sufficient speed to cause injury.

Therefore the installation of a guardrail should ensure that the hazard is protected using a sufficiently long section of guardrail. In doing this, the guardrail terminal will be installed well forward of the protected hazard.

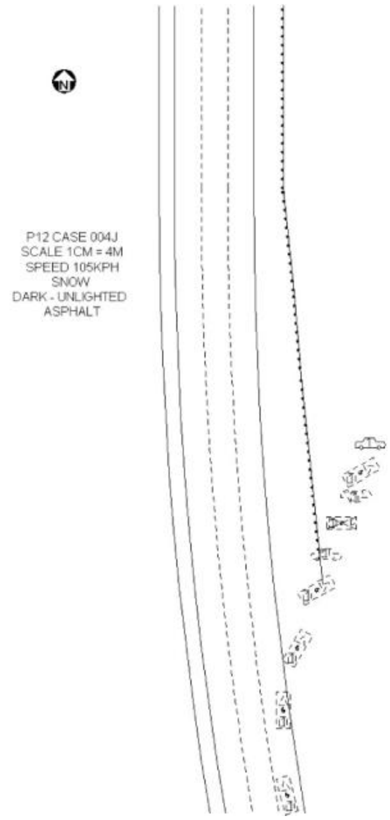
Other Similar Cases: 1998-12-18, 1999-73-12, 2000-12-4, 2000-8-190

Important Factors

- Location of End-Terminal Relative to Hazard
- Length of Deformation of End Terminal
- Vehicle Door Sill Height
- Average Mid-Size Vehicle door Sill Height
- Height of Treatment (bottom edge)
- Researcher Determined Impact Angle

2 Case 2000-12-4

Summary:
V1 WAS HEADED NORTH ON A 3 LANE, SNOWY, ASPHALT ROADWAY AFTER DARK AND WITH LITTLE OR NO ARTIFICIAL LIGHTING. TRAVELING IN LANE 1, V1 LOST CONTROL OF HIS VEHICLE DUE TO WEATHER CONDITIONS AND LEFT THE ROADWAY TO THE RIGHT STRIKING A GUARDRAIL PRIOR TO FINAL REST ON THE LEFT SIDE OF THE VEHICLE OFF ROAD. THE VEHICLE WAS TOWED DUE TO DAMAGE AND THE DRIVER WAS TRANSPORTED TO MEDICAL ATTENTION DUE TO THE SEVERITY OF HIS INJURIES.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	2DR SEDAN/HT/CPE	Pontiac	Grand Prix	1997	1	32	MALE	3 = SERIOUS INJURY

Figure 2.05: Case 2: Summary

Occupant: 2000-12-4-1-1

Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	OTHER FIXED OBJECT
Location on Vehicle where Principal Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	5 QUARTER TURNS
Impact Speed	< 0.5 KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with Sequence Number	DELTA V CODED 1
CDC	11 L D E W 3
Run off Road	
Damage (C1-C6)	29 15 13 23 7 4
Crush (L and D)	443 0

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	THREE
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	SNOW OR SLUSH
Light Conditions	DARK
Atmospheric Conditions	SNOW
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	16

Vehicle Factors

Make-Model	Pontiac Grand Prix
Year	1997
Class	PASSENGER CAR
Body Type	2DR SEADAN/HT/CPE
Weight	151

NASS Weighting Factor

Weighting factor	46.019742061

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	POOR ROAD COND
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	LATERAL SKID-CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age 32 Height 180 Weight 86

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	NONDEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment – 1st Seat	NONDEPLOYED
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	CHEST	BELT WEBB/BUCK

Figure 2.06: Case 2: Crash Information

Case 3: 1999-11-70

This case showed a Ford Escort that impacted a concrete barrier while trying to avoid another car. The occupant in this case suffered severe injuries, although he was belted and did not hit a concrete barrier at a severe angle.

This case demonstrates the typical behavior of small and midsize vehicle impacting concrete median barriers. Although the occupant was belted, he sustained head injuries due to steering wheel contact. The contact marks on the barrier indicates that the impact angle was shallow enough to lift and deflect the vehicle downstream so that the PDOF is estimated to be about 11 o'clock. Further, scrapes on the rear of the vehicle indicate that the vehicle yawed/rotated back out toward traffic without a high longitudinal acceleration of the vehicle.

For this impact scenario, a more vertical barrier profile may have reduced the longitudinal acceleration of the vehicle, which leads to the head strike. However, a reduction in longitudinal deceleration would result in a higher lateral acceleration force of the vehicle and occupant. Further analysis is necessary to understand if this tradeoff would lead to increased or decreased occupant risk. The contribution of frontal airbag systems (not available here) would also change occupant injury potential for this impact condition. Any new design of concrete median barriers must not only consider interaction with cars, but also trucks and SUVs, which may benefit from increased barrier slopes as well.

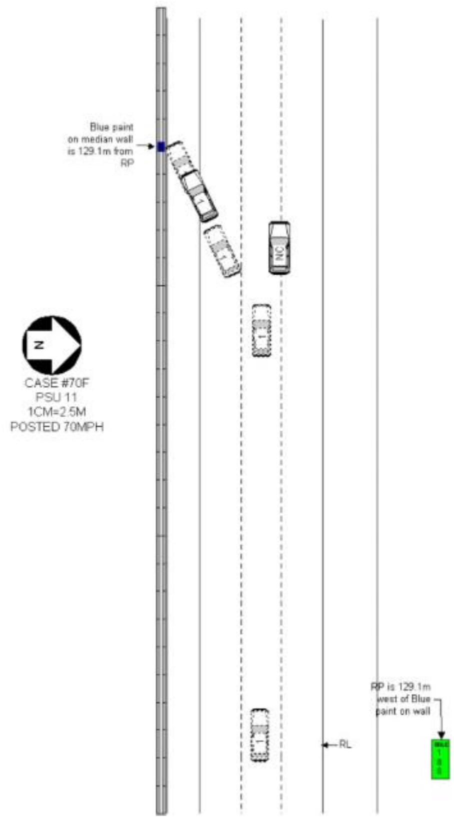
Important Factors

- Barrier Impact Speed
- Barrier Profile
- Occupant Restraint system and Kinematics
- Researcher Determined Impact Angle

Other Similar Cases: 1999-12-120,1999-72-71,1999-73-92, 1999-9-7, 2000-73-167, 1999-8-226, 1997-45-198, 1998-12-161

3 Case 1999-11-70

Summary:
V1 A 1988 FORD ESCORT WAS TRAVELING WESTBOUND IN LANE TWO ON AN EXPRESSWAY. THE EXPRESSWAY IS PHYSICALLY DIVIDED BY A MEDIAN WALL. A NON-CONTACT VEHICLE CAME INTO LANE TWO AND V1 STEERED LEFT TO AVOID THE VEHICLE. V1 LOST CONTROL AND WENT OFF ON THE LEFT SIDE OF THE ROADWAY (ON THE SHOULDER) AND THE FRONT LEFT BUMPER OF HIS VEHICLE CONTACTED THE MEDIAN WALL. V1 WAS TOWED DUE TO VEHICLE DAMAGE. THE DRIVER OF V1 WAS TRANSPORTED AND HOSPITALIZED DUE TO HIS INJURIES HE SUSTAINED FROM THE ACCIDENT.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	3DR/2DR HATCHBAK	Ford	Escort/EXP	1988	1	17	MALE	3 = SERIOUS INJURY

Figure 2.07: Case 3: Summary

Occupant: 1999-11-70-1-1

Rollover Classification

Number of Harmful Events	1
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	30 28 10
Estimated delta-V with Sequence Number	DELTA V CODED 1
CDC	11 F D E W 2
Run off Road	
Damage (C1-C6)	45 38 26 16 4 0
Crush (L and D)	140-16

Pre-Crash Environment

Traffic Flow	DIVIDED WITH BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAY LIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Ford Escort/EXP
Year	1988
Class	PASSENGER CAR
Body Type	3DR/2DR HATCHBACK
Weight	101

NASS Weighting Factor

Weighting factor	213.58406145

Pre-Crash Driver Data

Accident Type	8
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	SAME DIR-OV LEFT
Attempted Avoidance Maneuver	STEERING RIGHT
Pre-impact Stability	LONGITUDINAL SKID
Pre-impact Location	LEFT TRAVEL LANE

DRIVER Factors

Age 17 Height 180 Weight 82

Gender	MALE
Restrain	LAP BELT
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment – 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	HEAD-SKULL	STEERING RIM

Figure 2.08: Case 3: Crash Information

Case 4: 2000-13-113

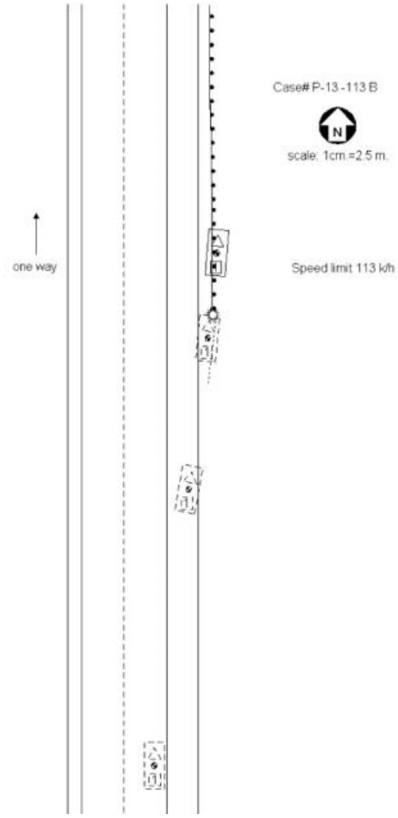
In this case, an Oldsmobile Cutlass drifted off of the road and impacted a guardrail without an end terminal head on. The vehicle was severely damaged and the occupant was fatally injured. The magnitude of the vehicle deformation suggested a very large deltaV or a stiff barrier system. Critical information was missing within this case to draw either conclusion.

The occupant suffered fatal injuries. It should be noted that the driver was not belted in a non-airbag equipped vehicle. Due to the delayed investigation of this case, it is unclear what the resulting barrier characteristics were. No estimate of deltaV has been provided due to limitation in NHTSA accident reconstruction software (WinSmash). This software does not include models of typical roadside barriers from which deltaV calculations can be made. This case provides a good example of flaws in currently available crash data.

Other Similar Cases: 1997-41-14, 1997-73-37, 1997

4 Case 2000-13-113

Summary:
DRIVER WAS NORTHBOUND IN THE RIGHT LANE ON A WET 2 LANE EXPRESSWAY WHEN SHE DRIFTED OFF THE RIGHT SHOULDER AND STRUCK A GUARDRAIL HEAD-ON. THE NEWLY INSTALLED GUARDRAIL DID NOT HAVE THE END ATTENUATOR INSTALLED AND WAS DRIVEN THROUGH THE WINDSHIELD, STRIKING THE DRIVER AND CONTINUING OUT THROUGH THE BACKLIGHT. THE DRIVER WAS FATALLY INJURED.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	2DR SEDAN/HT/CPE	Oldsmobile	Cutlass FWD	1991	1	44	FEMALE-NOT PREG	6 = MAXIMUM INJURY

Figure 2.09: Case 4: Summary

Occupant: 2000-13-113-1-1

Rollover Classification

Number of Harmful Events 1
Rollover Initiation Type NO ROLLOVER
Location of Rollover Initiation NO ROLLOVER
Rollover Initiation Object Contacted NO ROLLOVER
Location on Vehicle where Principal
Tripping Force was Applied NO ROLLOVER
Direction of Initial Roll NO ROLLOVER

Crash Severity

Nr. Quarter Turns NO ROLLOVER
Impact Speed < 0.5KMPH
Total, Longitudal, and Lateral delta-V < 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with Sequence Number DELTA V CODED 1
CDC 12 F D E W 3
Run off Road
Damage (C1-C6) 19 40 64 66 35 33
Crush (L and D) 140 0

Pre-Crash Environment

Traffic Flow DIVIDED/NO BARRIER
Number of Travel Lanes TWO
Roadway Alignment STRAIGHT
Roadway Profile DOWNHILL GRADE
Roadway Surface Type ASPHALT
Roadway Surface Condition WET
Light Conditions DARK
Atmospheric Conditions RAIN
Relation to Intersection NONINTER/NONJUNC
Traffic Control Device
Police Reported Alcohol Presence ALCOHOL PRESENT

Alcohol Test (< 95 indicates BAC 0.xx) 1

Vehicle Factors

Make-Model Oldsmobile Cutlass FWD
Year 1991
Class PASSENGER CAR
Body Type 2DR SEDAN/HT/CPE
Weight 114

NASS Weighting Factor

Weighting factor 86.712829417

Pre-Crash Driver Data

Accident Type 1
Pre-event Movement GOING STRAIGHT
Critical Pre-crash Event OFF EDGE-RIGHT
Attempted Avoidance Maneuver NO AVOIDANCE
Pre-impact Stability TRACKING
Pre-impact Location DEPARTED ROADWAY

DRIVER Factors

Age 44 Height 160 Weight 61
Gender FEMALE-NOT PREG
Restrain NONE USED/AVAIL
Airbag Deployment NOT EQUIP/AVAIL
Ejection NO EJECTION
Ejection Area NO EJECTION
Entrapment NOT ENTRAPPED
Airbag Deployment – 1st Seat NOT EQUIP/AVAIL
Airbag Deployment – Other Seat NOT EQUIP W/ OTH
AOPS YES-RES DET

Injuries

Occupant 1
MAIS 6 = MAXIMUM INJURY
Seat Position FRONT LEFT SIDE

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	HEAD-SKULL	STEERING RIM

Figure 2.10: Case 4: Crash Information

Case 5: 1997-12-114

This case indicates correct performance of a guardrail where a severe injury still occurred. In this case a Mercury Sable left the road and impacted a double W-beam guardrail installation (mounted one above the other). The angle of impact was not severe, the driver was belted but she sustained severe injuries to her arm. Evidence of significant steering wheel loading is seen which may have lead to the serious (AIS-3) lower arm injury.

The deformation of the vehicle and barrier system is not well documented however; a significant amount of barrier penetration has taken place. In addition, sections of the upper beam have failed which contributed to the extreme frontal damage to the vehicle. The presence of the stiff bumper point may have caused the rupture of the W beam (in a manner similar to the results of section 3.4). This behavior during deformable longitudinal barrier interaction was detrimental. However, the presence of the lower section here may have prevented subsequent barrier penetration.

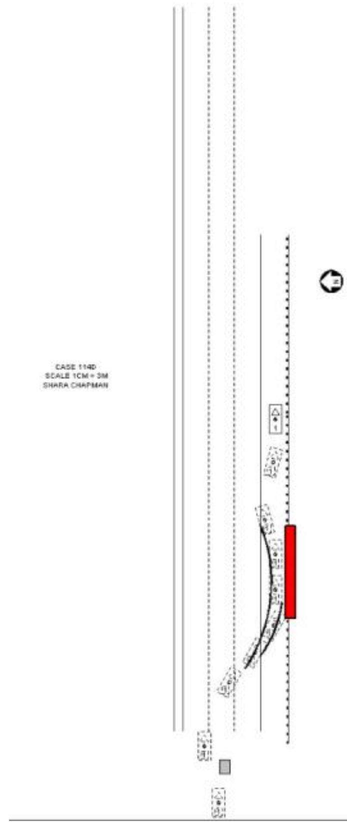
Important Factors

- Frame Rail Spread
- Barrier Installation
- Researcher Determined Impact Angle

Other Similar Cases: 1998-2-148, 1998-9-123, 1998-9-72, 1999-41-65, 1999-75-70, 2000-43-115

5 Case 1997-12-114

Summary:
V1 WAS SOUTHBOUND ON AN EXPRESSWAY. THERE WAS AN OBJECT IN THE CENTER LANE WHICH THE DRIVER SUCCESSFULLY AVOIDED, BUT STILL LOST CONTROL OF THE VEHICLE AFTER OVER CORRECTING AND LEFT THE ROADWAY STRIKING A GUARDRAIL MORE THAN ONCE. THE VEHICLE WAS TOWED, AND THE DRIVER WAS TAKEN TO A LOCAL FACILITY FOR TREATMENT OF INJURIES.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Mercury	Sable	1989	1	52	FEMALE-NOT PREG	3 = SERIOUS INJURY

Figure 2.11: Case 5: Summary

Occupant: 1997-12-114-1-1

Rollover Classification

Number of Harmful Events 3
Rollover Initiation Type NO ROLLOVER
Location of Rollover Initiation NO ROLLOVER
Rollover Initiation Object Contacted NO ROLLOVER
Location on Vehicle where Principal Tripping Force was Applied NO ROLLOVER
Direction of Initial Roll NO ROLLOVER

Crash Severity

Nr. Quarter Turns NO ROLLOVER
Impact Speed < 0.5 KMPH
Total, Longitudal, and Lateral delta-V < 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with Sequence Number MODERATE 1
CDC 1 F D E W 1
Run off Road
Damage (C1-C6) 2 7 0 0 0 0
Crush (L and D) 155 0

Pre-Crash Environment

Traffic Flow ONE WAY
Number of Travel Lanes THREE
Roadway Alignment STRAIGHT
Roadway Profile LEVEL
Roadway Surface Type ASPHALT
Roadway Surface Condition DRY
Light Conditions DAY LIGHT
Atmospheric Conditions NO ADVERSE COND
Relation to Intersection NONINTER/NONJUNC
Traffic Control Device
Police Reported Alcohol Presence NO ALCOHOL

Alcohol Test (< 95 indicates BAC 0.xx) 0

Vehicle Factors

Make-Model Mercury Sable
Year 1989
Class PASSENGER CAR
Body Type 4DR SEADAN/HT
Weight 141

NASS Weighting Factor

Weighting factor 98.655342224

Pre-Crash Driver Data

Accident Type 2
Pre-event Movement SUCES AVOID PREV
Critical Pre-crash Event OTH CRIT EVENT
Attempted Avoidance Maneuver BRAKE+STEER RT
Pre-impact Stability LATERAL SKID-CLK
Pre-impact Location DEPARTED ROADWAY

DRIVER Factors

Age 52 Height 160 Weight 122
Gender FEMALE-NOT PREG
Restrain LAP AND SHOULDER
Airbag Deployment NOT EQUIP/AVAIL
Ejection NO EJECTION
Ejection Area NO EJECTION
Entrapment NOT ENTRAPPED
Airbag Deployment – 1st Seat NONDEPLOYED
Airbag Deployment – Other Seat NOT EQUIP W/ OTH
AOPS NO

Injuries

Occupant 1
MAIS 3 = SERIOUS INJURY
Seat Position FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	FOREARM LEFT	INTERIOR
3 = SERIOUS INJURY	FOREARM LEFT	INTERIOR

Figure 2.12: Case 5: Crash Information

Case 6: 1998-6-31

End Terminal - Door Penetration

This case is an example of a guardrail terminal penetration into the side structure of a car. In this case, a Lexus GS 300 lost control and spun into the median. Once off of the road, the car impacted the guardrail end at the driver's side door. Due to the lack of rigid structure within the door, the guardrail penetrated the occupant compartment and caused serious injuries to the driver's thigh.

The case presented the need for the guardrail end to engage the door sill/rocker panels of automobiles. In side impact, the rocker panel is a major structural element. If this feature is engaged, the vehicle stiffness should exceed that of the barrier system leading to controlled deformation at the end terminal system.

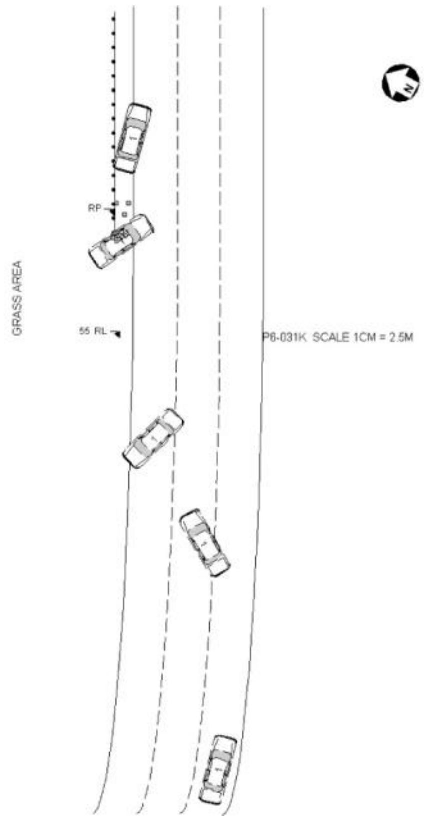
Important Factors

- Door Sill Height
- Average Door Sill Height for Full Size Vehicles
- End Terminal Height

Other Similar Cases: 1999-49-209

6 Case 1998-6-31

Summary:
V1 TRAVELING EAST ON A 3 LANE, 1 WAY HIGHWAY. THE BACK OF V1 WAS HIT BY AN UNKNOWN VEHICLE. V1 ROTATED COUNTERCLOCKWISE AND IMPACTED A GUARDRAIL WITH ITS LEFT SIDE. V1 CAME TO FINAL REST FACING EAST. A SERIOUS INJURY WAS REPORTED. THE VEHICLE WAS TOWED FROM THE SCENE.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Lexus	GS-300	1993	1	18	MALE	3 = SERIOUS INJURY

Figure 2.13: Case 6: Summary

Occupant: 1998-6-31-1-1

Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5 KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with Sequence Number	>24 AND <40 KMPH 2
CDC	11 L Y A W 3
Run off Road	
Damage (C1-C6)	10 10 20 40 13 6
Crush (L and D)	350 5

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	CURVE LEFT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	WET
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Lexus GS-300
Year	1993
Class	PASSENGER CAR
Body Type	4DR SEADAN/HT
Weight	166

NASS Weighting Factor

Weighting factor	8.6703603942

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OVER LINE LEFT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	LATERAL SKID-CTR CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age 18 Height 178 Weight 74

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment – 1st Seat	NONDEPLOYED
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	THIGH	LEFT HARDWARE

Figure 2.14: Case 6: Crash Information

Case 7: 1997-41-51

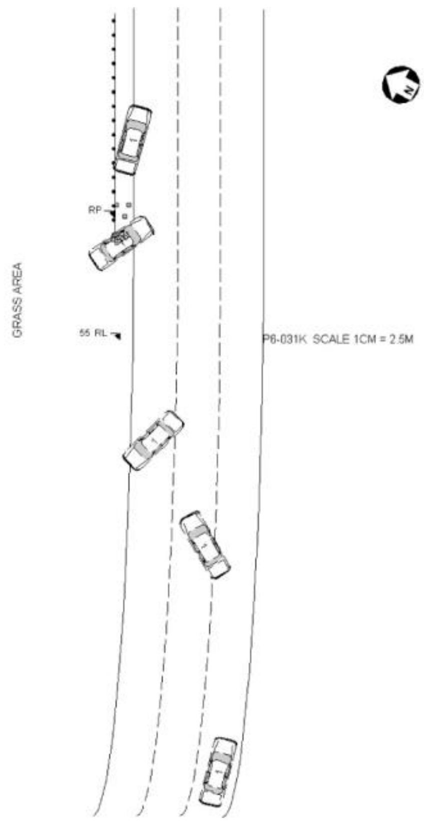
During this case, a Ford Explorer collided with another passenger vehicle. This force the Explorer to veer into concrete median barrier at a fairly steep impact angle (estimated 45 deg.). Upon impact the interaction with the barrier lead to a counterclockwise rotation of the Explorer followed by a roll onto its right side.

Important Factors

- Frontal Overhang of Ford Explorer
- Average Frontal Overhang of Mid-Size SUVs
- Researcher Determined Impact Angle

7 Case 1997-41-51

Summary:
V1 WAS TRAVELING SOUTHBOUND ON SIX LANE INTERSTATE ROADWAY, ROAD SURFACE BLACKTOP, LEVEL, WET DURING DAYLIGHT HOURS. V1 WAS IN SIXTH LANE. V2 WAS TRAVELING SOUTHBOUND IN FORTH LANE WHEN V1 COLLIDED WITH RIGHT SIDE AT WHICH TIME V2 VEERED LEFT STRICKING CONCRETE MEDIAN WITH FRONT THEN ROTATED IN COUNTERCLOCKWISE ROTATION AND FLIPPING OVER ONTO RIGHT SIDE COMINT TO FINAL REST FACING S/E. V3 WAS TRAVELING SOUTHBOUND IN FORTH LANE WHEN V1 CAME TO FINAL; REST IN FORTH LANE,V3 COLLIDED WITH THE REAR OF V1. V1 and V2 WERE TOWED FROM SCENE, V3 LEFT SCENE UNDER OWN POWER, DRIVERS OF V1 and V2 PLUS PASSENGERS IN V1 WERE TRANSPORTED TO A MEDICAL FACILITY.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Chrysler	Lebaron	1987	1	35	FEMALE-NOT PREG	1 = MINOR INJURY
1	4-DR SEDAN/HDTOP	Chrysler	Lebaron	1987	2	6	MALE	0 = NOT INJURED
1	4-DR SEDAN/HDTOP	Chrysler	Lebaron	1987	3	7	FEMALE-NOT PREG	1 = MINOR INJURY
2	COMPACT UTILITY	Ford	Bronco II	1995	1	31	MALE	3 = SERIOUS INJURY

Figure 2.15: Case 7: Summary

Occupant: 1997-41-51-2-1

Rollover Classification

Number of Harmful Events	4
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	CONCRETE BARRIER
Location on Vehicle where Principal Tripping Force was Applied	END PLANE
Direction of Initial Roll	ROLL RIGHT

Crash Severity

Nr. Quarter Turns	1 QUARTER TURN
Impact Speed	998
Total, Longitudal, and Lateral delta-V	27 -24 14
Estimated delta-V with Sequence Number	DELTA V CODED 2
CDC	11 F D E W 2
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	SIX
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	WET
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Ford Bronco II
Year	1995
Class	PASSENGER CAR
Body Type	COMPACT UTILITY
Weight	192

NASS Weighting Factor

Weighting factor	58.819306296

Pre-Crash Driver Data

Accident Type	45
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	SAME DIR-OV RGHT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	STAYED IN LANE

DRIVER Factors

Age 31 Height 193 Weight 95

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	BAG DEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	DR PAS BAG DEPLY
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	THIGH	TRANSMISS LEVER
3 = SERIOUS INJURY	THIGH	TRANSMISS LEVER

Figure 2.16: Case 7: Crash Information

Case 8: 1997-6-92

In this case, a grossly overloaded (11 occupants) Isuzu Rodeo collided with a concrete barrier. This collision although minor, resulted in the rollover of the vehicle and serious injuries to the occupants. The driver (belted) did not sustain serious injuries; however, a two year old occupant who was unrestrained sustained serious injuries during the crash.

This case exemplifies the difficulty in designing roadside hardware for SUVs. In the summary to this case, it appeared the vehicle impacted the barrier at a relatively shallow angle. It also appeared that the barrier performed as designed (i.e. redirect the vehicle). The vehicle photos appeared to confirm this. The damage to the vehicle was mostly due to the vehicle sliding along the ground.

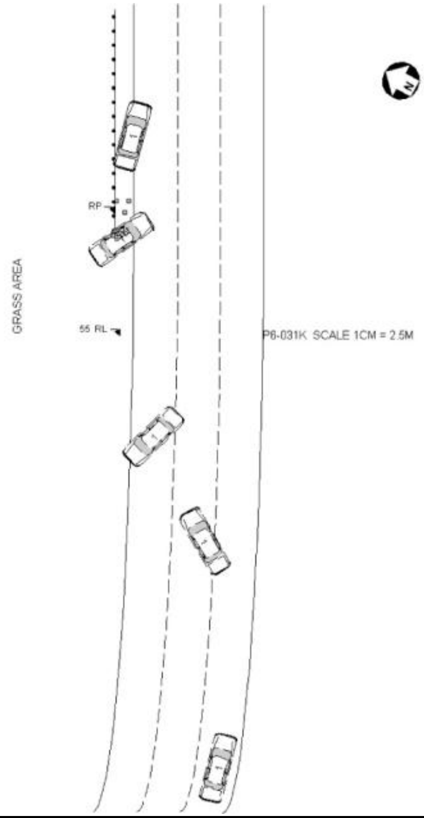
It is unclear how the vehicle interaction with the barrier on the right side lead to a positive roll direction about the longitudinal axis of the vehicle (roll right). It is speculated by the research team that the barrier introduced a slight instability to the Rodeo and the driver was unable to recover.

Important Factors

- Height of Contact With Barrier
- CG Height of Isuzu Rodeo
- Average CG Height of Mid-Size SUVs
- Average CG Height of Full Size Pickup Trucks
- Researcher Determined Impact Angle

8 Case 1997-6-92

Summary:
V1 TRAVELING EAST ON A 3 LANE POSITIVLY DIVIDED HIGHWAY. VEHICLE CONTACTED A BARRIER TO THE RIGHT SIDE AND THEN BOUNCED OFF ON ROLLED TO RIGHT SIDE COMING TO FINAL REST ON RIGHT SIDE FACING EAST. SERIOUS INJURIES REPORTED TO VEHICLE. TOWED FROM THE SCENE.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Isuzu	Rodeo	1997	1	28	FEMALE-NOT PREG	1 = MINOR INJURY
1	COMPACT UTILITY	Isuzu	Rodeo	1997	2	27	FEMALE-NOT PREG	3 = SERIOUS INJURY
1	COMPACT UTILITY	Isuzu	Rodeo	1997	3	33	FEMALE-NOT PREG	1 = MINOR INJURY
1	COMPACT UTILITY	Isuzu	Rodeo	1997	4	2	MALE	3 = SERIOUS INJURY
1	COMPACT UTILITY	Isuzu	Rodeo	1997	5	8	MALE	1 = MINOR INJURY
1	COMPACT UTILITY	Isuzu	Rodeo	1997	6	7	FEMALE-NOT PREG	1 = MINOR INJURY
1	COMPACT UTILITY	Isuzu	Rodeo	1997	7	8	FEMALE-NOT PREG	1 = MINOR INJURY
1	COMPACT UTILITY	Isuzu	Rodeo	1997	8	3	FEMALE-NOT PREG	1 = MINOR INJURY
1	COMPACT UTILITY	Isuzu	Rodeo	1997	9	8	MALE	1 = MINOR INJURY
1	COMPACT UTILITY	Isuzu	Rodeo	1997	10	10	FEMALE-NOT PREG	0 = NOT INJURED
1	COMPACT UTILITY	Isuzu	Rodeo	1997	11	4	FEMALE-NOT PREG	0 = NOT INJURED

Figure 2.17: Case 8: Summary

Occupant: 1997-6-92-1-4

Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	CONCRETE BARRIER
Location on Vehicle where Principal Tripping Force was Applied	SIDE PLANE
Direction of Initial Roll	ROLL RIGHT

Age 2 Height 61 Weight 23

Crash Severity

Nr. Quarter Turns	1 QUARTER TURN
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with Sequence Number	MODERATE 2
CDC	0 R D A O 2
Run off Road Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	DVDED/NO BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Isuzu Rodeo
Year	1997
Class	PASSENGER CAR
Body Type	COMPACT UTILITY
Weight	181

NASS Weighting Factor

Weighting factor	10.465799133

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	CHANGING LANES
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	STEERING LEFT
Pre-impact Stability	TRACKING
Pre-impact Location	LEFT TRAVEL LANE

PASSENGER Factors

Age 2 Height 61 Weight 23

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT DEPLOYED
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	4
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT ON/IN LAP

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	FOREARM	UNKNOWN SOURCE

Figure 2.18: Case 8: Crash Information

Case 9: 1998-72-44

The events of this case include a Chevrolet Blazer drifting off of the left side of the road and impacting a concrete median barrier. This impact caused the Blazer to roll and resulted in a severe head injury for the driver. Although the vehicle experienced a deceleration severe enough to result in significant steering wheel deformation, the airbags in this vehicle did not deploy. It should be noted that the left front (driver-side) wheel was torn from the upper and lower a-arms due to the high interactive forces with the barrier as well.

This case indicates that excessive conditions are not required to roll less stable SUVs. A sudden vertical loading of one wheel will initiate a rollover event. Although the Blazer drifted off of the road at a slight angle, there was enough roll moment to cause the vehicle to overturn. This case also suggests that airbag sensors in recent model vehicles may not be well suited to sense these off axis impacts with longitudinal barriers. This hypothesis requires additional investigation using crash testing of airbag equipped vehicles or simulation study.

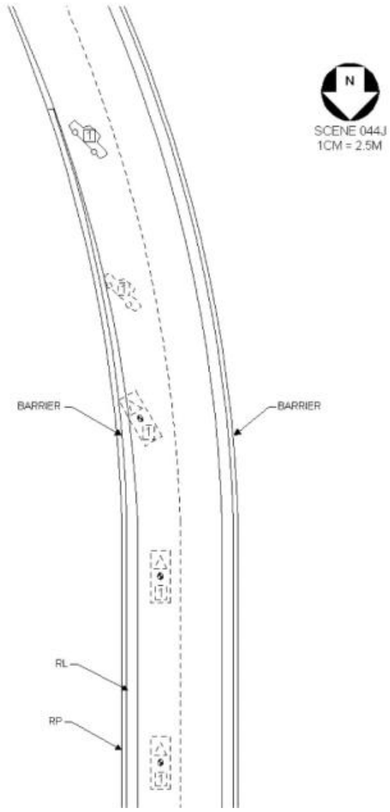
Unfortunately, in this case, the vehicle was already in the shop before the NASS investigator could photograph the damage. Since it was impossible to tell the exact location of vehicle impact with the barrier, the importance of a timely investigation was also illustrated.

Important Factors

- Height of Contact With Barrier
- Slope of Roadway at Impact Point
- CG Height of Chevrolet Blazer
- Average CG Height of Mid-Size SUVs
- Average CG Height of Full Size Pickup Trucks
- Researcher Determined Impact Angle

9 Case 1998-72-44

Summary:
V1 WAS TRAVELING SOUTHBOUND ON A TWO-LANE DIVIDED EXPRESSWAY RAMP IN THE SECOND TRAVEL LANE. V1 DRIFTED OFF TO THE LEFT SHOULDER AND IMPACTED THE CONCRETE BARRIER WITH ITS' FRONT PLANE. THIS IMPACT CAUSED V1 TO ROLL ONTO ITS' RIGHT SIDE AND SLIDE TO FINAL REST IN THE SECOND TRAVEL LANE. V1 WAS TOWED FROM THE SCENE AND THE DRIVER WAS TRANSPORTED TO THE HOSPITAL WITH "A" INJURIES.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Chevrolet	S-10 Blazer	1995	1	45	FEMALE-NOT PREG	4 = SEVERE INJURY

Figure 2.19: Case 9: Summary

Occupant: 1998-72-44-1-1




Rollover Classification

Number of Harmful Events 2
Rollover Initiation Type BOUNCE-OVER
Location of Rollover Initiation ROADSIDE/MEDIAN
Rollover Initiation Object Contacted CONCRETE BARRIER
Location on Vehicle where Principal Tripping Force was Applied END PLANE
Direction of Initial Roll ROLL RIGHT

Crash Severity

Nr. Quarter Turns 1 QUARTER TURN
Impact Speed < 0.5KMPH
Total, Longitudinal, and Lateral delta-V < 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with Sequence Number DELTA V CODED 1
CDC 0 F 9 9 9 0
Run off Road Damage (C1-C6) 0 0 0 0 0 0
Crush (L and D) 0 0

Pre-Crash Environment

Traffic Flow DVDED/W/BARRIER
Number of Travel Lanes TWO
Roadway Alignment CURVE LEFT
Roadway Profile LEVEL
Roadway Surface Type ASPHALT
Roadway Surface Condition DRY
Light Conditions DARK
Atmospheric Conditions NO ADVERSE COND
Relation to Intersection INTERCHANGE REL
Traffic Control Device
Police Reported Alcohol Presence ALCOHOL PRESENT

Alcohol Test (< 95 indicates BAC 0.xx) 20

Vehicle Factors

Make-Model Chevrolet S-10 Blazer
Year 1995
Class PASSENGER CAR
Body Type COMPACT UTILITY
Weight 157

NASS Weighting Factor

Weighting factor 6.5847139881

Pre-Crash Driver Data

Accident Type 6
Pre-event Movement NEGOTIATE CURVE
Critical Pre-crash Event OFF-EDGE-LEFT
Attempted Avoidance Maneuver NO AVOIDANCE
Pre-impact Stability TRACKING
Pre-impact Location LEFT TRAVEL LANE

DRIVER Factors

Age 45 Height 168 Weight 98
Gender FEMALE-NOT PREG
Restrain NONE USED/AVAIL
Airbag Deployment NONDEPLOYED
Ejection NO EJECTION
Ejection Area NO EJECTION
Entrapment NOT ENTRAPPED
Airbag Deployment - 1 st Seat NONDEPLOYED
Airbag Deployment – Other Seat NOT EQUIP W/ OTH
AOPS YES-RES DET

Injuries

Occupant 1
MAIS 4 = SEVERE INJURY
Seat Position FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts	
4 = SEVERE INJURY	HEAD - SKULL	FRONT	HEADER

Figure 2.20: Case 9: Crash Information

Case 10: 1998-49-184

This case involved a Ford Explorer that lost control on a 3 lane divided highway. In the first collision, the Explorer hit a concrete median barrier dividing the opposing lanes of traffic. During this collision, the driver was partially ejected and the driver's head impacted a light post adjacent to the roadway. The vehicle, after this collision, traveled across the roadway and collided into the concrete barrier on the opposite side of the roadway. The collision with this wall caused the vehicle to rollover, and the occupant was fully ejected.

As a result of the first barrier impact, the Explorer climbed quite high on the barrier introducing enough vehicle motion to partially eject the unbelted occupant. During the second collision and following a severe head strike, the combined high impact angle and lack of driver control lead to the subsequent rollover event and complete occupant ejection.

This case shows the necessity of controlling the lateral Delta-V during impact with roadside structures. In this case, a midsized SUV impacted a barrier with sufficient force to partially eject the driver. In addition, this case shows the need for proper vehicle to guardrail interaction so that rollover is not initiated after vehicles to guardrail interaction.

Other similar cases:

1997-6-92, 1998-49-184, 1998-72-44, 1999-43-152, 1997-45-109,2000-49-107, 2000-79-15, 1997-12-151, 1999-9-61, 1999-11-150, 1998-75-40, 1998-8-157, 1999-49-75, 1997-72-125

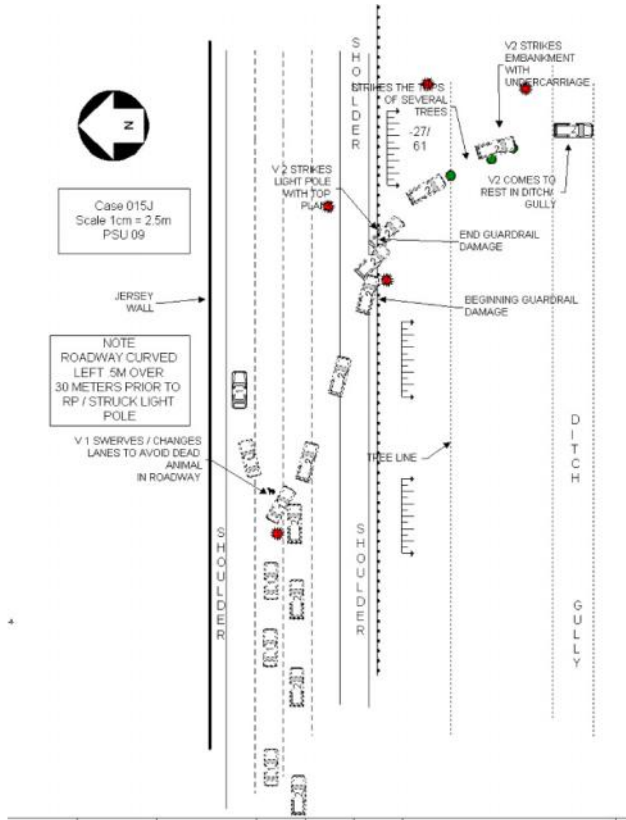
Important Factors

- Height of Contact With Barrier
- Profile of Impacted Barrier
- Lateral DeltaV for First Impact
- Researcher Determined Impact Angle for Second Impact

10 Case 1998-49-184

Summary:

V1 WAS TRAVELING NB IN THE 1ST LANE OF A WET 3-LANE DIVIDED CONCRETE URBAN TOLLWAY. V2 WAS TRAVELING IN THE SAME LANE OF THE SAME ROADWAY. V1 BEGAN A CCW ROTATION CROSSED ALL LANES, AND IMPACTING THE CONCRETE RETAINING WALL, PARTIALLY EJECTING DRIVER ALSO CAUSING THE PARTIALLY EJECTED DRIVER TO IMPACT A LIGHT POLE WITH HIS HEAD. V1 CONTINUED BACK IN A CLOCKWISE ROTATION, AGAIN CROSSING THE THREE LANES AND A SHOULDER, IMPACTING THE RETAINING WALL ON THE EAST SIDE OF TRAFFIC. THEN ROLLED TO THE LEFT, EJECTING DRIVER. V1 THEN CAME TO REST FACING EAST ON THE CONCRETE SHOULDER. V2 WAS BEHIND V1 IN THE 1ST LANE AND, IN AN ATTEMPT TO AVOID V1 COMING BACK ACROSS THE TRAFFIC, TURNED RIGHT AND IMPACTED FRONT TO THE EAST RETAINING WALL AND CAME TO REST STILL NORTHBOUND ON THE SHOULDER JUST TO THE SOUTH OF V1. V1 WAS TOWED DUE TO DAMAGE AND THE DRIVER WAS PRONOUNCED DEAD AT THE SCENE. V2 WAS RELEASED AT THE SCENE.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Ford	Bronco II	1993	1	24	MALE	6 = MAXIMUM INJURY

Figure 2.21: Case 10: Summary

Occupant: 1998-49-184-1-1

Rollover Classification

Number of Harmful Events	4
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	4 QUARTER TURN
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with Sequence Number	MINOR 1
CDC	3 F D E W 1
Run off Road	
Damage (C1-C6)	0 0 2 4 5 6
Crush (L and D)	152 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	STRAIGHT
Roadway Profile	DOWNHILL GRADE
Roadway Surface Type	CONCRETE
Roadway Surface Condition	WET
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	RAIN
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	24

Vehicle Factors

Make-Model	Ford Bronco II
Year	1993
Class	PASSENGER CAR
Body Type	COMPACT UTILITY
Weight	175

NASS Weighting Factor

Weighting factor	6.8343921903

Pre-Crash Driver Data

Accident Type	98
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age 24 Height 170 Weight 70

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	COMPLETE EJECT
Ejection Area	LEFT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1 st Seat	NOT EQUIP/AVAIL
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

Occupant	1
MAIS	6 = MAXIMUM INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
6 = MAXIMUM INJURY	HEAD - SKULL	OTHER VEH OR OBJ

Figure 2.22: Case 10: Crash Information

Case 11: 1998-49-71

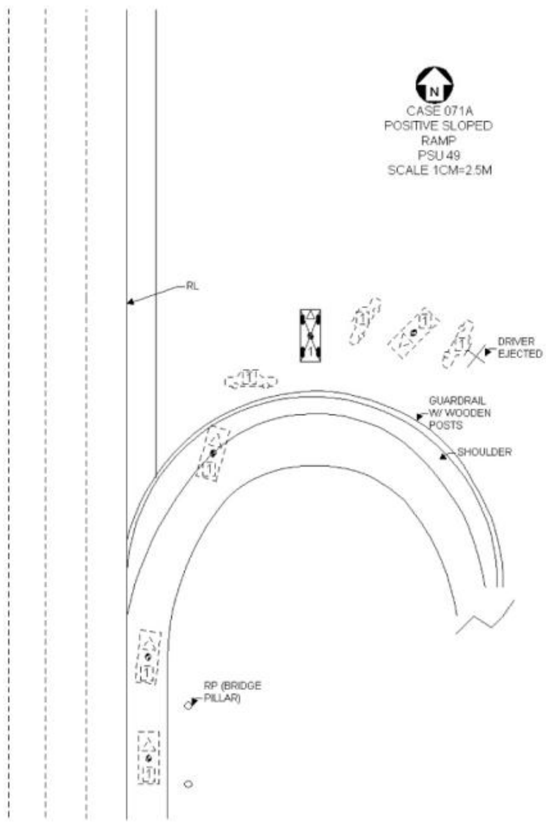
This case involved a Jeep Grand Cherokee that failed to negotiate a right hand turn. The vehicle engaged a guardrail surrounding the turn, however the vehicle climbed over the guardrail and a roll was induced. Due to the roll, the driver was ejected came to rest between the vehicle and the ground. He died shortly after the collision due to his injuries.

An investigation into the vehicle damage pictures shows that there was little damage to the front of the vehicle during the barrier impact. For this reason, it is believed that the vehicle mounted the barrier at the turned down end which began just after the start of the circular exit ramp. In addition, due to the lack of photographic evidence, it was impossible to know whether the barrier was ruptured during the collision. Therefore, in order to improve the effectiveness of this type of investigation, it would be helpful for investigators to visit crash scenes before roadside repairs are completed if possible.

This case indicates the need for review of barrier installations particularly at critical locations like this one. It should be noted that the Grand Cherokee has a CG height which is lower than other mid-size SUVs in its class.

11 Case 1998-49-71

Summary:
V1 ON EXIT RAMP FROM A N. BOUND DIRECTION TO W.BOUND. THE RAMP IS POSITIVELY SLOPED, CURVING RIGHT, SINGLE LANE OF DRY ASPHALT. V1 CONTACTED ITS FRONT LEFT CORNER WITH A GUARDRAIL - CLIMBED OVER THE RAILING, DID A COMPLETE ROLL, EJECTED DRIVER, CAME TO REST ON ITS LEFT PLANE ATOP DRIVER. VEH TOWED. DRIVER TRANSPORTED AND WAS LATER REPORTED DEAD, LESS THAN 1 HOUR AFTER CRASH.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Jeep	Cherokee84	1998	1	30	MALE	5 = CRITICAL INJURY

Figure 2.23: Case 11: Summary

Occupant: 1998-49-71-1-1

Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	CLIMB-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	OTHER BARRIER
Location on Vehicle where Principal Tripping Force was Applied	UNDERCARRIAGE
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	5 QUARTER TURN
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with Sequence Number	MODERATE 2
CDC	0 T D D O 3
Run off Road Damage (C1-C6)	0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	ONE
Roadway Alignment	CURVE RIGHT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	17

Vehicle Factors

Make-Model	Jeep Cherokee 84
Year	1998
Class	TRUCK
Body Type	COMPACT UTILITY
Weight	169

NASS Weighting Factor

Weighting factor	8.7992799451

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age 30 Height 168 Weight 84

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NONDEPLOYED
Ejection	COMPLETE EJECT
Ejection Area	LEFT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1 st Seat	NONDEPLOYED
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	1
MAIS	5 = CRITICAL INJURY
Seat Position	FRONT LEFT SIDE

Figure 2.24: Case 11: Crash Information

Case 12: 2000-9-15

In Case 2000-9-15, a Toyota 4-Runner impacted an Acura Integra. After this initial collision, the damaged 4-runner collided with the guardrail at a moderate angle. Unfortunately the guardrail did not contain the 4-runner, and the vehicle climbed the guardrail and started to roll. This roll however was averted by a collision with a light pole. Eventually the vehicle comes to rest in a ditch and with the driver sustaining incapacitating injuries.

This case exemplified a failure of the guardrail to contain the vehicle. The 4-Runner, although damaged, should have hit the guardrail and come to rest. As it stood however, the vehicle was able to vault over the guardrail and only avoid a rollover by a secondary collision with a light pole.

Investigation of the pictures of the guardrail and the vehicle showed that the guardrail in place was of a standard design and seemed to be installed properly. It was hypothesized that the vehicle was able to vault this guardrail because the point of impact was below the center of gravity. Therefore possible future designs should be able to engage the vehicle in a manner such that the projected point of impact is at or above the vehicle CG while avoiding vehicle under ride of the barrier.

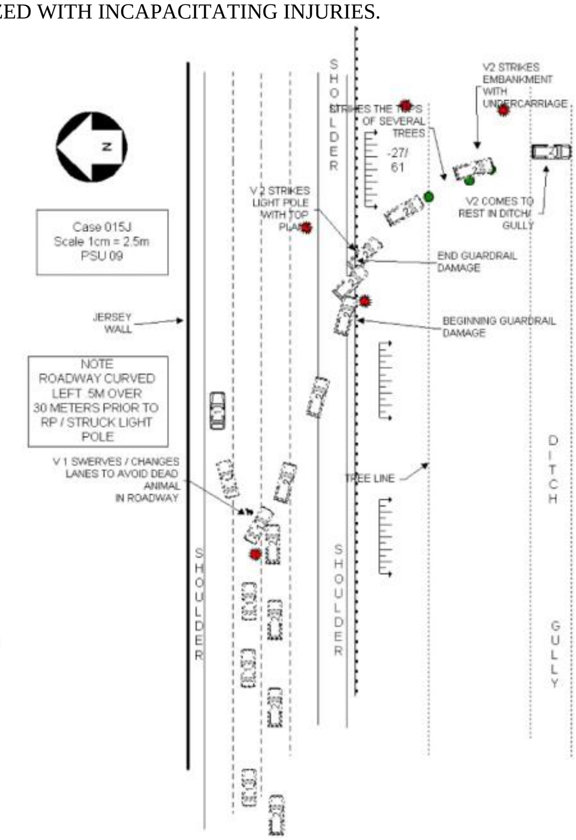
Other Similar Cases: 1999-73-12, 2000-48-169, 2000-9-15

Important Factors

- Frontal Overhang of Toyota 4-Runner
- Average Frontal Overhang for Midsize SUVs
- CG Height of Toyota 4-Runner
- Average CG Height of Mid-Size SUVs
- Average CG Height of Full Size Pickup Trucks
- Researcher Determined Impact Angle

12 Case 2000-9-15

Summary:
V1, A 1997 ACURA INTEGRA WAS TRAVELING EAST, IN LANE THREE, OF A FOUR LANE DIVIDED HIGHWAY(JERSEY WALL LEFT GUARDRAIL RIGHT). V2, A 1997 TOYOTA 4-RUNNER SUV WAS TRAVELING THE SAME HIGHWAY, IN LANE NUMBER TWO. V1 SWERVES/CHANGES LANES TO THE RIGHT TO AVOID A DEAD ANIMAL IN THE ROADWAY. V2'S FRONT PLANE STRIKES V1'S RIGHT SIDE PLANE. V1 TRAVELS BACK ACROSS LANE THREE AND COMES TO REST IN LANE FOUR. V2 CROSSES LANE ONE AND DEPARTS THE ROADWAY TO THE RIGHT. V2 STRIKES A GUARDRAIL WITH IT'S FRONT PLANE. V2 CLIMBS THE GUARDRAIL, STARTS TO ROLL (NO ROLLOVER OCCURRED / LIGHT POLE IMPACT PREVENTED ROLL) AND BECOMES AIRBORNE. V2 THEN STRIKES A LIGHT POLE WITH ITS TOP PLANE (NON-HORIZONTAL). V2 THEN DESCENDS A STEEP EMBANKMENT (UNKNOWN IF STILL AIRBORNE) AND STRIKES MULTIPLE TREES AND THEIR RELATED BRANCHES WITH ITS UNDERCARRIAGE. V2 THEN STRIKES THE NEAR SIDE EMBANKMENT WITH ITS UNDERCARRIAGE AND COMES TO REST AT THE BOTTOM, IN A DITCH/GULLY (V2 AT REST ON ALL FOUR WHEELS). BOTH VEHICLES ARE TOWED. THE DRIVER AND SOLE OCCUPANT OF V1 IS NOT INJURED OR TRANSPORTED. THE DRIVER AND SOLE OCCUPANT OF V2 IS TRANSPORTED AND HOSPITALIZED WITH INCAPACITATING INJURIES.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	3DR/2DR HATCHBAK	Acura	Integra	1997	1	26	MALE	0 = NOT INJURED
2	COMPACT UTILITY	Toyota	4-Runner	1997	1	47	FEMALE-NOT PREG	5 = CRITICAL INJURY

Figure 2.25: Case 12: Summary

Occupant: 2000-9-15-1-1

Rollover Classification

Number of Harmful Events	5
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	33 11 -31
Estimated delta-V with Sequence Number	DELTA V CODED 1
CDC	4 R P A W 3
Run off Road	
Damage (C1-C6)	3 22 40 43 11 2
Crush (L and D)	200 23

Pre-Crash Environment

Traffic Flow	DIVIDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	CURVE LEFT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAY LIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Acura Integra
Year	1997
Class	PASSENGER CAR
Body Type	3DR/2DR HATCHBACK
Weight	115

NASS Weighting Factor

Weighting factor	35.411450506

Pre-Crash Driver Data

Accident Type	46
Pre-event Movement	CHANGING LANES
Critical Pre-crash Event	OVER LINE - RIGHT
Attempted Avoidance Maneuver	STEERING RIGHT
Pre-impact Stability	NO DRIVER
Pre-impact Location	LEFT TRAVEL LANE

DRIVER Factors

Age 26 Height 178 Weight 64

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	NONDEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment – 1st Seat	NONDEPLOYED
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	1
MAIS	0 = NOT INJURED
Seat Position	FRONT LEFT SIDE

Figure 2.26: Case 12: Crash Information

Case 13: 1998-12-54

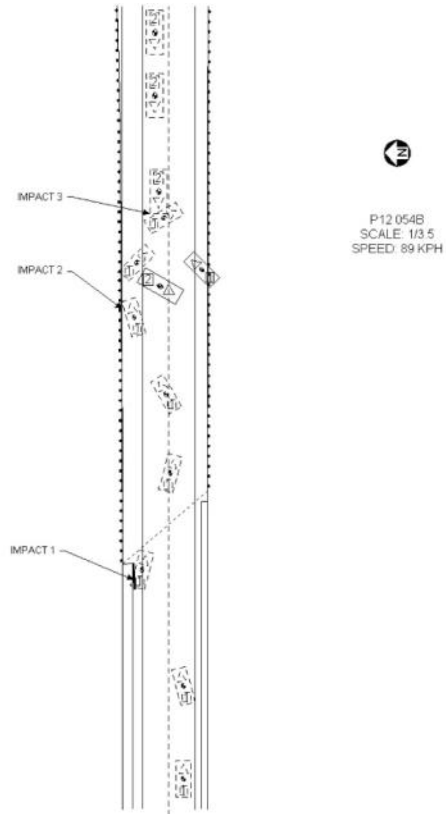
A Jeep Grand Cherokee lost control while traveling and struck its left rear on a concrete retaining wall. The driver, while trying to regain control, then hit another guardrail with the left front of the vehicle. The collision with the retaining wall redirected the vehicle back into traffic where it collided with a Chevrolet Pick-up. This T-bone collision resulted in severe injuries for the driver of the Grand Cherokee.

The concrete wall in this case showed an incompatibility due to of the high re-direction angle of the bullet vehicle. When the driver of the Cherokee hit the guardrail the second time, he was not traveling at a high angle in relation to the retaining wall. Therefore, the vehicle should have come to rest against the guardrail or a short distance away. As it happened, the vehicle was redirected sharply into traffic, which resulted in a second, T-bone, collision with a full size pick-up truck.

- Redirection Angle following Initial Barrier Impact
- Frontal Overhang of Grand Cherokee
- Average Frontal Overhang for Midsize SUVs
- CG Height of Jeep Grand Cherokee
- Average CG Height of Mid-Size SUVs
- Average CG Height of Full Size Pickup Trucks
- Researcher Determined Impact Angle

13 Case 1998-12-54

Summary:
VEHICLE ONE WAS HEADING EAST ON A TWO LANE, TWO WAY, ICY, ASPHALT ROADWAY. V2 WAS HEADING WEST ON THE SAME ROADWAY. V1 LOST CONTROL ON AN ICY OVERPASS AND STRUCK THE LEFT, BACK OF THE VEHICLE ON A CONCRETE BARRIER. THE VEHICLE BOUNCED OFF THE BARRIER AND CONTINUED IN A SOUTH EASTERLY DIRECTION. V1, STILL SLIDING ON THE ICE, THEN HIT A GUARDRAIL WITH THE LEFT, FRONT, GLANCING OFF AND HEADING INTO ONCOMING TRAFFIC. WITH VEHICLE ONE IN ITS TRAVEL OF PATH, THE FRONT OF V2 CONTACTED THE LEFT SIDE OF V1. BOTH VEHICLES WERE TOWED DUE TO DAMAGE. OCCUPANTS ONE AND THREE OF V1 WERE KILLED IN THIS ACCIDENT. OCCUPANT TWO OF V1 WAS TRANSPORTED FOR MEDICAL TREATMENT. OCCUPANTS 1 AND 2 OF V2 WERE TRANSPORTED FOR MEDICAL TREATMENT. ALL OCCUPANTS INVOLVED IN THIS ACCIDENT WERE WEARING LAP AND SHOULDER BELTS.



Vehicle	Body Type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Jeep	Cherokee84	1993	1	34	FEMALE-NOT PREG	2 = MODERATE INJURY
1	COMPACT UTILITY	Jeep	Cherokee84	1993	2	8	MALE	5 = CRITICAL INJURY
1	COMPACT UTILITY	Jeep	Cherokee84	1993	3	7	FEMALE-NOT PREG	7 = INJURY, UNK SEV
2	COMPACT PICKUP	Chevrolet	S-10	1982	1	31	MALE	1 = MINOR INJURY
2	COMPACT PICKUP	Chevrolet	S-10	1982	2	31	MALE	1 = MINOR INJURY

Figure 2.27: Case 13: Summary

Occupant: 1998-12-54-1-2



Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	45 –22 39
Estimated delta-V with Sequence Number	DELTA V CODED 3
CDC	10 L D A W 3
Run off Road	
Damage (C1-C6)	17 36 20 39 12 0
Crush (L and D)	286 -53

Pre-Crash Environment

Traffic Flow	NOT DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	ICE
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Acura Integra
Year	1997
Class	PASSENGER CAR
Body Type	3DR/2DR HATCHBACK
Weight	115

NASS Weighting Factor

Weighting factor	32.466587775

Pre-Crash Driver Data

Accident Type	9
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	POOR ROAD CONDIT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	LEFT TRAVEL LANE

DRIVER Factors

Age 8 Height 122 Weight 34

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment – 1st Seat	NONDEPLOYED
Airbag Deployment – Other Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	2
MAIS	5 = CRITICAL INJURY
Seat Position	SECOND LEFT

Figure 2.28: Case 13: Crash Information

2.2.1 Case Review Summary

The NASS/CDS cases reviewed above indicate that a series of vehicle and roadside device characteristics are critical for the proper performance of the vehicle/roadway system in the event of a crash. These characteristics are as follows:

- Vehicle CG height
- Vehicle Frontal Overhang (propensity for Snagging)
- Vehicle Mass
- Roadway Profile and Design
- Barrier Height
- Impact Severity (i.e. deltaV)

The current vehicle fleet is shifting towards a higher percentage of larger SUV, crossover and pickup style vehicles. These vehicles have higher ground clearances, shorter frontal overhangs and higher CGs. This combination of characteristics leads to greater risk of negative interaction with barrier systems. This interaction includes barrier snagging, tearing and overriding. The cases reviewed indicate that subsequent instability of higher CG vehicles is often involved in subsequent rollovers and increases injury risk. This behavior must be improved from the vehicle design perspective as well as design of the barrier systems so that this rollover propensity is reduced.

For the passenger car fleet, favorable interaction with the longitudinal sections of the barriers is observed. Few vehicle penetrations, high redirective accelerations or vehicle rollovers were found in the crash cases. The deployment timing of airbags during vehicle/roadside hardware crashes is in question however.

As airbag systems are designed to deploy based on deceleration of the vehicle structure in the event of a crash, low acceleration forces brought about by longitudinal barrier interaction may lead to delays in deployment from first contact. To determine if any negative effects are brought about by airbags and soft barrier systems further crash investigation is required. In the future, enhanced crash testing procedures should be used which include airbag equipped vehicles, human surrogates to measure crash forces and visual documentation of belted occupants to understand their kinematics in the event of an oblique barrier crash. Automotive manufacturers should consider the nature of vehicle crash signatures to ensure that vehicle sensor systems and deployment algorithms effectively select deployment regimes to best protect occupants. This testing should be conducted for all vehicle body types.

Chapter 3
Assessment of Vehicle Characteristics

In order to identify vehicle body styles and structural characteristics which were influential during crashes with roadside systems, a review of full scale crash tests was conducted. This review provided a clear indication of the roadside systems that performed best under a series of test conditions with the chosen NCHRP test vehicles (i.e. 820kg and 2000kg vehicles). The review provided the research team with an understanding of the characteristic behavior of vehicles during these crash events. Since only these two vehicle classes have been observed during tests, little was learned about the vehicle attributes that influence crash performance during roadside impacts. Influential characteristics would be recognized if two tests of identical roadside systems were conducted using different impacting vehicles. Under these conditions, a direct comparison of geometric and dynamic vehicle properties indicates possible sources of incompatibility. Alternative methods to study the effect of vehicle attributes on compatibility with roadside hardware using analytical modeling of vehicles and barrier systems is included in Section of this report.

Information regarding characteristics of passenger vehicles that are influential during vehicle crashes with roadside structures was gathered through individual crash case reviews shown in Chapter 2 of this report and through information compiled during the literature review for this project. These sources provided the basis for the following list of vehicle attributes that potentially are influential during roadside hardware crash events.

1. Vehicle mass
2. Height of vehicle front structure and profile
3. Stiffness and geometry of vehicle front and side structure
4. Frontal overhang ahead of front wheels
5. Front and rear suspension characteristics
6. Vehicle door rocker geometry
7. Vehicle door latch/structural geometry
8. Vehicle wheelbase

9. Vehicle Static Stability Factor

In addition, the literature review provided insight into the most appropriate characteristics which should be considered to assess vehicle performance during roadside crashes. A comprehensive FHWA project conducted by the Texas Transportation Institute (TTI) was reviewed. The objective of this project was to develop protocols that could be used to identify compatibility issues caused by changes in the future motor vehicle fleet. The final report of this project included many relevant findings and recommendations regarding vehicle compatibility with roadside hardware. Some highlights from this project are shown below [2].

1. Vehicle platforms will be face lifted every 3 - 4 years with new platforms every 5 - 7 1/2 years. A protocol needs to be in place to categorize the vehicle fleet to assess the level of performance.

2. Light truck population will continue to increase from its current exceedance of 50% of total vehicle markets. The greater vehicle height which is unregulated will make vehicle stability a continuing concern.

3. Curb weight and size of the 820 kg class vehicle will continue to increase requiring a selection of heavier vehicles for the lower weight class.

4. Driver and passenger side airbags will approach 100 percent in the next decade. It may be appropriate to consider this and the increased safety restraint usage (i.e. over 70% seat belt usage) when evaluating roadside hardware.

5. Recently introduced crumple zones in light truck subclasses have shown a significant reduction in occupant compartment deformation.

6. Vehicle manufacturers are producing less full-size passenger cars.

7. Market share of the two midsize car platforms continue to increase above the two small car platforms.

8. Large pickups (1/2 ton and 3/4 ton) continue to dominate the sub-class in terms of market share among light trucks.

9. Some of the more significant characteristics identified are: Total mass, front overhang, height of vehicle center of gravity, suspension height, bumper height, geometric profile, and frontal crush stiffness.

10. Because wheelbase, weight, overall length, overall width, and front track width were highly correlated, by retaining one of them, all of the statistical information contained in original data was preserved.

Many of the vehicle characteristics highlighted by the TTI study were further reviewed to understand their correlation with real world crash outcomes and results of full scale tests. Further, it was determined that a thorough survey of the current vehicle fleet to understand the variability and range of characteristics that exist today was necessary. The following section outline the methodology used to gather those relevant characteristics.

3.1 Geometric Characteristics

During the literature survey portion of this project, trade magazines and engineering resources were compiled to document a series of vehicle characteristics for US model automobiles. Some of those resources include: The Mitchell Automotive Repair Series by Mitchell Automotive and the "Consumer Review 2001 Car Prices" By Harris Publications. The Mitchell Series documents dimensions of all vehicle sub structures for body shop repair professionals. The "Consumer Review" Magazine documents consumer information such as vehicle weight, height, wheelbase and engine type. Following review of these resources, a large amount of data was compiled however, a series of critical vehicle attributes were still unknown. Since this necessary data was not available directly from the manufacturer, the research team performed measurements by hand on a large number of new and used vehicle structures. Those attributes and procedures for these measurements were conducted as follows.

1. **Frame rail spread-** The frame rail spread is the distance between the left and right frame rails. When viewing the car from the front, this measurement is taken from the inside of the left frame rail to the inside of the right frame rail at the point closest to the front of the car possible.

   This vehicle attribute is important during oblique and frontal impact events. During oblique impacts, including interaction with longitudinal barriers, the proximity of this stiff body structure to the impacting device often dictates the acceleration and crush profile exhibited by the body structure. A soft outer body structure surrounding frame rails positioned well inboard (close to the vehicle longitudinal centerline) often leads to high body deformation and a high likelihood of snagging with barrier systems. Conversely, if the stiff vehicle structure is positioned more outboard, the stiff vehicle structure will engage with the rigid or flexible barrier without absorbing large amounts of impact energy. Higher levels of lateral acceleration result in this case.

During frontal impacts with narrow objects, the position of these frame rails is important when considering optimal engagement of the pole/post with rigid structure (engine) or deformable structures (rails).

2. **Bumper structure (lower and upper)-** The bumper structure is defined as the hard portion of the bumper that will not deform in a minor accident. Usually the bumper structure is made of steel or a hardened plastic. Foam and light plastic have less significant effect on the impact and are not included in the bumper structure measurements. In some cases, when the vehicle could not be disassembled or direct measurements of the front bumper structure could not be performed, the actual bumper structure height was estimated by the measurement of the outer fascia.

   The bumper structure location as well its overall height could have significant effect on the outcome of a crash. The bottom and top aspects of the bumper structure are important to determine the approximate region of first engagement with guardrail devices. These beams or U-shaped channels are responsible for transferring a large percentage of loading during frontal impacts to the vehicle structure before crushing occurs. The size (height) of the structure is important during pole impacts to understand the likelihood of pole bending, fracture or collapse as well as the likelihood of release of breakaway devices during those impact conditions.

3. **Bumper fascia (lower and upper)-** The bumper fascia is defined as the continuous metal or plastic cover surrounding the bumper structure. The measurements of the fascia are always taken at the center of a vehicle from the ground to the upper most and the lowest point on the front fascia. These measurements do not include structures such as chin spoilers unless these spoilers are directly cast into the fascia (i.e. it does not include bolt on spoilers). If the grill is continuously integrated into the bumper fascia, the measurements are taken to the top of the grill. However if there is a gap between the bumper and the grill, the measurements do not include the grill area.

   The geometry of this fascia is important to determine the likelihood of post snagging with the vehicle structure. Also, this "flexible" structure that is often plastic gives the impression that impact forces will be distributed over a larger area than the bumper structure explained above.

4. **Rail height (lower and upper)-** The rail height is the height of the frame rail measured at the most forward point possible. The frame rails are two longitudinal members that carry most of the

frontal impact force during impact. These rails are often tubular, box or c-channels welded to the vehicle structure in the case of unibody constructed vehicles.

The dimensions of these members are important to understand the probable center of force that results during frontal impacts with a wide variety of devices. The lowest and upper-most points on the frame rail will indicate the likelihood of favorable interaction with guardrails, end terminals and semi-rigid longitudinal barriers during high-energy impacts. Often during these types of impacts, the outer body and bumper structure collapse and all remaining engagement with the barriers occurs with the engine or frame structures.

5. **Free Space-** Free space is measured from the aft most point of the radiator to most forward hard point of the engine. Hard points are defined as engine components and frame components (Plastic fans, belts and pulleys are not considered hard points in this measurement). If the engine protrudes underneath the radiator, the free space is defined to be 0.

   This dimension is important during frontal impact with narrow objects and partner vehicles. Often vehicle crash sensors deploy airbags based on sudden deceleration of the vehicle structure. Usual deceleration levels experienced by the vehicle during deformation of the bumper structure and the radiator often fail to trigger airbag sensors. The larger the free space is, the later the airbag deployment will occur. If the sensors do not trigger airbags before the pole structure begins interacting with the engine block, a sudden peak in deceleration forces will take place leading to airbag deployment. In some cases, the occupant has moved forward or out of position relative to the deploying airbag causing an unfavorable late deployment crash scenario. During interaction with partner vehicles, a large amount of free space creates a more favorable situation for impacted vehicles as this region is more compliant than the engine block itself.

6. **Frontal Overhang-** The frontal overhang is the distance from the lowermost potion of the front fender to the most forward position of the vehicle. This gives an indication of the exposure of the wheel, suspension and power train to objects struck during frontal impact conditions.

   The ride height combined with the front overhang dictate the level of interaction seen between impacted and rotating tires/suspension structures. In the case of Pickup Trucks and SUVs, a short frontal overhang and higher ride height often lead to higher potential for snagging with guardrail posts and rail members themselves. This condition is prevalent during guardrail impacts with pickups and may occur during impacts between barriers and similarly configured sport utility vehicles.

7. **(Window) Sill Length-** The Sill length is measured from the front most position of the lower portion of the driver's side window to the rear most position of the driver's window. If the rear view mirror is incorporated in the main frame of the window, the measurement begins at the beginning of the rear view mirror housing.

   During crash events with narrow objects (posts or poles) or end terminals in a side impact configuration, the length of the door or window sill will indicate some potential for occupant compartment intrusion. A door structure securely fixed at door hinge points and the door latch point which are closer together are likely to resist intrusion well. Conversely, a structure where these points are further apart often has a more compliant door allowing for greater levels of intrusion. Also, as the ratio of windowsill length to total vehicle body length increases, the likelihood of contact between the deforming door and nearside occupants also increases.

8. **(Window) Sill Longitudinal Location-** The longitudinal location is the distance from the gap between the hood and the front fascia/fender and ending at the lower portion of the driver's side window.

   This measurement indicates two characteristics. First, this distance provides a metric for location of the front door versus the front of the car. Second, the distance from the front most impact point to the base of the windshield can be estimated as well. During frontal impacts with small sign support structures, the likelihood of contact between the sign blank and the windshield are a direct function of this distance. Other factors that indicate this are vehicle bumper height, ride height and vehicle mass. In some cases the sign blank strikes may strike the hood, the roof or the windshield. Windshield contact is least desirable.

9. **(Window) Sill Height-** The sill height is the height from the ground to the lower part of the driver's side window. This measurement is taken at the rear most portion of the driver's window. Plastic sheathings are not included in the measurement of sill height.

   This metric provides an estimate of occupant head position in the event of a side impact. A life threatening situation exists if the occupants head strikes and breaks the driver side window during a near side collision. In this situation, there is potential for contact of the head with the stiff impacted device. This information is critical to properly determine barrier heights including longitudinal and end terminals in use.

10. **Rocker height (lower and upper)-** The measurement for the lower rocker height is taken from the ground to the beginning of the rocker panel. This height does not include the jack mount points or the rail channel below the vehicle. The upper rocker height is measured from the ground to the upper most portion of the rocker panel. The measurement of the upper rocker panel only measures the metal portion of the rocker panel. Vinyl and plastic coatings are not included.

    During side impact events, a critical factor determining crash severity is the degree of structural interaction of the vehicle rocker and pillars with the impact partner. If the center of force generated by the impacted device is above or below the rocker panel, poor engagement and high levels of compartment intrusion are likely. Trends in new vehicle design indicate increased overall height of rocker panels in order to maximize potential interacting space. The Volvo Side Impact Protection System (SIPS) is an example of this design enhancement without compromising the ease of vehicle entry and exit.

11. **Striker Height-** The distance from the ground to the lowest portion of the striker perpendicular to the doorframe (i.e. from the ground to the lowest portion of the striker that engages the door).

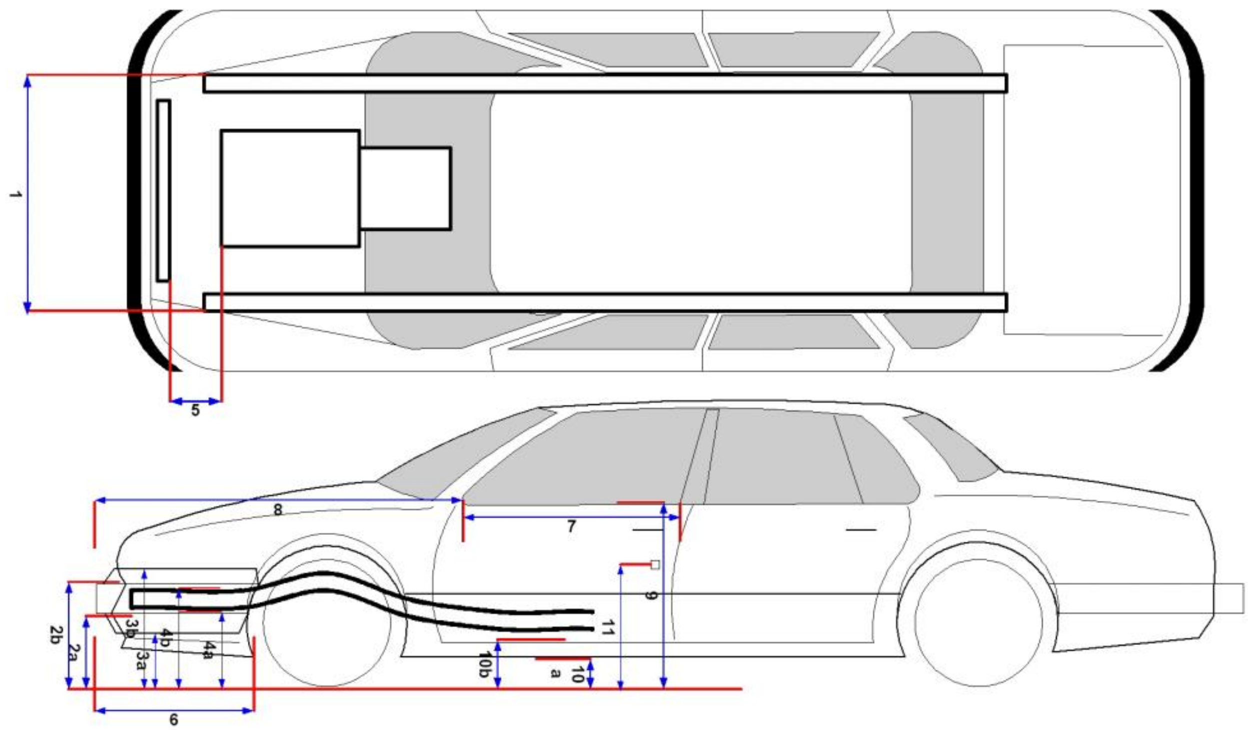
    The striker or latch point is a structurally rigid point where a positive connection is made between the door structure and the B-Pillar. Often manufacturers will attach side impact door beams at this rigid point and the hinge attachment points at the vehicle A-Pillar. Knowledge of the striker height, provides an indication of the potential for interaction between the door's side impact beam and the impacted structure.

12. **Static Stability Factor-** The Rollover Resistance Ratings assigned by NHTSA are based on the Static Stability Factor (SSF). The SSF is essentially a measure of how top heavy a vehicle is. This factor is the ratio of one half the track width to the center of gravity (c.g.) height. The Rollover Resistance Ratings of vehicles were compared to 220,000 actual single vehicle crashes, and the ratings were found to relate very closely to the real-world rollover experience of vehicles. Based on these studies, NHTSA found that taller, narrower vehicles, such as sport utility vehicles (SUVs), are more likely than lower, wider vehicles, such as passenger cars, to trip and roll over once they leave the roadway. Accordingly, NHTSA awards more stars to wider and/or lower

vehicles. The Rollover Resistance Rating, however, does not address the causes of the driver losing control and the vehicle leaving the roadway in the first place.

One criticism for the static stability factor is the fact that it is an oversimplification of the true structure of the vehicle. It does not include the effects of suspension deflections, tire traction and electronic stability control (ESC).

The above vehicle characteristics are shown graphically in Figure 3.1.



1.Frame Rail Spread	6.Frontal Overhang
2.Bumper Structure Height (a.Lower b.Upper)	7.Window Sill Length
3.Bumper Fascia Height (a.Lower b.Upper)	8.Window Sill Longitudinal Location
4.Rail Height (a.Lower b.Upper)	9.Window Sill Height
5.Free Space	10.Rocker Panel Height (a.Lower b.Upper)
	11.Striker Height

Figure 3.1: Vehicle Characteristics As Measured

Tables 3.1, 3.2, and 3.3 below contain average vehicle specifications for each class reviewed. All available resources were used to obtain this data. It is believed that if a vehicle with attributes closest to the class average is chosen for future crash testing, the entire class should be well represented. However, current practices utilize the "worst case vehicle" approach where the attributes of the test vehicle lie at the boundary of the population. To aid the selection of an average vehicle, Appendix B lists over 342 vehicle makes and models and their corresponding design attributes.

		Average of Moments of Inertia			
Vehicle Type	Class	Pitch	Roll	Yaw	Avg. SSF
Car	Compact	1584	374	1685	1.342
	Midsize	2438	495	2544	1.354
	Large	2946	560	3081	1.346
Car Total		2208	460	2320	1.347
SUV	Compact	2059	515	2143	1.064
	Midsize	3353	692	3399	1.083
	Large	5165	1019	5206	1.076
SUV Total		3172	674	3233	1.074
Truck	Compact	2627	474	2669	1.205
	Large	4644	846	4693	1.172
Truck Total		3782	676	3824	1.171
Van	Large Van	5953	1198	5912	1.110
	Minivan	3481	822	3536	1.154
Van Total		3991	884	3996	1.145
Grand Total		3152	640	3212	1.187

Table 3.1: Average Inertial Properties per Vehicle Type and Class

		Length	Width	Ht	Whlbase	Curb Wgt.	Front Ovrhng	Rear Ovrhng	Ft. Rock Height
CAR	compact	168.19	65.21	52.88	96.42	2380.01	34.75	36.93	7.56
	mid	186.68	70.11	53.43	104.41	3159.74	38.86	43.44	7.87
	large	206.27	74.46	55.40	114.21	3831.85	41.43	50.56	8.45
CAR Tot		184.19	69.23	53.72	103.68	3012.77	37.91	42.75	7.88
SUV	compact	157.92	66.33	66.61	94.89	2849.49	28.17	34.56	10.99
	mid	177.68	69.59	68.83	104.54	4022.32	31.12	41.67	15.07
	large	195.89	78.19	72.56	116.08	4907.71	33.62	46.02	15.59
SUV Tot		178.06	71.56	69.48	105.63	3977.77	31.08	41.00	13.44
TRU	compact	186.55	66.94	63.58	112.79	3038.79	30.97	43.09	11.89
	large	212.66	77.32	71.36	132.18	4269.49	34.47	46.03	13.18
TRU Tot		196.46	70.88	66.49	120.15	3505.77	32.33	44.24	12.15
VAN	mid	186.51	72.34	66.92	112.25	3547.82	35.77	38.63	9.89
	large	200.33	77.56	77.75	121.18	4426.65	33.35	45.53	
VAN Tot		191.71	74.30	70.91	115.61	3878.47	34.90	41.11	9.89
Grand Tot		184.78	69.84	56.81	105.46	3183.29	36.78	42.56	8.35

Table 3.2: Structural Properties per Vehicle Type and Class (Averages)

		Rr. Rocker Height	Ft. Bumper Height	Rr. Bumper Height	Door to Ground	Front Track	Ft. Wght Percent	Rr. Wght Percent
CAR	compact	7.35	11.23	11.68	10.95	56.98	60.7%	39.3%
	mid	7.62	11.18	11.83	11.30	59.17	59.8%	40.3%
	large	8.37	11.55	12.51	11.19	61.46	59.2%	40.8%
CAR Tot		7.69	11.29	11.94	11.10	59.12	60.0%	40.0%
SUV	compact	11.21	12.83	13.42	15.75	57.18	54.7%	45.3%
	mid	15.23	16.64	17.04	18.41	58.45	53.1%	46.9%
	large	16.57	15.89	18.50	19.49	64.73	52.9%	47.1%
SUV Tot		13.72	15.15	15.85	17.94	59.92	53.6%	46.4%
TRU	compact	13.34	15.03	13.92	14.70	57.21	61.0%	39.0%
	large	14.74	18.08	16.91		64.50	0.0%	0.0%
TRU Tot		13.65	15.59	14.95	14.70	60.50	61.0%	39.0%
VAN	mid	10.41	10.10	12.13	12.80	61.61	57.7%	42.3%
	large					65.55	55.8%	44.2%
VAN Tot		10.41	10.10	12.13	12.80	62.80	57.4%	42.6%
Grand Tot		8.26	11.55	12.19	11.44	59.67	59.5%	40.5%

Table 3.3: Average Structural Properties per Vehicle Type and Class- (Population Weighted Averages)

3.2 Barrier Force Data

Vehicle to vehicle crash incompatibility has been attributed to three factors: (1) mass incompatibility, (2) stiffness incompatibility, and (3) geometric incompatibility [14]. These factors may be effectively applied when considering compatibility between vehicles and roadside hardware objects as well. The measurement of vehicle mass is relatively straightforward. However, measurement of stiffness and geometric compatibility needs further definition. Without exhaustive investigation of individual vehicle attributes as shown in the following section, a method has been developed to understand vehicle metrics critical to the interface between striking vehicles and objects struck. This method is repeatable and objective making it ideal for side by side comparison of a variety of structures.

It has been suggested that the height of the forward-most load-bearing member of the vehicle structure as a metric for geometric incompatibility. Since this element has no precise definition, the rocker panel height was used as the geometric metric. For the stiffness metric, the vehicle crush at the maximum barrier force during a 35-mph rigid barrier crash was utilized. [14]

NHTSA's crash test program produces additional measurements, which can contribute to assessing stiffness and geometric characteristics of vehicle frontal structures. For most of the 35-mph crash tests conducted under the NCAP program, the time history of the distribution of force applied by the vehicle to the barrier was measured. These measurements indicate the geometric location of "hard spots" and the amount of force the vehicle imparts to a rigid barrier. This data permits the calculation of local stiffness and of load paths at various heights.

Different aggressiveness metrics may be applicable to different crash modes. The efficacy of any proposed metric would need to be verified using on-the-road crash and injury data. However, a number of metrics can be proposed and developed from the available NCAP test data.

For a front to side impact, the front of the striking vehicle may crush less than 125 millimeters. The force developed in this intermediate crush range and the height of the force measured on the barrier face may be the critical parameters. For a frontal-offset crash, the force and geometry of only the left or right portion of the vehicle front may be applicable. For interaction with reasonably compliant roadside devices such as roadside hardware crush levels rarely exceed 125 millimeters unless localized intrusion by barrier sections occurs.

The use of barrier force data permits a finer discrimination of vehicle stiffness and geometry that can be further investigated as appropriate aggressivity metrics. From this approach, metrics may be derived from barrier test data that may be used to assess vehicle geometric and stiffness aggressiveness in frontal type crashes.

Barrier Information

The barrier used in the New Car Assessment Program (NCAP) is a rigid, fixed barrier with 36 force measuring load cells on its surface. The load cells array consists of 4 rows of 9 cells, as shown in Figure 3.2. The rows are designated by letters A through D, with A at the bottom. The columns are numbered 1 through 9, starting at the left, facing the barrier. The array is subdivided in 6 groupings, 1 through 6, numbered left to right, and beginning with lower left grouping (see Figure).

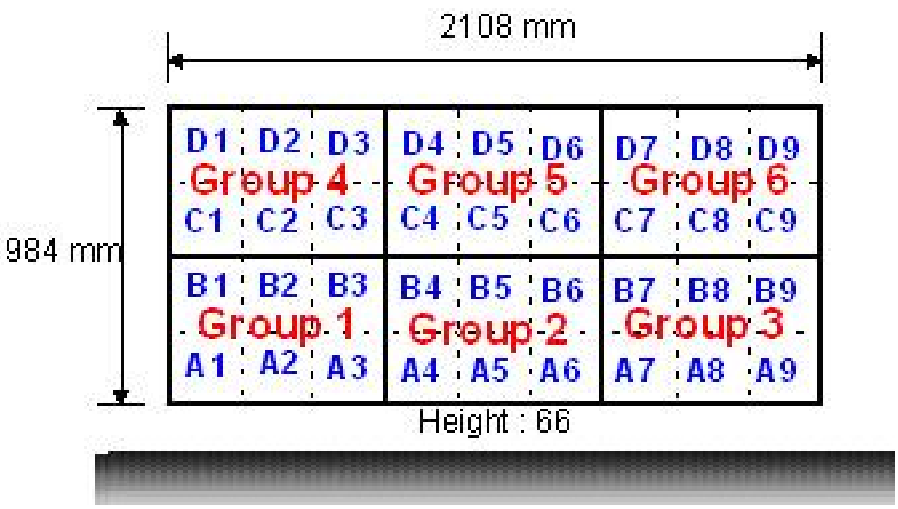


Figure 3.2: Configuration of Load Cells on Barrier

The array of load cells provides the opportunity to assess the distribution of forces that the vehicle imposes on the barrier during the crash. In this study, the relationship between barrier forces and their geometric location are of particular interest. In offset crashes, the left or right side of the structure principally deforms and absorbs energy. In centerline impacts with narrow objects, the center response is primary. In head-on crashes with large overlap, the entire width of the force array may be required. The vertical force distribution of the vehicle structures in contact during the crash is important in assessing the geometric compatibility.

To address these various requirements, the barrier measurements have been used to graphically present the forces measured by all 36-load cells. The force distributions are examined at three points during the crash. The stiffness is calculated by dividing the force measured by the load cells at a particular time by the calculated vehicle crush at that time. The vehicle crush is determined by double integration of the longitudinal acceleration measured on a structural member close to the vehicle's center of gravity.

To quantify the height of the structural loading, a center of impact force was calculated for three columns of cells. The left column contained the 1 and 4 groupings, the center column the 2 and 5 groupings, and the right the 3 and 6 groupings. In addition, the height of the center of force for the total loading was calculated. For each grouping, the force on each row of cells was assumed to be uniformly distributed. The height of the center of the force was calculated, applying static equilibrium relationships as shown in Figure 3.3. The center of force was calculated for vehicle crush of five inches, 10 inches and 15 inches. In the tables and figures given here all data are reported in metric units. The three crush levels are reported as the approximate metric equivalent - 125mm, 250 mm and 375 mm.

In Figure 3.3, static equilibrium is first applied. The force (F) that is required to resist the sum of the load cell forces from rows A, B, C, and D is determined. The height of force F is then found by applying moment equilibrium to the barrier forces and moment arms. The height H is defined as the Center of Force. The center of force calculation is made for the entire rows of load cells as well as for the left third, the center third, and the right third of the rows.

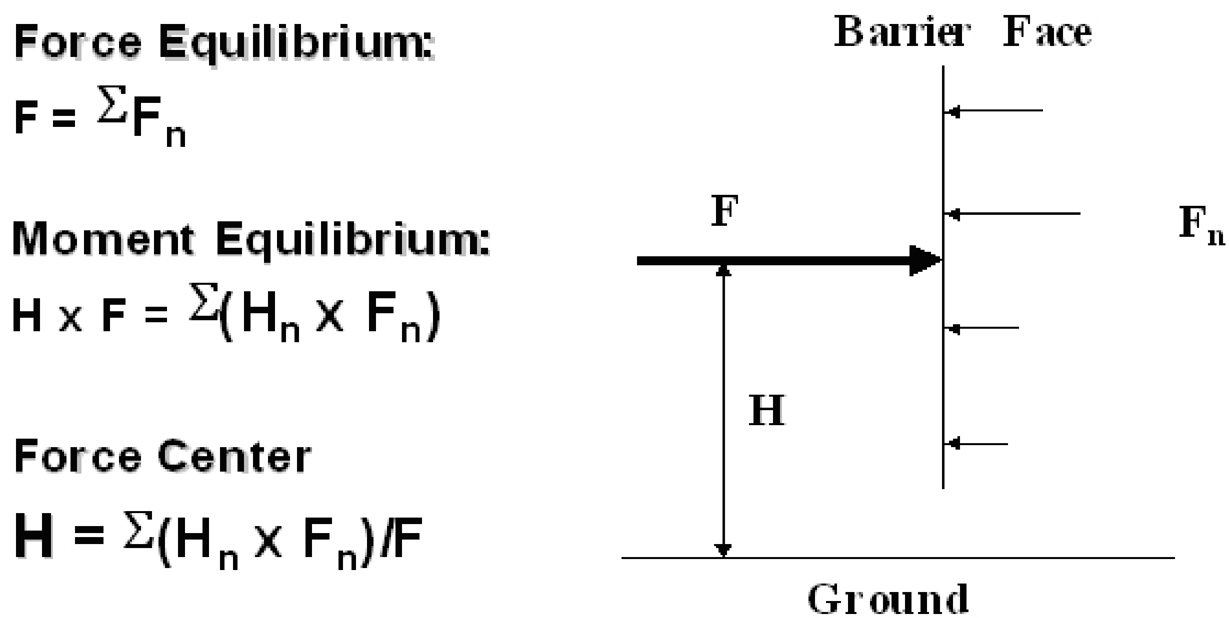


Figure 3.3: Definition of Center of Force, H

The linear stiffness is sensitive to the accuracy of the zero time step selected for the barrier force data. The force level is less sensitive than the stiffness to the zero time step selection. Consequently, force rather than stiffness is a preferred metric at the selected crush values.

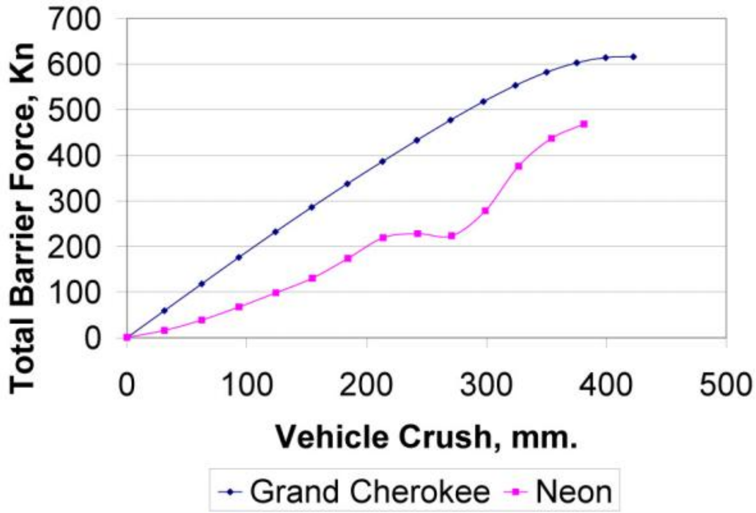


Figure 3.4: Total Barrier Force vs. Vehicle Crush

At a crush of 200 mm, the Jeep Grand Cherokee exerts almost twice as much force as the Dodge Neon. This difference in stiffness will result in a higher extent of crush for the Dodge Neon in a frontal crash involving the two vehicles. This difference illustrates the stiffness differences between the two vehicles. These differences are shown in Figure 3.4 above.

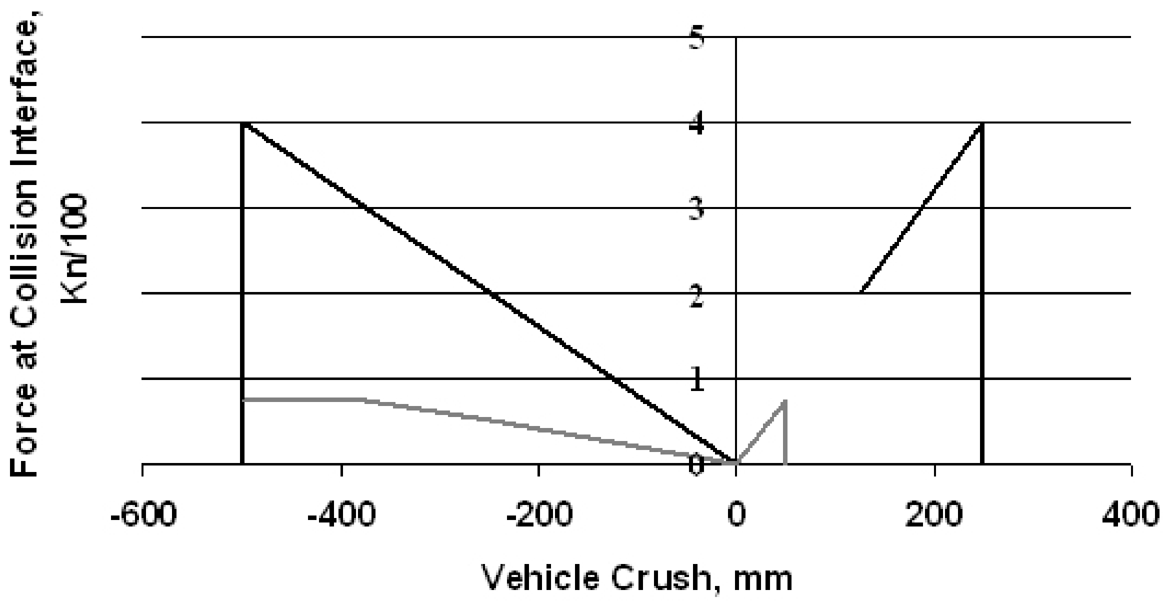


Figure 3.5: Force Deformation Relationships in Vehicle to Vehicle Frontal / Side Crashes

An idealized relationship between the crash forces of cars with different frontal stiffnesses is shown in Figure 3.4. In a frontal-to-frontal collision, the soft car crushes more than the stiff car at the same interface force. In the example, the interface force level is 400 kN. The crush of the soft car is 500mm and the crush of the stiff car is 250 mm. The area under the force-deformation curve is proportional to the energy absorbed. Consequently, the soft car has absorbed about twice as much crash energy as the stiff car. This difference illustrates the stiffness incompatibility of the two vehicles. As shown in Figure 3.5, the force vs. crush relationship may not be linear, as assumed in the figure.

It should be noted that the difference in the geometric location of the forces generated by the vehicle structures could influence the idealized interaction presented in Figure 3.5. This difference will be addressed under the discussion of geometric compatibility.

The maximum force produced during the crash and the linear stiffness based on the crush at maximum force have been suggested as metrics for stiffness incompatibility. In view of the force vs. crush non-linearities, and geometric influences during the crash, some more robust metrics may be needed. In this study, we propose to investigate the force levels at 125, 250, and 375 mm. The forces developed by the vehicle left, center, or right segments of the vehicle front may be applicable in offset collisions.

Tabular Summaries of Load Cell Barrier Data

This report presents summary data from 50 vehicles. The 50 vehicles are listed in Appendix B of this report. Another 14 vehicles have been analyzed, but the data was found to be of unsuitable quality. In 17 of the cases, data was not reported for three of the four rows of load cells.

The data on the 50 vehicles included in this report should be considered preliminary. Several adjustments in the data will be necessary. For example, some vehicles may not have impacted the center of the barrier. Shifting of the load cell columns to the right or left will be needed in these cases. In other cases, a single load cell in the array may produce unrealistically high readings. Finally, adjustments to gain a precise zero time step may be necessary in a few cases.

The vehicle characteristic table shown in Appendix B provides selected results of the barrier data analysis. The nine columns of load cells are divided into three groups as described earlier. The groups are: left, center and right. The sums of the forces left, center, right, and total are designated by FCRT, FCCT, FCLT, and FCT, respectively. The percent of the barrier force on the A, B, C, and D rows are designated in the last four columns of the tables. The values listed in the table are for a vehicle crush of 375 mm.

Data Processing Procedures

The acceleration data points were the average of two accelerometer readings. The two accelerometers selected were the left and right rear floor pan or the left and right rear seat accelerometers. In the event inaccurate velocity changes of the vehicle were predicted, the best available accelerometers were selected.

The raw data from all 36 load cells was processed. The raw acceleration and barrier load cell data points were filtered according to SAE J211 Standard, with a corner frequency of 18, using a filter supplied by NHTSA. It was assumed that the zero time steps provided in the data were accurate, and were identical for the force and acceleration data. Beginning with the zero time step, acceleration data and barrier force data were sampled every 2 ms for 120 ms. The resulting acceleration data and load cell data were the input for subsequent analysis.

In examining the resulting data, several inconsistencies were observed. The most frequent was an initial force on load cells at time zero. In the event the total force at time zero was greater than 10% of the maximum barrier force, the data was rejected. A second problem was the presence load on cells outside the contact region, or unrealistically high loads on cells inside the contact region. These cases were not rejected in the event the consequence was negligible. Finally, in some cases, the acceleration readings produced a higher or lower delta-V than expected. In the event that the delta-V prediction from the accelerometers up to the time of maximum crush was reasonable, the data was not rejected.

Discussion

The results of the barrier data provide useful insights into the geometry and height of the stiffest portions of the vehicle structure in a barrier crash. By developing metrics for these properties, it may be possible to quantify more precisely vehicle compatibility with a variety of impacted structures. Other structures may include any aspects of opposing vehicles or roadside safety systems. The proposed metrics need to be further evaluated. The evaluation should include the assessment of a large number of vehicles and an assignment of proposed compatibility metrics based on barrier crash test data and physical measurements. The resulting metrics should be evaluated by determining the extent to which they explain the aggressiveness characteristics observed in the on-the-road crash data.

The application of load cell barrier data provides valuable measurements for assessing the loading of vehicles in a crash. The metrics developed from barrier data needs to be evaluated against NASS/CDS and FARS data to assess the viability of the metrics, and their applicability to understand compatibility issues between the current vehicle fleet and existing roadside safety structures.

3.3 Application of Vehicle Characteristics

For this task, the relationship between vehicle characteristics, roadside hardware design characteristics and impact scenario are studied. Metrics such as vehicle mass, geometry (bumper height, sill height, and hood profile) and structural factors such as body type and stiffness can be used in combination to assess effectiveness of roadside hardware devices during impact. Ideally, design and performance corridors for vehicles and roadside hardware devices should be aligned to ensure optimal performance of highway systems during crashes.

The following full-scale crash tests (#472580-1 and #472580-2) were performed at the Texas Transportation Institute (TTI). During this testing, two different vehicles of similar size, class and mass impacted a W-beam guardrail under the same conditions yet resulted in drastically different post impact vehicle behavior. Tables 3.4 and 3.5 present general information regarding test vehicles and test configuration.

Vehicle 1:	1996 Ford Taurus:	Vehicle 2:	1995 Chevrolet Lumina
Mass:	1449 kg	Mass:	1505 kg
Speed:	99.5 km/h	Speed:	98.4 km/h
Impact Angle:	26.4°	Impact Angle:	25°
Test #:	472580-1	Test #:	472580-2
Length (m):	5.04	Length (m):	5.1
Width (m):	1.85	Width (m):	1.84
Height (m):	1.42	Height (m):	1.4
Wheelbase (m):	2.76	Wheelbase (m):	2.73

Table 3.4: Vehicle Specifications for TTI Test #472580-1 & 2

Barrier Specifications:	
Type:	Modified G4(1S) Strong Post
Installation Length:	53.4 m
Barrier:	W-beam (12 gauge)
Rail Length:	3.82 m
Post Spacing:	1.905 m (29 posts)
Post Length:	1.83 m
Blockouts:	140mm x 195 mm x 360 mm routed timber
Rail Mount Height:	550 mm
Anchorage:	BCT SKT-350

Table 3.5: Barrier Specifications for TTI Test #472580-1 & 2

The guardrail system used consists of a series of 2-Space W-Beam Guardrail sections each 4130 mm long. Steel wide-flange posts are placed 1905 mm apart (2 per section) and embedded in packed soil. Timber block-outs separate the post and the guardrail by 150 mm and are mounted using a single steel bolt through the block center. The guardrail system in pre-tensioned using a BCT Cable anchor assembly in conjunction with a strut and yolk assembly.

During the first test (#472580-1) where the impacting vehicle was a 1996 Ford Taurus, the guardrail provided adequate protection during the 25 degree impact. The vehicle was redirected without serious deformation to large parts of the vehicle structure or excessive deceleration of the vehicle in the longitudinal or lateral direction.

Conversely, the interaction of the Chevrolet Lumina and the W-beam system during test #472580-2 raises several questions regarding performance of this system. The Lumina impacted the barrier at approximately the same location as that described above (3 ft. before the thirteenth post of the complete barrier system). As the vehicle traveled longitudinally along the length of the W-beam, the first block-out released from the W-beam at its single attachment point similar to the Taurus test. Shortly following the release of the block-out, the front left corner of the vehicle reached the splice connection point between the thirteenth and fourteenth barrier sections (first and second contacted). At this time, an out pocketing of the steel W-beam is created and travels longitudinally along the rail until it reaches the splice section. This localized region of high deformation (and stress) is due to underlying structure that initiates a fracture that travels vertically from the bolt attachment point. With the failure of the W-beam, the vehicle intruded further behind the barrier and past the midline of the vehicle. Later, an off center frontal impact with the next post initiated rollover of the vehicle.

It has been hypothesized that similar vehicle mass, CG height and outer body dimensions would yield similar results during crash testing. For these tests, great care was taken during guardrail installation to produce repeatable barrier behavior. One remaining factor not eliminated by identical test conditions is vehicle structural properties. These include varying stiffness of underlying structural members (frame rails, engine configuration, drive train geometry, suspension characteristics, etc.) Using vehicle characteristics sited in Task 3 described in this report, differences that may have led to divergent test behaviors has been discovered.

Upon inspection of the underlying frame structure of both the Taurus and Lumina, it can be seen that geometric differences do exist. Figure 3.6 shows an overlay of schematics for the underbody structure of the two vehicles. Individual structural diagrams were obtained from the 2000 Mitchell Automotive Repair Database and images were subsequently overlaid. It can be seen that an upward distance of 12 cm exists between the lowest structural point of the forward frame structure (engine cradle) of the Chevrolet Lumina and the lowest structural point of the Taurus. In addition, the lateral location of the bumper mounts between the two vehicles indicates that the Lumina structure is 5 cm wider than the Taurus (i.e. mount points of the Lumina lie slightly outboard of the Taurus). Geometric characteristics of the Lumina show a reduced distance between the vehicle outer body and the hard point at the engine cradle mount point on the vehicle frame in the lateral direction. In other words, crush distance has been reduced in the lateral direction before direct interaction between structural members and adjacent hardware. In the vertical direction, the lowest structural point of the Lumina falls at nearly the same height as the bottom edge of the W-beam section as installed. This vertical and lateral location of this hard point creates a more favorable condition for loading at splice of the W-beam section. Upon examination of crash test footage, the tear in the W-beam appears to initiate along the lower portion of the rail at the first upstream bottom bolt of the splice and subsequently travels upwards. A larger area of vehicle/beam interaction may prevent this localized rail deformation. Also, reduced levels of outer body deformation of the vehicle may have a similar positive effect. This design for the front portions of rail structures is observed in other vehicle platforms; however, it is certainly not a common feature across all passenger vehicle structures.

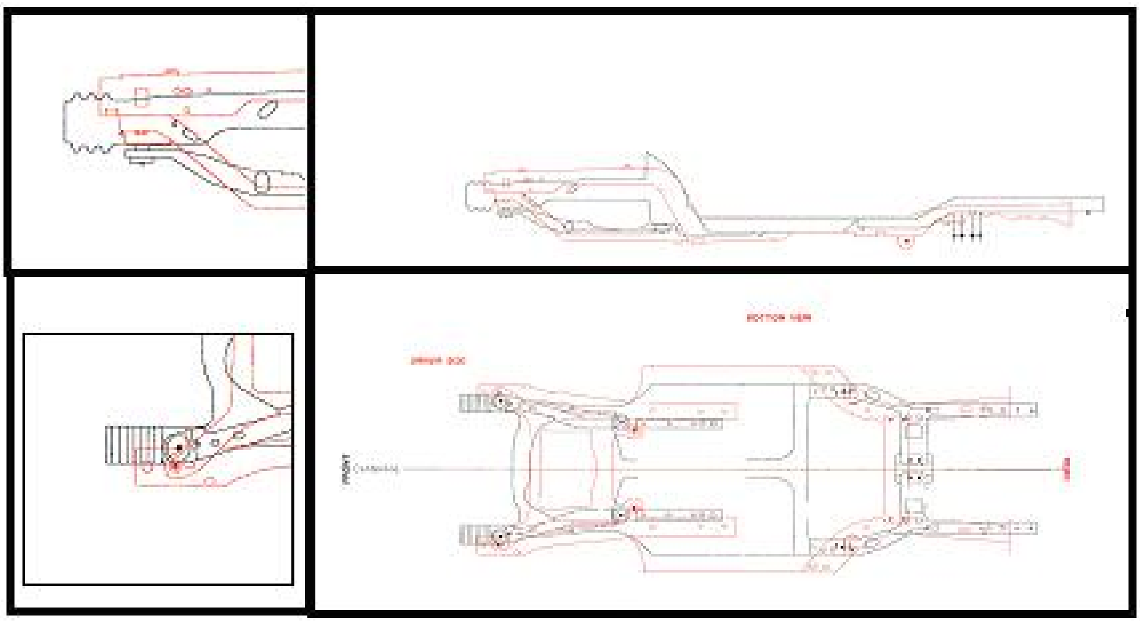


Figure 3.6: Overlay of Chevrolet Lumina (light) and Ford Taurus (dark) lower frame structures

(Permission for Reprint Given by Mitchell Automotive Repair, 2002)

Geometric factors are hypothesized to have an effect on the potential for W-beam failure during these impact conditions; however other influential structural differences exist between the two vehicles as well. Upon comparison of the frontal stiffness profiles outlined earlier in this report, considerable differences may be observed. Figures 3.7 and 3.9 below show stiffness levels across the frontal structure of each vehicle at increasing levels of vehicle crush. During interaction with guardrail systems or other similar longitudinal barrier devices, crush levels rarely exceed 10 inches. Accordingly, only stiffness profiles at 2 inches, 5 inches and 10 inches will be discussed.

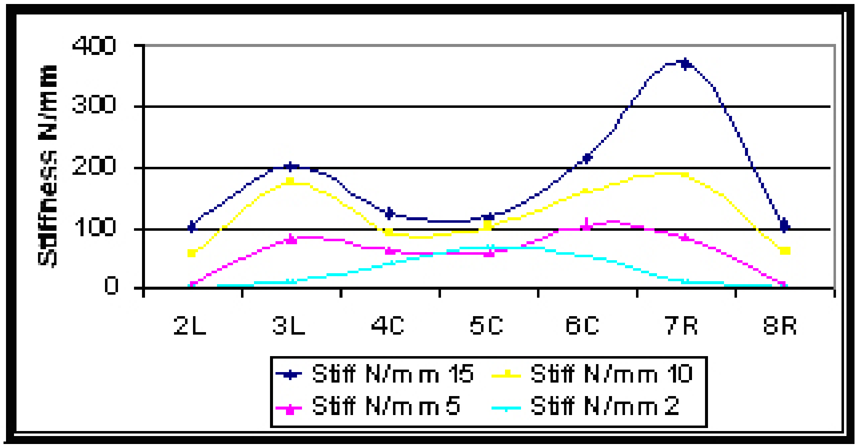


Figure 3.7: Ford Taurus Stiffness Profile

Figure 3.8: Ford Taurus Underbody- Post Crash

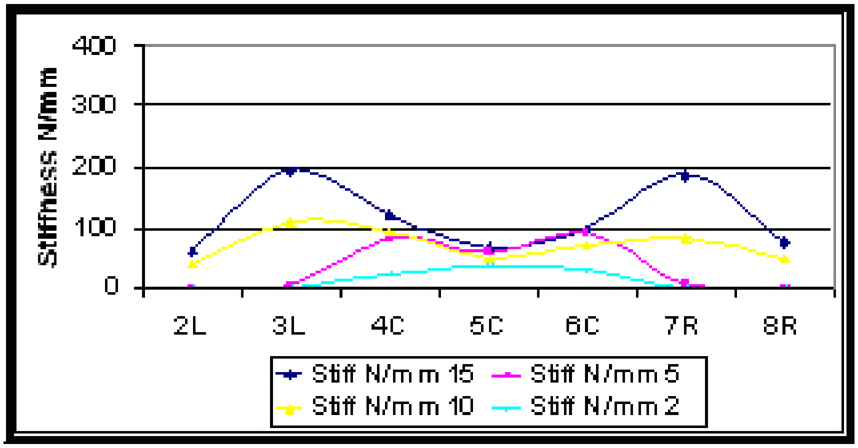


Figure 3.9: Chevrolet Lumina Stiffness Profile

Figure 3.10: Chevrolet Lumina Underbody- Post Crash

At 2 inches of crush, the stiffness profile of the Ford Taurus peaks at approximately 75 N/mm and the shape of the stiffness curve spans from the 3L location to the 7R column. For the Lumina, this curve peaks at 45 N/mm and spans a narrower region across the vehicle. Upon comparison, the differences in stiffness between the two vehicles indicate that the outer-body structure of the Lumina will deform more significantly than the Taurus. This difference should be more considerable at the most outboard regions of the vehicle face.

At 5 inches of crush, important differences become obvious. The stiffness profile for the Taurus, which peaks at 100 N/mm, is very broad spanning from the 2R level to the 8R level. It should be noticed that this high stiffness level evenly spans the entire front face of the vehicle. In comparison, the Lumina stiffness at this level of crush also peaks at nearly 100 N/mm but spans a much smaller percentage of the vehicle frontal structure, It spans from the 3L location to the 7R location. The implication of this during an oblique guardrail impact would be high levels of deformation of the outer body structure of the Lumina at the outboard regions of the vehicle. Deformation of this structure would expose a vehicle hard-point to the opposing guardrail structure. This, in turn, creates pocketing to the metal guardrail structure, a region of increased stress concentration and higher likelihood for failure of the W-beam. In order to expose the hard-point which exists beneath the outer body of the Taurus, a larger force in an oblique direction would be required.

It may be observed from the post impact photos shown in Figures 3.8 and 3.10 above, that the integrity of the front driver side structure of the Taurus remains intact throughout the test while significant deformation is observed in the frontal structure of the Lumina. This deformation exposes the underlying structural hard-point discussed previously. It should be noted that severe deformations along the centerline of the Lumina shown in the photos are the result of interaction with guardrail posts during and after beam failure. This interaction does not contribute to the failure of the system; however they indicate the severity of the resulting vehicle behavior leading to rollover.

In order to investigate the nature of the rail/vehicle interaction more closely, a finite element model of the Modified G4 (1S) systems was assembled. This model accurately represents all aspects of the barrier system including accurate ground properties and post interactions, accurate geometry and material properties of posts, block-outs and rails plus accurate bolts and other attachment hardware. Further, a model of the 1995 Chevrolet Lumina, created by EASi Engineering International in 1997 exists and has been combined with the Modified G4(1S) system for the simulation cases.

To understand the likelihood of rail failure during impact, stresses of each element within the W-beam have been monitored. High levels of localized stresses seen in the lower half of the W-beam section confirm excessive contact forces with the underlying engine cradle/frame hard-point.

A second simulation case was created where the Lumina structure impacted the guardrail section under identical impact conditions. For this case, the vehicle structure was rigidized so that the outerbody would not deform. This stiffening of the outerbody prevented the narrow underlying hardpoint from directly interacting with the W-beam structure. During this case, it was shown that the high levels of localized stress seen in the previous case were reduced to levels where material failure is unlikely. This type of analysis provides an opportunity to vary both vehicle and roadside hardware design characteristics to confirm hypothesized mechanisms and occurrences of incompatibility.

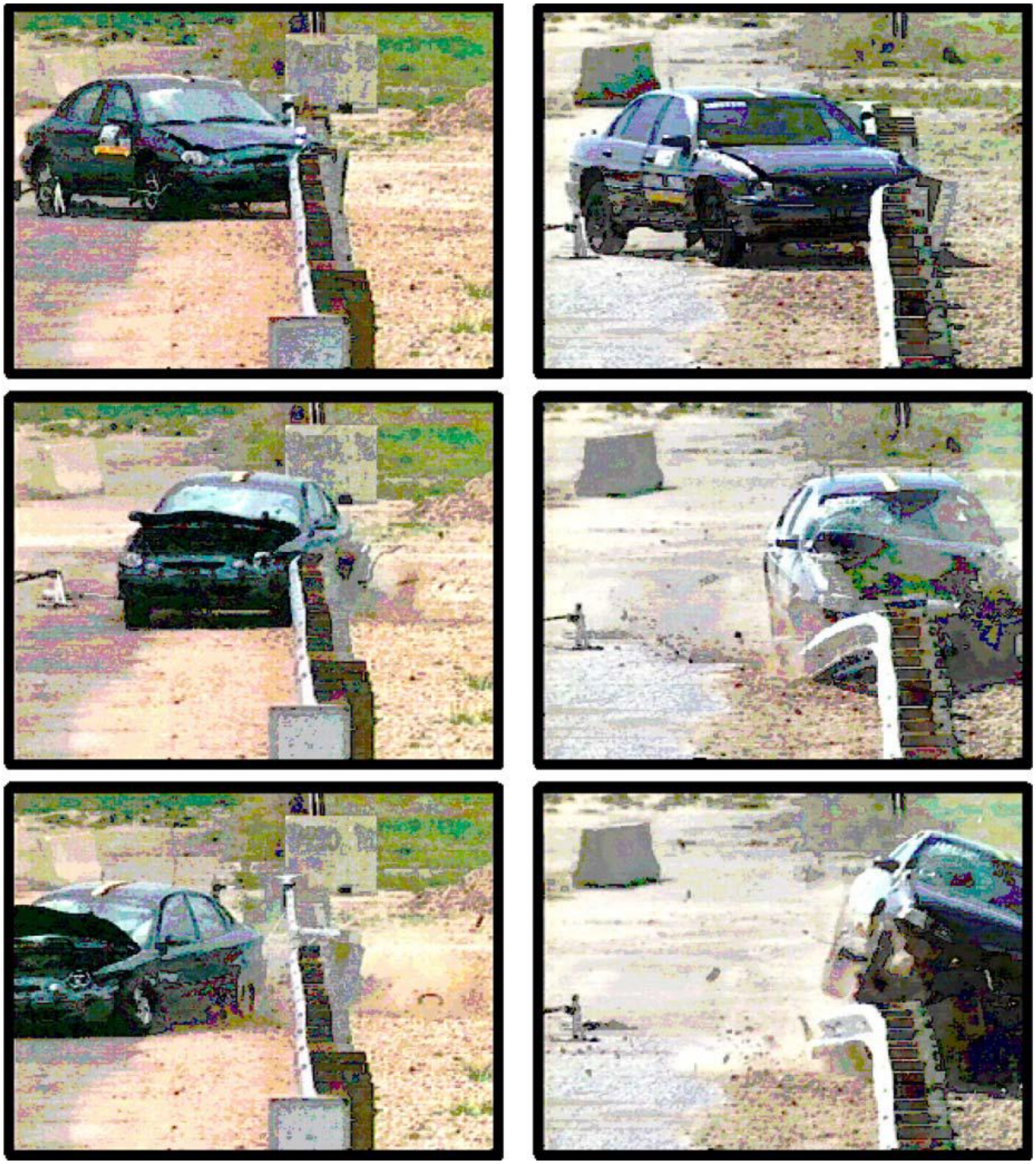


Figure 3.11: Interaction of Ford Taurus and Chevrolet Lumina impacting Modified G4(1S)

Chapter 4
Strategies to Improve Vehicle/Roadside Hardware Compatibility

Throughout the research period, a number of techniques and available data sources were used to evaluate compatibility between vehicles and roadside hardware systems. Findings presented in previous chapters offer some insight into existing compatibility issues. In this chapter, a number of future strategies to further improve compatibility were synthesized based on research discoveries and findings.

Overall, these strategies are as follows. Each of the following four sections overview suggested approaches and ideas to improve research in these areas. These include:

- Increasing awareness of roadside safety related organizations including vehicle manufacturers, DOT regulatory groups and roadside safety engineers regarding compatibility issues. This effort requires significant commitment from both automotive and roadside safety engineers to regularly communicate and work together to optimize both components of the roadside/vehicle system simultaneously.

- Improve current methods used to collect real world accident data so that future studies may benefit from improved information. Suggested data collection forms targeting roadside features are included here so that NHTSA's NASS Crash Investigators can consider their implementation.

- Proposed methods to improve test methodologies so that vehicle to roadside hardware compatibility can be better assessed using test results. This testing should include a wider yet non-excessive sample of vehicle platforms to better characterize vehicle interaction for the entire fleet. Methods to select these vehicles have been proposed using average vehicle characteristics compiled within Chapter 3.

- Initiating the use of advanced modeling techniques to isolate occurrences of incompatibility across an expanded group of vehicle platforms. As a supplement to testing or as a more cost effective method for verifying vehicle to roadside hardware, a protocol for the use of advanced simulation techniques should be implemented.

4.1 Industry Interaction and Workshop Findings

A workshop involving representatives from the automotive industry, Federal and State DOTs, roadside hardware manufacturers and other related groups was held to discuss roadside hardware compatibility issues. This open forum allowed relevant groups to learn about ongoing research and offer valuable suggestions to improve safety in this area. Attendees for the workshop and their affiliations are as follows:

1. Maurice Bronstad, Research Team Contractor- Dynatec Engineering
2. Monique Evans, Ohio DOT
3. Gene Buth, Texas Transportation Institute
4. Chuck Niessner, NCHRP
5. Daniel Godrick, Research Team- GWU
6. Steve Kan, Research Team- GWU
7. Leonard Meczkowski, FHWA
8. Michele McMurtry, NTSB
9. Paul Bedewi, Ford
10. Michael Griffith, FHWA
11. Stephen Maher,
12. Michael Cammisa, Alliance International Automotive Manufacturers
13. Ralph Hitchcock, Honda
14. John Laturner, E Tech
15. Richard Powers, FHWA
16. Harry Taylor, FHWA
17. Kennerly Digges, Research Team- GWU
18. George Bahouth, Research Team- GWU
19. Dhafer Marzougi, Research Team- GWU
20. Azim Eskandarian, Research Team- GWU

At the workshop, the nature of future vehicle characteristics in relation to roadside hardware and the expected safety implications were discussed. The workshop agenda also included the discussion of potential changes in technology affecting roadside hardware and design, e.g., new materials, new trends in manufacturability and assembly, and new federal and/or state initiatives affecting transportation policy.

This workshop initiated dialog and interaction between groups who do not typically communicate on such topics.

A primary feature of this workshop was the exchange of information between the roadside community and vehicle safety researchers/manufacturers. No forum currently exists in which vehicle manufacturers learn about observed performance of roadside systems in relation to their vehicle design features. Additionally, current Federal Motor Vehicle Safety Standards (FMVSS) do not mandate that new vehicles meet any minimum standards in terms of roadside hardware crash performance.

One overwhelming response and intended outcome of the workshop was the initiation of communication and further interactions of this type between the roadside safety and vehicle safety communities. Future collaboration between roadside researchers and vehicle manufacturers to address key workshop finding was proposed and efforts to begin this process is underway.

The workshop began with an overview of research presented by the GW Team. Following these presentations, a questionnaire was used to guide discussion on a variety of relevant topics. The exchange of ideas related to the proposed questions was found to be very valuable for the research team and other in attendance. Below, a summary of the discussion surrounding the questionnaire is given.

Note: The text below has been reproduced based on workshop discussions. This information contains opinions of the workshop attendees; however the accuracy and validity of the ideas have not been verified by the research team.

4.1.1 Accident Data Related Results

1. Midsize and large SUVs far exceed the car market regarding fatal rollovers during impact with guardrails. What is the reason for this?
    - SUVs differ from cars in center of gravity height, front overhang, width, wheelbase and height and therefore react differently with guardrails. In particular, the static stability factor (track width/(2*cg) is usually lower with these vehicles. i. It is more difficult to keep an SUV from rolling after it hits a guardrail. ii. Car based or Unibody constructed SUVs seem to have lower CGs and structures. Pickup based SUVs seem to have relatively higher CGs and structures.

- Driver behavior is a confounding issue. SUV drivers may behave differently than automobile drivers. Also, it may make sense to examine only driver fatalities to control for the fact that SUVs may transport more occupants. This characteristic has not been proven.

- It is impossible to say definitively that a barrier caused a rollover. It would be nice to know whether the SUVs rolled over before guardrail engagement or if the guardrail was a contributing factor to the rollover. Currently there is not enough granularity in the data (in some cases there is often not enough cases or data presented). i. In order to address this further, NASS data needs to be examined to see evidence where the outcome would have been different had a different guardrail been installed. These cases would have the most harmful collision with a guardrail.

- Impacts with guardrails are often difficult to test and computer simulations can help model the circumstances surrounding rollover. When doing a computer simulation of an SUV into a guardrail, a real world scenario must be modeled.

- In terms of frontal compatibility, the structure of the pickup trucks and SUVs needs to be lower to engage the current guardrails properly. Currently there is no bumper standard with SUVs (unlike cars). It is not necessary to lower the CG, just the vehicle structure so the vehicle can engage the guardrail. Ideally the guardrail and vehicle will distribute the forces since a more uniform distribution prevents penetration.

- In hardware tests that have been performed, the thrie-beam performed far worse for the pickup than the standard W-beam - although a modified (14 inch block in vertical plane added) thrie-beam performed well. Severe failures were found with G41S - even with wood block-outs. These tests may not have been indicative of real world conditions though. During these tests, it was found that higher barriers were not necessarily safer. Also, if changes are made for the pickup truck, this may lead to serious delta-v problems for small cars. Currently, no tests have been performed with an SUV in a 25-degree 100km impact.

- During rollovers, risk of ejection is high. This risk can be reduced with the introduction of side curtain airbags.

- Time is an important issue- in order to replace all of the guardrails in operation, it will take many years.

2. Large and compact SUVs were shown to have high fatality rates during impacts with concrete barriers.
    - Is there any evidence that higher safety shape (NJ or F) barrier might reduce this? i. Passenger cars would not benefit from the use of Jersey or F shape barriers. Taller barriers were not necessarily better since vehicles ride up and roll over these barriers ii. The concrete barrier held no advantage over guardrails when testing with SUVs iii. Higher barriers did have less intrusion into oncoming traffic.

    - Is there any evidence that the higher constant slope barriers reduce these fatality rates compared to the lower safety shapes? i. Vertical walls were best at preventing rollovers ii. Not much real world accident data exists about the type of barrier impact- either in police data or NASS. Some state DOT's have information, but police and accident investigators rarely examine the guardrails for failure. iii. To get more information it would be best to work with state highway inspectors and receive data and pictures. Another option would be to include more information in the NASS database.

3. Buckled guardrails have penetrated into passenger compartments of SUVs and pickup trucks. What causes this?
    - Guardrails have seams that break, and these exposed ends may lead to increased risk of intrusion.

    - When the end terminals of flexible longitudinal barriers penetrate vehicles, this may not be a compatibility issue. If it is a compatibility issue, it is difficult to determine whether the guardrail penetrated due to a vehicle issue or a guardrail issue.

4. Should guardrails be tested with mid-sized SUVs due to the high fatality rate of occupants in these vehicles involved in rollovers?

- Many of the fatalities were caused when people were ejected from the vehicle during a rollover. Also, since SUVs roll more without engaging a guardrail, the fatalities of occupants in mid-sized SUVs might not be a guardrail issue.

- The costs of testing roadside hardware with SUVs are potentially high. SUVs are expensive to buy as used vehicles. The SUV category falls within the range of the small car to large pickup.

- Installation problems are larger issues. The installation is often performed improperly due to terrain constraints and the training of the construction crew.

- Tests of popular guardrails should be run with SUVs - such as a 25-degree impact to see how they perform in these impacts.

5. Due to the significance of the compact SUV fatality rate, should testing with a compact SUVs replace the 820 kg car for redirection tests?
    - Previous tests show these vehicles pass the redirection tests and during testing have demonstrated that they are not necessarily less stable than a passenger car (vehicle characteristics do not support this claim however). Compact SUVs do have potential snagging issues though.

6. Do the current 2000 kg pickup truck and 820 kg car adequately represent the range of high sales vehicles?
    - These vehicles are satisfactory given the budget considerations. The categories of small car and large truck encompass most vehicles. However, testing end terminals with different classes may be worthwhile. In addition, computer analysis can be used to reduce the cost and possibly test more vehicles.

4.1.2 Assessment of Vehicle Compatibility

1. What are your thoughts on the available data sources to search for compatibility issues?

- More granularity is needed in the accident data in order to know what to test. Anecdotal evidence can be used to determine where the issues lie. The NASS cases can be investigated to show where vehicles are having engagement issues.

- Full-scale tests are good for finding compatibility issues, however these are costly therefore more than one platform is rarely tested.

- Computer simulation is also good at unearthing issues, and it is cheaper than full-scale tests.

2. How can the accident data be improved to assess the performance of roadside hardware?
   - Better granularity is needed in the accident data (i.e. type of barrier hit/ end treatment was used?) Pictures are also valuable tools in investigating accidents and should be included whenever possible. This is something that should be brought up to NASS.

   - It would be interesting to take an inventory of currently used roadside hardware and evaluating the real world performance.

3. What improvements can be made to full scale crash tests?
   - Dummies could be used, although this increases the number of factors that are being tested and increases that cost of the test. Since cost considerations limit the amount of tests than can be run and analyzed, the inclusion dummies might limit the amount of tests that could be run.

   - It is theorized that event data recorders would also give more information into what is happening in real world scenarios. With this information more realistic tests can be created. It was indicated that roadside crash events often have a very long duration. For that reason most EDRs do not capture enough information to make their data useful.

   - Computer simulations can test different configurations. Since these are possibly cheaper than full-scale crash tests, more scenarios can be run.

4. Can the design of barrier systems be modified to allow for improvements in airbag systems?
    - If airbags and dummies are used, is it a vehicle or a guardrail test?
    - If airbags are considered in guardrail development, the guardrails may be made stiffer rather than softer. This might have unintended negative consequences. However, if the hardware is made too soft, it might complicate airbag firing logic leading to less sub-optimal firing during a collision.

5. What are vehicle characteristics that may have an impact on guardrail performance?
    - The vehicle height (especially the height of the front structure) influences how the vehicle engages the guardrail. Also the frontal overhang of the vehicle affects the potential for snagging of the front wheel and guardrail engagement. The center of gravity and yaw moment of inertia also have an impact since these characteristics determine how the vehicle yaws and rolls. Side curtain airbags may help the occupants inside of the vehicle. In addition, ABS and other vehicle handling countermeasures like Dynamic Stability Control (DSC) may help vehicles from engaging the guardrails altogether.

4.1.3 Policy Issues Regarding Compatibility

1. What is the best course to take with regards to compatibility?
    - More communication within the industry of the vehicle manufacturers and hardware creators. If the hardware test is a failure, it is hard to tell if this failure is fault of the vehicle or the hardware. Often the test failures can be attributed to several different causes. Therefore it is important to change the mindset from vehicle versus hardware to vehicle and hardware working together to reduce the severity of these accidents.
    - The ideal scenario would use a broad range of vehicle models to test compatibility with hardware.
    - Passenger cars usually have no problems with guardrails since these vehicles have standard frontal structure requirements. Since SUVs do not have standard frontal structure requirements, the guardrail design for these vehicles is made more difficult.

2. What is the best way to resolve hardware concerns?
    - It would be good for FHWA to rate hardware like NHTSA rates new cars. In order to do this, a grading system needs to be developed where devices are judged on a scale opposed to current criteria where each device passes or fails at a given test level. These grades could be arrived at using data including occupant (dummy) injury values in addition to current vehicle acceleration, dynamics and deformation criteria.
    - There are 2 types of barriers - those that absorb energy and those that break away. Because of this, the designs need to evaluate based on performance. In particular, "In service performance" needs to be monitored to examine how well the designs are performing in real world accidents. Also, since no state wants to pay too much for roadside hardware, cost is of utmost concern.
    - Formal and informal communication in the industry and government is necessary to ensure that both parties are moving in the same direction regarding vehicle to guardrail impacts.

4.1.4 Computer Simulation

1. How much faith do you have in computer simulation and its ability to identify roadside safety problems?
    - Models are validated and perform with 80-90% similar responses, but the timing of guardrail rupture is still a shortcoming.
    - Currently, the validation of wood and soil models is underway.
    - FHWA has confidence in modeling as a prediction tool. It is a good way to see what should be tested and as a supplemental source of data from the tests.

2. What role should simulation have in the NCHRP report 350 update?
    - It is a tool that definitely should be used to help choose vehicles for future tests.

- It is a less expensive approach to examine the existing vehicle platforms used.
- At the very least, it should be used as a first step in the research before full scale tests are performed.

3. Are 6-year-old vehicle models OK for tests?
   - Yes. The designs of vehicle structures has not changed dramatically within this period of time, however, vehicle fleet populations (relative numbers of small passenger cars vs. large cars vs. SUV's vs. Pickups) can drastically change within this period.

4. What should be the basis of vehicle selection?
   - Models should be made based on sales of the platform. The more common vehicles should be modeled and tested.
   - The mid-sized vehicle classes need to be updated and simulated based on characteristics of real world accidents (impact angles, yaw angles, speeds, etc.)

5. What are the challenges for side impact simulation?
   - Side impacts leave less room for energy absorption. Therefore it is necessary to look in the accident data to determine typical impact speeds that cause injuries.

Conclusions and Future Steps

This workshop showed that dialog between the automakers and the roadside hardware creators was valuable to share ideas regarding vehicle to guardrail impacts. More workshops like this were seen as an effective way to disseminate information to all parties interested in reducing the severity of vehicle to roadside hardware collisions. A formal committee should be put into place, possibly within SAE, that directly addresses these issues on an on-going basis.

In order to determine if there is a true compatibility problem, steps should be taken to not only get more data surrounding accidents with roadside hardware, but also to get more out of the data that is currently available.

With increased support, more modeling can be done to address the problems of vehicle compatibility with guardrail systems. Test methods, vehicles and criteria can be evaluated to understand if the tests truly assess the compatibility of guardrails with the most appropriate segments of the US vehicle fleet.

4.2 Crash Data Collection

Accident databases that provide some insight into vehicle compatibility were evaluated in this study. The Fatality Analysis Reporting System (FARS), National Automotive Sampling System / Crashworthiness Data System (NASS/CDS) and the Highway (HSIS) databases were reviewed. It is believed that no database that exists today provides a large and complete enough data set to confidently identify compatibility issues. Clearly, as identified in other sections of this report; another try in this important area is warranted.

Of each database reviewed, the NASS/CDS system contains the most complete and relevant information to assess vehicle to roadside hardware compatibility occurrences however a series of shortcomings remain.

Current NASS/CDS data collection procedures focus on crash causation, vehicle handling, vehicle crashworthiness, restraint system performance, occupant characteristics and injury outcomes. Currently, over 500 crash variables are collect for the sampled crashes described above, however little attention if given to roadside attributes and safety systems.

In order to adequately characterize roadside crash dynamics, suitability of installation configurations and compatibility of vehicles with roadside systems it appears that a large collection of additional variables must be considered to improve the NASS System for use by the roadside safety community for compatibility investigation.

In 1983, a research project, known as the Longitudinal Barrier Special Study(LBSS), was initiated to collect additional data for NASS collected barrier crashes[29]. Additional variables were added to the NASS systems and NASS investigators were trained to collect these variables related to roadside systems. The study was successful in determining relevant information for a limited population of roadside events, however the large number of data points collected and corresponding high cost of such collections lead to the eventual termination of the study.

During statistical evaluation of NASS data during data collection years following the LBSS, it was found that critical crash attributes necessary to conduct accurate analyzes were missing from the CDS coded variables. These variables include pre-impact dynamics of vehicles that interact with roadside hardware systems, barrier characteristics and resulting barrier interaction/performance. Further, the concept of improper installation of barrier systems must be addressed during accident investigations.

It is believed that this additional information should be gathered by NASS investigators if possible. The use of electronic photos with sufficient detail to post process case information collected is one method to significantly increase information collected while limiting time spent in the field by accident investigators. Items including barrier designs, dimensions and deformations may be extracted from photos by a roadside expert at the completion of NASS investigation. This approach would require improved photos with geometric indicators (measurement guides/rulers) and adequate labeling.

A number of practical considerations remain regarding roadside investigations as well. These relate to current practices used by NASS investigators and safety concerns related to on-road investigations.

Many roadside crash events occur on state roads and busy highways. In order to perform the necessary evaluations of the crash scene, investigators would be exposed to dangerous environments in some cases. This was evident during the investigation of individual cases shown in Chapter 2. Many photos were "drive by" shots of accident scenes because it was not possible to walk to the impact location.

Another issue concerning barrier interactions involves the timeliness that the crash scene is reviewed by investigators. Often state DOTs repair barrier sections and impacted devices before the arrival of accident investigators. The process for selection and inclusion is outline in the NASS/CDS coding manual. It involves preliminary review of the police accident report to determine if it is eligible for study inclusion by the PSU. This process may occur in as little as one day but up to two weeks from the time of the crash. On average investigation occurs 1-2 weeks from the crash event and in some cases, limited deformed barrier data can be collected.

The following forms have been created based on information found lacking in current NASS/CDS Cases for roadside safety investigations and using the Longitudinal Barrier Special Study (LBSS) data collection forms which were previously developed. A number of variables and sections have been eliminated which were found to be of limited importance for compatibility evaluation. These forms are proposed as a starting point for improved collection strategies for NASS/CDS investigations.

NCHRP 22-15 Proposed Roadside Form

NASS/CDS Data Collection Format

I. Header Variables

1. Primary Sampling Unit Number _________
2. Case Number- Stratification _________
3. Record Number _________
4. Investigator I.D. _________
5. Accident Year _________

II. Location Data

6. State _________
7. County _________
8. Route Number _________
9. Mile-point _________
10. Transaction Code _________
11. Investigator I.D. _________
12. Accident Year _________

III. Impact Sequence Data

*See current NASS/CDS Accident Form Shown in Appendix C of this report

13. Indicate Objects Impacted (from column 2 list) and Associated Event Sequence Number as shown in Form A.2 (Variable 29)

Object Number	Sequence Number
(1)______________	________________
(2)______________	________________
(3)______________	________________
(4)______________	________________
(5)______________	________________
(6)______________	________________
(7)______________	________________
(8)______________	________________
(9)______________	________________
(10)_____________	________________

14. Total Number of Longitudinal Barrier Impacts
____ (0)-(6) Code Actual Number of Barrier Impacts
____ (7) 7 or more
____ (9) Unknown

Vehicle Number or Object Contacted Codes
(01-30) - Vehicle Number

Non-collision
(31) Overturn - rollover (excludes end-over-end)
(32) Rollover - end-over-end
(33) Fire or explosion
(34) Jackknife
(35) Other intra unit damage (specify): ___________
(36) Non-collision injury
(38) Other non-collision (specify):________________
(39) Non-collision - details unknown

Collision with Fixed Object
(41) Tree (< 10 cm in diameter)
(42) Tree (> 10 cm in diameter)
(43) Shrubbery or bush
(44) Embankment
(45) Breakaway pole or post (any diameter)

Non breakaway Pole or Post
(50) Pole or post (< 10 cm in diameter)
(51) Pole or post (>10 cm but < 30 cm in diameter)
(52) Pole or post (>30 cm in diameter)
(53) Pole or post (diameter unknown)
(54) Concrete traffic barrier
(55) Impact attenuator
(57) Fence
(58) Wall
(59) Building
(60) Ditch or culvert
(61) Ground
(62) Fire hydrant
(63) Curb
(64) Bridge
(68) Other fixed object (specify):________________
(69) Unknown fixed object

Collision with Non-fixed Object
(70) Passenger car, light truck, van, or other vehicle not in transport
(71) Medium/heavy truck or bus not in-transport
(72) Pedestrian
(73) Cyclist or cycle
(74) Other non motorist or conveyance
(75) Vehicle occupant
(76) Animal
(77) Train
(78) Trailer, disconnected in-transport
(79) Object fell from vehicle in-transport
(88) Other non-fixed object (specify):_____________
(89) Unknown non-fixed object
(90) Traffic barrier (includes guardrail)
(91) Barrier End Terminal
(99) Other event (specify):_____________________

Figure 4.1: Proposed General Form, Roadside Crashes

NCHRP 22-15 Proposed Roadside Form
NASS/CDS Data Collection Format

I. General Roadside Form

1. Impacted Device
____ (0) None
____ (1) Deformable Guardrail
____ (2) Other Deformable Barrier
____ (3) Concrete Barrier
____ (4) Bridge Rail
____ (5) Longitudinal Barrier End Terminal
____ (6) Barrier Transition
____ (7) Crash Cushion
____ (8) Other (specify___________________)
____ (9) Unknown

2. Location of Feature (in direction of vehicle travel)
____ (0) Impact conditions not applicable (see manual)
____ (1) Off left side of roadway
____ (2) Off right side of roadway
____ (3) Other (specify___________________)
____ (9) Unknown

3. Impact Angle (è 1- angle formed by longitudinal axis of vehicle and primary axis of feature)
____ (00)-(90) Code Actual Angle in Degrees
____ (99) Unknown

4. Separation Angle (è 2- angle formed by longitudinal axis of vehicle and primary axis of feature at last contact)
____ (00)-(90) Code Actual Angle in Degrees
____ (99) Unknown

5. Vehicle Yawing Angle at Impact(è 3- angle formed by direction of vehicle travel and longitudinal axis of vehicle)
____ (000)-(180) Code Yawing Angle in Degrees
____ (999) Unknown

6. Vehicle Rotation at Impact (ù 1-about vehicle vertical axis)
____ (1) No
____ (2) Yes
____ (9) Unknown

7. Run length of impacted treatment section
____ (00) Not Applicable
____ (01-29)Estimated Distance in Meters
____ (30) Greater than 30 meters
____ (99) Unknown

8. End Treatment Type
____ (0) None
____ (1) BCT
____ (2) Free End
____ (3) Turned Down End
____ (4) Cable with Concrete Anchor
____ (9) Unknown

9. Impact Speed (derive based on vehicle/barrier deformation)
____ (01-98)Code speed in km/h
____ (99) Unknown

10. Treatment Performance
____ (1) Vehicle Redirected by Treatment
____ (2) Vehicle snagged/pocketed by treatment
____ (3) Vehicle overrode treatment
____ (4) Vehicle vaulted treatment
____ (5) Vehicle Penetrated Treatment
____ (6) Vehicle contained by treatment
____ (7) Other (specify___________________)
____ (9) Unknown

11. Post Impact Vehicle Trajectory
____ (1) Vehicle remained on roadside
____ (2) Vehicle returned to roadway
____ (3) Vehicle crossed roadway/ran off opposite side
____ (4) Vehicle crossed median other travel way
____ (5) Vehicle remained on top of, went over or through treatment
____ (6) Other (specify___________________)
____ (9) Unknown

12. Curb Type/Presence
____ (0) No curb present
____ (1) Barrier curb
____ (2) Mountable Curb
____ (3) Other (specify___________________)
____ (9) Unknown

13. Curb Height
____ (0) No curb present
____ (00)-(49) Code actual curb height to nearest cm.
____ (0) 50 cm. or higher

14. Perpendicular Distance from Curb to Struck Feature
____ (0) No curb present
____ (000)-(996) Actual distance to nearest cm
____ (997) 25 meters or greater or greater
____ (999) Unknown

15. Height of Treatment Relative to Roadway Edge
____ (-97) -97 cm or higher
____ (-96)-(96) Code actual height of treatment relative to roadway edge to the nearest cm.
____ (97) +97 cm or higher
____ (+99) Unknown

Figure 4.2: Proposed General Form, Continued

NCHRP 22-15 Proposed Roadside Form
NASS/CDS Data Collection Format

16. Treatment Height
____ (-97) -97 cm or higher
____ (-96)-(96) Code actual height of treatment to the nearest cm.
____ (97) +97 cm or higher
____ (+99) Unknown

17. Normal Treatment Height if different from height at impact point
____ (00) Constant height
____ (00)-(99) Actual height in cm.
____ (99) Unknown

18. Treatment Damage
Refer to the diagram below for recording of field measurements on barrier damage.
____ Length of Contact Damage in meters (Ld)
____ Length of Induced Damage in meters (Li)

19. Maximum Depth of Treatment Deformation
____ (0) No deformation
(ie. Minor scrapes, paint transfer)
____ (000)-(999) Code actual deformation in cm.

Figure 4.3: Proposed Longitudinal Barrier Data Form

NCHRP 22-15 Proposed Roadside Form
NASS/CDS Data Collection Format

Longitudinal Barrier Form

Complete this section for each impact involving a longitudinal barrier. (if multiple impacts with a barrier type take place, relative location by vehicle number should be indicated by sequence number for item 1 below.)

Code this form for the following Longitudinal Barrier Types
- a. Guardrails
- b. Median Barriers
- c. Bridge Rails

2. Sequence number of Impact with Longitudinal Barrier
____ (01)-(98) Code impact sequence number
____ (99) Unknown

3. Beam Type
____ (0) N/A- No Beam
____ (0) Cable
____ (0) “W” Beam
____ (0) Box Beam
____ (0) Aluminum Extrusion
____ (0) Thrie Beam
____ (0) Other (specify_________________.)
____ (0) Unknown

4. Beam Material

5. Beam Dimensions

6. Post Shape

7. Post Material
____ (0) Wood
____ (0) Steel
____ (0) Aluminum
____ (0) Concrete
____ (0) Fiberglass/Composite
____ (0) Plastic
____ (0) Other (Specify)

8. Blockout Type

9. Blockout Material
____ (0) Wood
____ (0) Steel
____ (0) Aluminum
____ (0) Concrete
____ (0) Fiberglass/Composite
____ (0) Plastic
____ (0) Other (Specify)

10. Post Spacing (center to center)
____ (0) N/A- No Posts
____ (0) Record actual distance from center to center in meters.
____ (0) 30 meters or greater
____ (0) Unknown

11. Post Dimensions

12. If the post spacing at the point of initial impact is different from that of the normal section of the barrier, record the normal spacing below to the nearest cm. Code the post spacing at the point of initial impact for variable B45

13. Concrete Barrier Type
____ (0) N/A- Not a Concrete Barrier
____ (1) Concrete Safety shape (indicate profile dim. cm.)
____ (2) Vertical Wall
____ (3) Constant Slope Barrier
____ (8) Other (provide sketch with dimensions)
____ (8) Unknown

14. Concrete Barrier Dimensions
____ (000) No Concrete Barrier
____ Vertical Rise
____ Lower Slope
(999) Indicates unknown quantity

15. Permanent Barrier
____ (0) N/A- Not a Concrete Barrier
____ (1) Moveable Barrier (in workzone)
____ (1) Permanent Barrier

16. Portable/Moveable Barrier Connections
____ (0) N/A- Not a Moveable Barrier
____ (0) No Connections
____ (0) Pin and loop with fastening nut
____ (0) Pin and loop with no nut
____ (0) Pin and loop with fastening nut /w spacer
____ (0) Tongue and groove
____ (0) Fastening Plate
____ (0) Top C-Channel

Figure 4.4: Proposed Crash Cushion Data Form

NCHRP 22-15 Proposed Roadside Form
NASS/CDS Data Collection Format

End Treatment/Crash Cushion

Complete this section for each impact involving an end treatment or crash cushion. (if multiple impacts with a barrier type take place, relative location by vehicle number should be indicated by sequence number for item 1 below.)

1. Sequence number of Impact with End Treatment/Crash Cushion
____ (01)-(98) Code impact sequence number
____ (99) Unknown

Barrier end-treatment/crash cushion Dimensions

2. Upstream End Treatment Type
____ (0) N/A- Impact not with Barrier End
____ (0) Blunt
____ (0) Non-Breakaway Cable Terminal
____ (0) Turndown
____ (0) Breakaway Cable Terminal (BCT)
____ (0) Anchoring to backslope
____ (0) Attached to parapet wall/bridgerail/abutment
____ (0) Best
____ (0) ET-2000/ ET-Plus
____ (0) FLEAT
____ (0) SKT
____ (0) SENTRE
____ (0) TREND
____ (0) MELT
____ (0) ELT
____ (0) REGENT
____ (0) SRT 350
____ (0) WYBET 350
____ (0) MELT
____ (0) VT Lowspeed
____ (0) Quad Trend 350

1. Crash Cushion Type
____ (0) Sand Barrels
  ____ (0) Number of Barrels
____ (0) Great
  ____ (0) Number of Bays
  ____ (0) Material (1,2,3)
____ (0) Quad Guard
____ (0) Number of Bays
____ (0) Material (1,2,3)
____ (0) React 350
____ (0) CAT 350
____ (0) Brake Master
____ (0) CTAS
____ (0) TRACC
____ (0) ABSORB 350
____ (0) DRAGNET
____ (0) Other (specify_____________)
____ (0) Unknown

2. Location of End Treatment (in direction of vehicle travel)
____ (0) N/A- Impact not with Barrier End
____ (0) Upstream
____ (0) Downstream
____ (0) Other (specify_____________)
____ (0) Unknown

3. Distance From End Treatment to Initial Point of Impact
____ (0) N/A- Impact not with Barrier End
____ (0) Impact with barrier or within .5 meters of barrier
____ (01)-(96) Code Actual Distance to nearest meter
____ (99) Unknown

4. Length of Flare

5. Flare Offset

6. Performance
____ (0) N/A- Impact not with Barrier End
____ (0) Vehicle came to rest in contact w/ treatment)
____ (0) Vehicle redirected by barrier
____ (0) Energy absorbing stage in mid-stroke
indicate stroke amount __________cm

Figure 4.5: Proposed End Treatment Data Form

In order for NASS/CDS investigators to accurately distinguish specific crash cushions, barriers and end treatments, additional training in this area is necessary. Alternatively, a requirement for clear labeling on each device may facilitate data coding required by proposed Figure 4.5.

4.3 Crash Test Methodology

Crash test results allow detailed evaluations of vehicle interaction with impacted roadside devices. The crashworthiness performance of roadside structures is currently is determined through crash testing according to the procedures of NCHRP Report 350 [38]. The number of required tests varies with the device ranging from 2 for longitudinal barriers, supports structures, and TMAs to 7 for terminals/crash cushions. A number of different Test Levels (TLs) are specified in Report 350. The number ranges from 6 for longitudinal barriers to 2 (TL 2 and 3) for terminals and crash cushions, support structures, and truck mounted attenuators.

Currently, the basic test level (TL-3) and TL-2 require testing with a 820 kg car and a 2000 kg pickup. Higher test levels also use larger vehicles including an 8000 kg 2 axle truck, a 36,000 kg tractor/van trailer and a 36,000 kg tractor/tanker trailer. Report 350 recommends various geometric property ranges for the test vehicles for each test that provide some uniformity in vehicles used.

The crash tests are conducted using a very limited number of vehicles that are not more than 6 years old. For economy of testing, it is not surprising that vehicles near the age cut off are normally used. This practice may be a significant contributor to the lag in roadside device improvement when compared with the rate that new vehicle platforms emerge.

Current test methods do not include representations of occupants. Largely the longitudinal and lateral acceleration limits are designed to limit the severity of loading experienced by occupants. As new occupant restraint systems emerge including advanced frontal and side impact airbags, plus pretensioned and force limited belt systems, the crash environment will change significantly.

In the case of longitudinal barrier design, increasing stiffness to avoid vehicle pocketing and penetration would have a divergent effect. First, barrier penetrations and deformations such that vehicle override becomes possible will be avoided. However, lateral accelerations during vehicle redirection following impact with a stiff barrier could increase injury risk for occupants. Newly emerging side impact airbags and improved energy absorbing vehicle side structures may mitigate the effects of this increased risk. Without the use of human surrogates during testing and analysis, the true nature of occupant loading and injury risk cannot be quantified.

Similarly, airbag systems may not be well designed to trigger during oblique impacts at low angles with longitudinal barriers. If late deployments occur after an occupant has move out of position, the resulting interaction with a deploying airbag could have harmful effects. Human surrogates and/or close attention to airbag deployment timing is necessary to understand this phenomenon.

At this time, an effort to update NCHRP Report 350 has begun. Many of these issues discussed above should be addressed by future updates in some way. Based on current indications, specific areas to be addressed include the following:

- Test vehicles used
- Number of tests
- Transition/Temporary Barrier Test Conditions
- Higher Test Speed Reflecting 70-75 mph Speed Limits
- TMA Crash Test
- Occupant Risk
- Occupant Compartment Intrusion
- Soil Specification
- Side Impact Requirement

4.3.1 Test Vehicle Selection

During this project, definite behavioral trends were observed when comparing vehicle response during impacts with roadside devices. It was determined that pickup trucks do not represent the behavior of SUVs adequately during all impact conditions. Further, the compact car category does not represent a significant population of vehicles on the roads today and therefore its use should be reconsidered. Rather, one vehicle per identifiable class should be selected for crash testing. Although this approach would greatly increase the number of tests required, the benefit in terms of lives saved and injuries reduced would greatly outweigh the financial implication of more tests.

Table below provides information regarding vehicle characteristics for a series of vehicle classes. Those classes include compact, mid-size and large cars and SUVs. Compact/full-size pickups as well as mid-size and large vans. The vehicle which most closely resembles the weighted average vehicle for its class should be considered during selection of future test vehicles. This vehicle may not be the most popular, yet behavior during crashes with roadside structures would represent the mean characteristics exhibited by its class.

Type	Class	Length (in.)	Width (in.)	Height (in.)	Wheel Base (in.)	Curb Weight (lb)	Front Bump Ht. (in.)	Front Overhng. (in.)
Car	Compact	168	65	53	96	2380	11	35
	Midsize	187	70	53	104	3160	11	39
	Large	206	74	55	114	3832	12	41
Pickup	Compact	187	67	64	113	3039	15	31
	Large	213	77	71	132	4269	18	34
SUV	Compact	158	66	67	95	2849	13	28
	Midsize	178	70	69	105	4022	17	31
	Large	196	78	73	116	4908	16	34
Van	Midsize	187	72	67	112	3548	10	36
	Large	200	78	78	121	4427		33

Table 4.1: Average population weighted vehicle characteristics per class

A second approach to selecting a set vehicle platforms for future testing would be through a review of vehicle whose characteristics lay at the extremes of each vehicle class. Those extremes may fall at the high or low end depending on the probable worst case per test. Appendix B of this report contains all specifications for all vehicles surveyed. A quick search of these parameters would provide an indication of the vehicle platform whose specifications place it at the extreme of each group. This philosophy resembles the current approach taken during the selection of future test vehicles.

4.3.2 Occupant Representation During Crash Testing

Federal Motor Vehicle Safety Standards (FMVSS) require that both active and passive restraint systems provide a minimum level of protection for belted and unbelted occupants. These standards have lead to the introduction of frontal driver and passenger airbags in all new vehicles and a rapid growth in the population of side impact airbag equipped vehicles.

The presence of these newly emerging restraint systems in roadside crash involved vehicles may lead to vastly different occupant injury potential however their effects have not been studied. Early development of test criteria shown in NCHRP Report 350 considered only unbelted occupants who were not protected by airbag systems. The fail space model, currently used during roadside testing, limits loading through vehicle lateral and longitudinal accelerations. In addition, this model allows an occupant compartment intrusion. Although these criteria may still correspond with reasonable injury thresholds, the effect of countermeasures between the accelerating vehicle and the occupant must be further evaluated using human surrogates (dummies) during crash testing.

Due to the nature of off angled impacts with deformable longitudinal barriers, one concern regarding airbag system function is their ability to sense an impact event before any occupant excursion or motion takes place. In other words, if a weak longitudinal crash pulse results following a crash with a barrier system, an occupant may move towards the steering wheel, A-Pillar or side glass before an airbag is triggered. If later during the crash the vehicle is suddenly decelerated, the airbag may then deploy. This would result in an out of position airbag deployment where occupant injury risk may be higher than during typical deployments. The possibility of these conditions must be evaluated. However current test procedures do not provide sufficient information to determine occupant kinematics during crashes. Full scale testing using instrumented human surrogates is required.

4.4 Application of Computer Simulation

The maturities of Finite Element (FE) simulation using codes like LS-DYNA now make it possible to use highly complex computer models to investigate compatibility issues. In 1995, FHWA created a consortium of university research centers to develop accurate models of roadside structures. Since that time, developed FE models have been used to evaluate and improve roadside hardware design safety. Similarly, both FHWA and NHTSA have supported the development of highly detailed vehicle models for a variety of uses.

These models and those that may be provided by vehicle and roadside safety manufacturers provide a wide ranging opportunity for investigations of vehicle/roadside hardware compatibility. One strategy to recognize potential occurrence of incompatibility would be to exercise all available roadside models with all available vehicle models to assess overall performance. To date, the only vehicles used for roadside hardware simulation studies have been limited to those specified by NCHRP report 350 requirements.

An aggressive effort by FHWA and NHTSA is recommended to maximize the number of computer models for vehicles and roadside safety features. A judicious selection process for future models developed will allow continuous monitoring of different classes of vehicles interaction with different roadside safety features.

Another approach to improving compatibility would be through joint studies by FHWA and vehicle manufacturers to evaluate the performance of newly emerging vehicle platforms with the most commonly installed roadside devices. NHTSA or FHWA could request that each manufacturer provides FE models for a selection of their passenger vehicles. At the same time, FHWA could require that FE models of each public or proprietary roadside device be delivered upon approval for use in the NHS system.

The process for creation and validation of these models has evolved sufficiently that any manufacturer producing roadside hardware features fit for use on US roadways should not find model creation prohibitive. Further, the safety importance of these devices should not be overshadowed by resource constraints of private and public companies developing these devices. The Centers of Excellence could be utilized when necessary to create and/or analyze features and their performance with emerging vehicles.

In the event that such an ideal partnership proves to be unattainable, more modest efforts using The Centers of Excellence and other sources could be used to reduce the reliance on expensive crash tests and accident data collection/analysis. These efforts would involve exercising currently available vehicle and roadside hardware models to simulate a variety of impact scenarios and identify potential compatibility issues. Furthermore, some of the previously identified vehicle characteristics, which could potentially lead to incompatibilities, can be changed in the computer models to understand their effects on the crash outcome. A list of currently available vehicle and roadside hardware models, which could be used for such a study are listed below:

List of currently or soon to be available computer Models:

Vehicle Models:

- Geo Metro (1997 year model)
- Toyota RAV4 (2000)
- Plymouth Neon (1996)

- Chevrolet S-10 Pickup Truck (1998)
- Ford Taurus (1991)
- Ford Taurus (2001)
- Honda Accord
- Crown Victoria
- Chevrolet Lumina
- Chevrolet C-1500/C-2500 Pickup Truck (1994)
- Dodge Caravan (1997)
- Ford Explorer
- Ford Econoline (1998)
- Ford F800 18,000 lb. Truck (1996)
- Freightliner Tractor/Trailer (1991)

Roadside Hardware Models:

- Slipbase Sign Supports
- U-Channel Sign Supports
- Dual Support Sign
- Portable Concrete Barrier (PCB)
  Several designs varying in length, shape, connection types, ... etc.
- G41S W-Beam Guardrail
  multiple versions with different posts type, post height, and blockouts
- Bullnose
- Thrie Beam Guardrail

- Three strand Cable Rail Barrier

- G42W W-Beam Guardrail

- Concrete Median Barriers (CMB)
  Four Shapes: F-Shape, NJ Shape, Vertical Wall, Single Slope

- W-Beam to CMB Transition
  -Four models: Thrie-beam/W-beam, Wood-post /Steel-post

- PCB to CMB Plate Transition

- Secure Mailbox

Chapter 5
Conclusions and Future Research

5.1 Conclusions

Throughout the research period, compatibility between vehicles and roadside hardware systems was investigated. Findings of the project indicated that the performance of roadside systems during typical crash configurations varied greatly according to the overall characteristics of the impacting vehicle class. However, the relationship between detailed vehicle characteristics and adverse crash outcomes could not be easily linked using currently available data.

5.1.1 Data Analysis

A review of NASS/CDS and FARS data was conducted to evaluate the compatibility of existing roadside systems and an evolving vehicle fleet. A historical review of fatalities during roadside hardware impacts was conducted using crash data from 1990-2000. Although NCHRP 350 criteria has lead to significant changes in roadside systems designs since it's publication, many roadside systems that remained in service during these years did not vary significantly in design. Using the assumptions and adjustments outlined in the following paragraphs, the variation in injury and fatality outcomes during impacts with roadside devices could be attributed to evolving vehicle characteristics.

Adjustments to crash exposure were based on vehicle population for each class. As more vehicles were registered, the occurrence of a fatal crash involving that vehicle class was expected to rise proportionally. R.L. Polk registration data was used to transform fatality counts into fatality rates per registered vehicle. Since the likelihood of an impact by an errant vehicle increases proportionally as the population of each device type increases, a second adjustment for the number of installed roadside devices would have been beneficial. However, most states do not maintain an accurate inventory of installed devices. Therefore the device installation counts could not be obtained. In addition the increased roadwork activity and resulting increase in the numbers of temporary barrier systems through the 1990’s may have been responsible for an increase in barrier related deaths.

In assessing fatality trends for vehicles impacting each class of device, the inherent crashworthiness and level of occupant protection provided by the vehicle directly relates to crash injury outcomes. The improvement in the safe design of vehicles was not adjusted for during this analysis. The effect of these improvements would lead to reduced fatality counts for a given impact condition when compared with crash outcomes for impacts involving earlier model vehicles.

Based on the analysis of guardrail, concrete median barrier and small to medium pole impacts involving each of the investigated vehicle classes (i.e. small, midsize and large cars, small, midsize and large SUV's, and small and large pickups), two clear trends were observed.

The first observation regarded fatality rates for longitudinal barrier (guardrails and concrete median barriers) impacts by small and midsize SUV's. These fatalities increased at a rate higher than the vehicle population increase. Further investigation of small and midsize SUV crash behavior indicated that the increase in fatalities correlated directly with the occurrence of vehicle rollovers. A comparison of fatality rates for these vehicles with and without rollover involvement (Tables 2.2 and 2.3) suggested that the inherent instability introduced to these vehicles during longitudinal barrier impacts had a more significant effect than the same condition involving pickup trucks. This finding suggests that pickups may not adequately represent the worst case impact for the vehicle fleet and selection of future crash test vehicles should account for this.

The second observation indicated improved outcomes involving small and midsize cars during impacts with longitudinal barrier systems. Small and midsize car impacts with longitudinal barrier systems occur frequently, however fatality rates have declined since 1990. This behavior may be attributed to improved vehicle handling characteristics reducing the frequency of such impacts, improved occupant protection by the vehicle, and improved roadside device performance.

5.1.2 Individual Case Review

Anecdotal evidence of poor interaction between roadside structures and impacting vehicles was gathered from review of existing NASS/CDS and CIREN case data. (See Section 2.2) This review lead to valuable insight into characteristics of common roadside crash configurations, however inadequate documentation of device characteristics and a lack of specific information regarding vehicle kinematics during impact hindered the analysis from drawing further conclusions.

Key findings from this review include the following.

1. Side impact crash outcomes involving barrier end-terminals depend largely on direct engagement of the vehicle structure (i.e. door sill or pillars). Taller SUV and pickup structures engage existing terminal devices adequately while lower small and midsize car structure often do not. Door structures often cannot prevent excessive door deformation and occupant compartment intrusion during these impact conditions.

2. Oblique longitudinal barrier impacts involving SUV's do not directly lead to rollover, however increased vehicle instability, driver overcorrection, and inherent vehicle kinematics lead to subsequent vehicle rollover.

3. The performance of airbag systems during roadside hardware crashes is not well understood, however it is possible that soft longitudinal pulses may delay airbag deployments. This condition may lead to reduced levels of occupant protection.

4. Frequently, existing NASS/CDS data collect techniques do not adequately document barrier crash conditions, barrier performance and structural interactions.

Currently, NASS/CDS investigators code a category of impacted device. While this information is helpful, an investigators ability to recognize cases of incompatibility is limited due to a lack of specific barrier/vehicle attributes. Case photos are available, however NASS/CDS investigations focus largely on the vehicle, the occupant compartment and restraint systems. Less consideration is given to the impacted device.

Through the case review process, additional data points have been defined that help to adequately characterize the performance of the vehicle/roadside device. Of particular interest are the specific installation attributes for crash involved devices. Currently, state highway engineers use guidelines for installation practices, however each installation is tailored to the terrain, road use and devices available. These conditions lead to complex installation practices and difficult crash investigations. To aid in data collection following a crash, three additional crash investigation forms, similar to existing CDS forms, have been created as a product of NCHRP 22-15.

These proposed forms improve data concerning the following items:

Device Design Characteristics

Post, block out, rail types, barrier profiles, installation heights

Location of impact relative to device features

Distance downstream, distance from splice, distance from roadway, curb presence

Verification of Proper device installation

Barrier heights, protection of dangerous features

Estimated Impact Mode

Impact angle, tracking vs. non-tracking, rotational conditions

Overall estimate of device performance

Improved crash photos, device deformation

5.1.3 Crash Testing

Currently, the test methods (NCHRP 350) evaluating the performance of roadside hardware devices use only a small sample of vehicle platforms. These tests are often performed without occupants or Anthropomorphic Test Dummys (ATDs). Due to the limited number of vehicles used, assessing compatibility of the entire fleet with a given device is not possible.

A broader cross section of test vehicles is required to verify the appropriate identification of the most extreme case. Currently only the 820kg car and full sized pickup truck are tested. To determine the vehicles included in this wider sample a database, which identified and measured the key attributes of over 300 different vehicles, was created. Additionally, less detailed data for over 5000 vehicles also was aggregated. This data, linked with vehicle registration data, was reviewed to establish trends in the vehicle markets and determine how the attributes of the United State's vehicle fleet are changing.

It was found that the small, midsize and large SUV populations were the most rapidly growing. These vehicles were somewhat similar to the full size pickup truck. However, these vehicles differ from the pickup truck in CG height, Static Stability Factor (SSF), weight distribution and other characteristics important in vehicle to roadside hardware impacts. These vehicles now account for a sizable portion of the US vehicle fleet, necessitating their compatibility with guardrails. It is important that testing be performed using these vehicles to determine that their level of compatibility with roadside hardware systems is adequate.

The crash test study shown in Chapter 3 is a compelling example of a vehicle to roadside system incompatibility. These test outcomes suggest that compatibility cannot be estimated using gross vehicle characteristics like vehicle mass, wheelbase and track width alone. Detailed structural attributes of vehicles must be considered with respect to the particular impacted device to understand crash behavior. The behavioral differences observed between these vehicles suggests that additional test requirements should be considered for all vehicle structures rather than a single representative vehicle or a vehicle chosen at the extreme of the entire vehicle fleet. The mechanism for implementing these additional tests must be determined however.

5.1.4 Industry and Government Awareness

The NCHRP 22-15 workshop displayed a gulf between Automobile manufactures and the roadside hardware creators in understanding the issue of roadside hardware compatibility. In order to improve the overall safety of vehicle entering the roadside, initiation of a cooperative approach between the roadside safety community and the automotive safety community is necessary. When such cooperation was discussed during the project workshop, both roadside and vehicle safety representatives expressed interest.

A proposed concept involves the creation of a working group within an existing professional society, The Society of Automotive Engineers (SAE). In addition, automotive industry involvement at the Transportation Research Board Annual meetings would stimulate future activity with the goal of safety improvement in mind.

5.2 Future Research

5.2.1 Roadside Collision Data Collection

Future evaluations of roadside hardware/vehicle compatibility will require improved data sources. Real world crash data is an important resource for the evaluation of roadside hardware compatibility. However, existing sources have a series of shortcomings. To rectify this, an evaluation of the proposed roadside crash investigation forms must be conducted. The ability for NASS/CDS investigators to collect additional barrier data must be evaluated through increased involvement of the National Center for Statistical Analysis (NCSA), the center that maintains the NASS systems. A pilot program to evaluate critical factors involved in the collection of this additional data must be performed. This program must address the following issues:

Data forms and collection techniques must be optimized so that investigators can collect the information within a reasonable time frame. The effect of the inclusion of additional barrier data on the time on scene and subsequent case analysis must be evaluated.

Roadside device crashes often occur on high-speed roadways. Performance of the detailed crash scene investigations, which were proposed in Section 4.3 of this report, requires some addition risk to investigators. An investigation into the willingness of investigators to assume this additional risk is necessary. Further, the authority of NASS/CDS investigators to block traffic when necessary for investigations must be understood.

Once new roadside crash investigation forms are adopted, guidelines must be established to ensure their suitability for investigation of existing and emerging roadside devices. A method to include new device designs into existing collection sheets must be implemented so that data collection remains useful.

The evaluation of proposed data forms and collection techniques should involve existing crash data collection studies. CIREN crash investigations offer great detail in evaluation of the causation, vehicle dynamics and occupant outcomes of vehicle crashes. These case investigations, although limited in number, currently include information that provides insight into vehicle/roadside hardware compatibility. A current shortcoming of this system however is the exclusion of vehicle rollovers. As demonstrated throughout the research period, rollover is a major component of vehicle to roadside hardware crash compatibility. A proposed special crash study would use these highly specialized CIREN investigators to inspect these types of crashes and their outcomes.

5.2.2 Evaluation of Alternative Test Methods

Since the US vehicle fleet is constantly changing, annual monitoring of vehicle populations should be conducted. As consumer tastes change, the vehicles that best represent the current vehicle fleet should be chosen for use in the hardware tests and the finite element models. Current development of vehicles that are compatible with one another are converging on higher degrees of geometric alignment for frontal structures. Synergy between the roadside community and vehicle manufacturers is necessary so that bumper and frame rail height requirements are common to serve vehicle to vehicle compatibility as well as vehicle to roadside hardware compatibility goals.

In order to verify improved performance of the vehicle/roadside system in the future, multiple vehicle platforms within a class should be tested (similar to Lumina and Taurus testing) for the most common roadside hardware devices being installed. Testing with similar vehicles within a class ensures that the barrier performs adequately across the class of vehicles, not only for a specific vehicle.

Current testing showed that that concrete barrier design uses barrier shape and vehicle lift to control vehicle damage and lateral accelerations. However, NASS/CDS and FARS data has shown that when vehicle lift is applied to some SUVs and pickups, these vehicles may roll or lose control due to their inherent instability. The HARM due to this increased instability and subsequent rollover is believed to exceed the potential HARM that results from the redirection of these vehicles by a more vertically oriented barrier. Further testing and research should be done to ensure the compatibility of these vehicles with these devices.

In addition, impacts with roadside systems may not provide a clear crash signature to airbag control modules. The emergence of improved side impact energy management systems (side airbags or energy absorbing side structures) has increased the levels of tolerance of occupants to the lateral acceleration of vehicle. In order to further address this issue, testing using occupants (ATDs) would help to identify if a more aggressive redirection of vehicles would lead to injury causing occupant loads.

Care also must be taken to ensure that the airbags continue to deploy properly when vehicles impact guardrails. Specifically, impacts at a 15-25 degree impact angle may lead to delayed or improper deployments of frontal and side airbags. Testing recent vehicle models with dummies is important to understand if the firing of the airbag is timed properly in these types of impacts.

5.2.3 Compatibility Evaluation Using Detailed Finite Element Models

A collection of finite element models, developed by the FHWA/NHTSA National Crash Analysis Center and the FHWA Centers of Excellence, has been created that can aid in the testing of roadside hardware devices. These models are publicly available to both the automotive manufacturers and the roadside hardware manufacturers. The models should be utilized to test a wide variety of vehicle types with several different roadside devices. In addition, the devices can be tested in almost any configuration at relatively low cost. Continuous renewal of these models is required to ensure that the effects of recent design trends can be simulated properly.

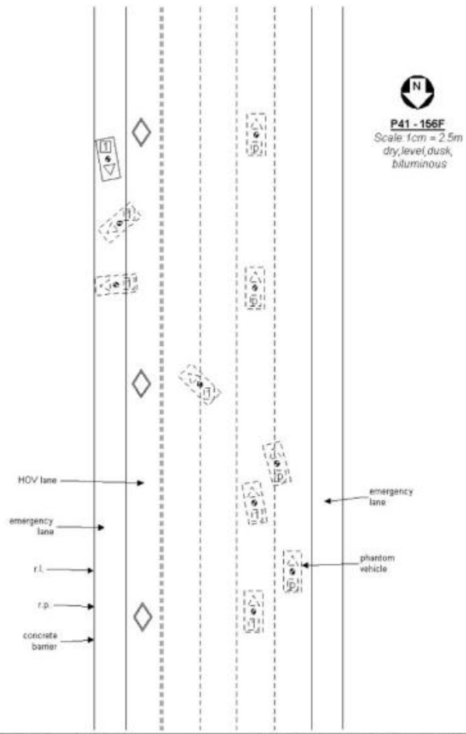
In addition, research should be done to combine the vehicle finite element models, provided by manufacturers, with roadside hardware models, created by the Centers of Excellence and other FHWA laboratories. These models may be exercised by an unbiased research organization, by safety engineers at the vehicle manufacturers, by FHWA staff or other proposed groups. This exploratory program will help to establish protocols and introduce the concept of vehicle design for improved interaction of emerging vehicles with roadside hardware systems.

Appendix A
NASS/CDS Cases

A.1 Passenger Cars- Roadside Hardware Crash Cases

18 Case 1999-41-156

Summary:
Vehicle one was south bound in the second lane of a five lane, divided, dry, level, bituminous highway during dusk. A phantom vehicle traveling south in the first lane, next to vehicle one, encroached into vehicle one's lane. Vehicle one took evasive action by steering left. Vehicle one lost control and started a counter clockwise rotation. Vehicle one rotated across three driving lanes and then struck the concrete highway divider with its front left. Vehicle one continued the rotation and then sideswiped the concrete barrier with it's back right corner, and came to final rest in the emergency lane facing north. The driver and passenger of Vehicle one were hospitalized with 'A' injuries . Driver v-1 was injured by flying broken glass and the steering assembly. The passenger was injured by the windshield and the lower instrument panel. Both occupants claim to have been belted. The vehicle had air bags which did not deploy. Vehicle one was towed due to damage.



Vehic	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occup
1	4-DR SEDAN/HDTOP	Lincoln	TownCar/Continental	1991	1	51	FEMALE-NOT PREG	3 = SERIOUS INJURY
1	4-DR SEDAN/HDTOP	Lincoln	TownCar/Continental	1991	2	55	MALE	1 = MINOR INJURY

Occupant: 1999-41-156-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	26 -17 -20
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	82 F D E W 2
Run off Road	
Damage (C1-C6)	16 30 41 43 39 31
Crush (L and D)	156 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FIVE
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DUSK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Lincoln Town-Car/Continental
Year	1991
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	165

NASS Weighting Factor

Weighting factor	1133.8545758

Pre-Crash Driver Data

Accident Type	8
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	SAME DIR-OV RGHT
Attempted Avoidance Maneuver	STEERING LEFT
Pre-impact Stability	LAT SKID-CTR CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	51	Height	170	Weight	109

Gender	FEMALE-NOT PREG
Restrain	LAP AND SHOULDER
Airbag Deployment	NONDEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

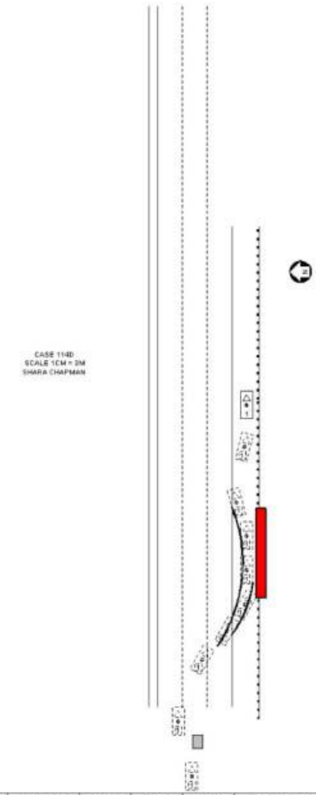
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	THIGH	RIGHT PANEL
3 = SERIOUS INJURY	THIGH	RIGHT PANEL

1 Case 1997-12-114

Summary:
VEHICLE 1 WAS SOUTHBOUND ON AN EXPRESSWAY. THERE WAS AN OBJECT IN THE CENTER LANE WHICH THE DRIVER SUCCESSFULLY AVOIDED, BUT STILL LOST CONTROL OF THE VEHICLE AFTER OVER CORRECTING AND LEFT THE ROADWAY STRIKING A GUARDRAIL MORE THAN ONCE. THE VEHICLE WAS TOWED, AND THE DRIVER WAS TAKEN TO A LOCAL FACILITY FOR TREATMENT OF INJURIES.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Mercury	Sable	1989	1	52	FEMALE-NOT PREG	3 = SERIOUS INJURY

Occupant: 1997-12-114-1-1




Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	MODERATE 1
CDC	1 F D E W 1
Run off Road	
Damage (C1-C6)	2 7 0 0 0 0
Crush (L and D)	155 0

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	THREE
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Mercury Sable
Year	1989
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	141

NASS Weighting Factor

Weighting factor	98.655342224

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	SUCES AVOID PREV
Critical Pre-crash Event	OTH CRIT EVENT
Attempted Avoidance Maneuver	BRAKE+STEER RT
Pre-impact Stability	LATERAL SKID-CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	52	Height	160	Weight	122

Gender	FEMALE-NOT PREG
Restrain	LAP AND SHOULDER
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	FOREARM	LEFT INTERIOR
3 = SERIOUS INJURY	FOREARM	LEFT INTERIOR

Occupant: 1999-12-120-1-2




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	29 -25 -14
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	1 F D E W 3
Run off Road	
Damage (C1-C6)	62 47 36 29 19 14
Crush (L and D)	140 -14

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	FOUR
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Chevrolet Baretta/Corsica
Year	1988
Class	PASSENGER CAR
Body Type	2DR SEDAN/HT/CPE
Weight	140

NASS Weighting Factor

Weighting factor	270.33506943

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OVER LINE-LEFT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age 20 Height 170 Weight 66

Gender	FEMALE-NOT PREG
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	2
MAIS	1 = MINOR INJURY
Seat Position	FRONT RIGHT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts

Occupant: 1999-12-120-1-3

Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	29 -25 -14
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	1 F D E W 3
Run off Road	
Damage (C1-C6)	62 47 36 29 19 14
Crush (L and D)	140 -14

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	FOUR
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Chevrolet Baretta/Corsica
Year	1988
Class	PASSENGER CAR
Body Type	2DR SEDAN/HT/CPE
Weight	140

NASS Weighting Factor

Weighting factor	270.33506943

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OVER LINE-LEFT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	LESS THAN ONE YR	Height	76	Weight	13

Gender	MALE
Restrain	LAP+SH W/CH SEAT
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

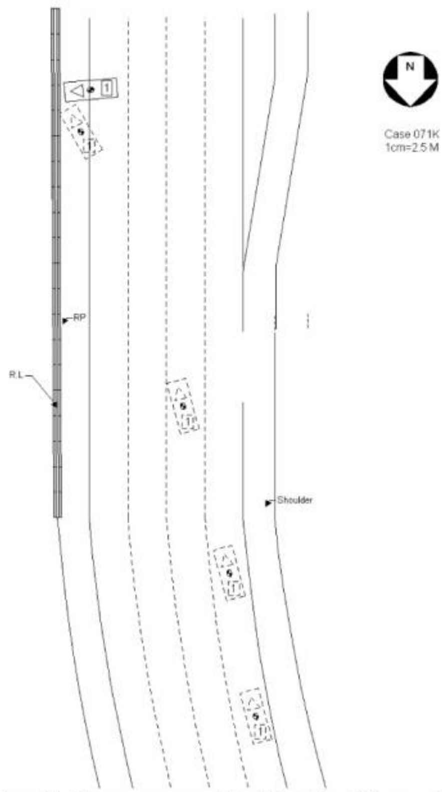
Occupant	3
MAIS	5 = CRITICAL INJURY
Seat Position	SECOND RIGHT

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
5 = CRITICAL INJURY	HEAD - SKULL	OTHER NONCONTACT

21 Case 1999-72-71

Summary:
Vehicle 1 was traveling southbound in the first lane out of four on a divided highway. Vehicle 1 then traveled across all four lanes of the expressway and impacted the left concrete traffic barrier. The front plane of the automoblie contacted theleft roadside barrier. Vehicle 1 was towed from the scene. The driver of Vehicle 1 was taken to the hospital with an A injury.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Buick	Electra/Park Avenue	1986	1	44	MALE	3 = SERIOUS INJURY

Occupant: 1999-72-71-1-1




Rollover Classification

Number of Harmful Events	1
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	MODERATE 1
CDC	1 F D E W 3
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Buick Electra/Park Avenue
Year	1986
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	147

NASS Weighting Factor

Weighting factor	7.296132528

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OVER LINE-LEFT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	LEFT TRAVEL LANE

DRIVER Factors

Age	44	Height	173	Weight	91

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

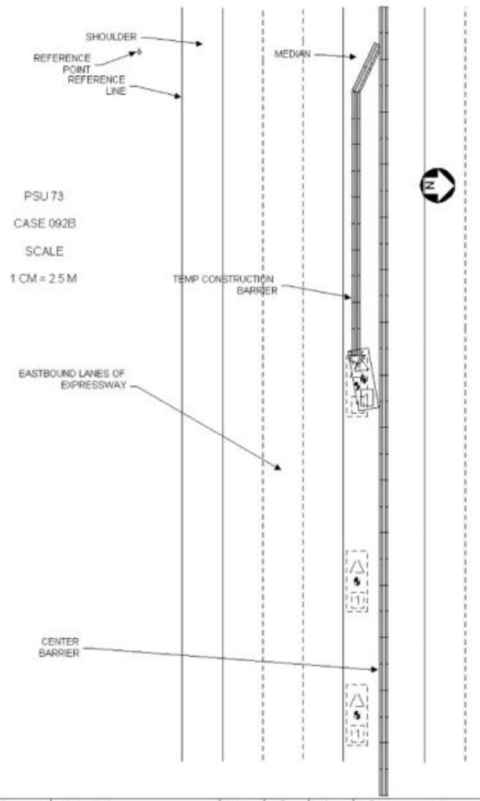
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	HEAD - SKULL	STEERING COMB
3 = SERIOUS INJURY	THIGH	LEFT PANEL

22 Case 1999-73-92

Summary:
V1 PROCEDEING WESTBOUND ON 6 LANE DIVIDED W/ POSITIVE BARRIER INTERSTATE EXPRESSWAY, IN EASTBOUND LANES. V1 WESTBOUND ON CENTER SHOULDER STRUCK THE END OF TEMPORARY CONCRETE CONSTRUCTION BARRIER SET UP TO PREVENT EASTBOUND TRAFFIC FROM TRAVELING IN CENTER MEDIAN LANE . DRIVER V1 PRONOUNCED DEAD. PASSENGER V1 FOUND WANDERING ON EXPRESSWAY APPROX 1.5 MILES EAST OF IMPACT. PASSENGER V1 TRANSPORTED TO TRAUMA CENTER, V1 TOWED DUE TO DAMAGE.



Vehicle	Body type	Make	Model	Year	Occ #	Age	Occupant's sex	Maximum known occupant ais
1	2DR SEDAN/HT/CPE	Cadillac	Deville/Fleetwood	1982	1	45	MALE	6 = MAXIMUM INJURY
1	2DR SEDAN/HT/CPE	Cadillac	Deville/Fleetwood	1982	2	45	MALE	4 = SEVERE INJURY

Occupant: 1999-73-92-1-1




Rollover Classification

Number of Harmful Events	1
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	56 -56 < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	12 F Y E N 3
Run off Road	
Damage (C1-C6)	52 80 93 84 42 0
Crush (L and D)	167 -33

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	24

Vehicle Factors

Make-Model	Cadillac Deville/Fleetwood
Year	1982
Class	PASSENGER CAR
Body Type	2DR SEDAN/HT/CPE
Weight	178

NASS Weighting Factor

Weighting factor	29.052152177

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age 45 Height 178 Weight 111

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	JAMMED DOOR/FIRE
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

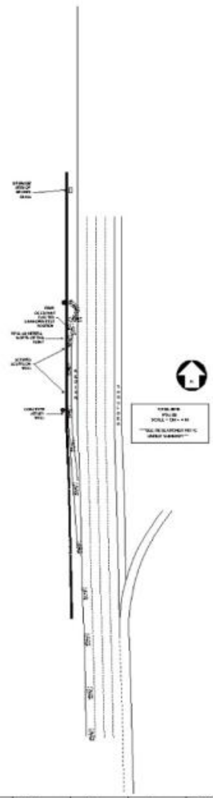
Occupant	1
MAIS	6 = MAXIMUM INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	CHEST	STEERING COMB
6 = MAXIMUM INJURY	CHEST	STEERING COMB
4 = SEVERE INJURY	CHEST	STEERING COMB
4 = SEVERE INJURY	CHEST	STEERING COMB

24 Case 1999-9-7

Summary:
Vehicle one(4dr 1992 volkwagen jetta) was traveling north on a four lane highway (positive barriers), in lane number four. The driver loses control and vehicle one departs the roadway to the left. Vehicle one strikes a concrete jersey wall (see footnote) with it's left side plane. Vehicle one rotates counter-clockwise and strikes the jersey wall again with it's right rear corner and comes to rest. The passenger in the 2nd row is fully ejected after the first impact and comes to rest in the roadway. The driver and right front passenger are transported. The driver is treated and released. The right front occupant is hospitalized for observations.
FOOTNOTE: The damage to vehicle one was severe. The first impact pulled the c-post/left rear door and sill areas apart. This caused a massive opening that included the left rear door area, left rear window, c-post area and back light. It is believed that the rear occupant was ejected thru the opening that comprised the left rear door and c-post. Also, the police report, driver and family of deceased all give different accounts and locations as to what section of the jersey wall was contacted. Based upon the damage, the researcher believes the vehicle struck an end portion of the jersey wall typical of areas used by emergency vehicles to cross over into opposite lanes of travel. This end portion of the jersey wall appears to have engaged the left rear c-post area as well as the left rear wheel/axle. However, no opening in the jersey wall was found in the location the police report stated. The scene depicted is of the area listed on the police report and scene evidence was found. The scene trafficway is representative of this vehicles environment. The scene diagram is based upon the area given in the police report, however, no crossover was found or noted. However, the scene(at this date) is representative of the roadway that vehicle one was traveling.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	VW	Jetta	1992	1	18	MALE	2 = MODERATE INJURY
1	4-DR SEDAN/HDTOP	VW	Jetta	1992	2	18	FEMALE-NOT PREG	1 = MINOR INJURY
1	4-DR SEDAN/HDTOP	VW	Jetta	1992	3	16	FEMALE-NOT PREG	4 = SEVERE INJURY

Occupant: 1999-9-7-1-3




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	37 -36 6
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	72 L D A W 3
Run off Road	
Damage (C1-C6)	33 20 23 2 8 0
Crush (L and D)	496 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	CURVE RIGHT
Roadway Profile	DOWNHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	VW Jetta
Year	1992
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	106

NASS Weighting Factor

Weighting factor	18.318853885

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OTH CRIT EVENT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	16	Height	173	Weight	75

Gender	FEMALE-NOT PREG
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	COMPLETE EJECT
Ejection Area	LEFT REAR
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

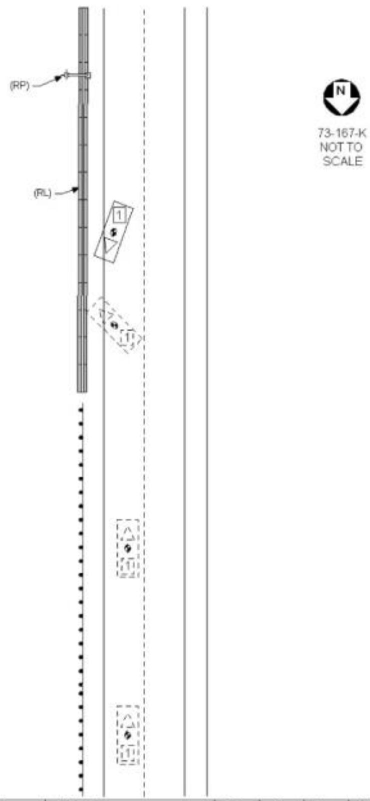
Occupant	3
MAIS	4 = SEVERE INJURY
Seat Position	SECOND LEFT

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	HEAD - SKULL	GROUND
3 = SERIOUS INJURY	CHEST	GROUND
4 = SEVERE INJURY	CHEST	GROUND
4 = SEVERE INJURY	ABDOMEN	GROUND
4 = SEVERE INJURY	ABDOMEN	GROUND
3 = SERIOUS INJURY	ABDOMEN	GROUND

28 Case 2000-73-167

Summary:
V1 was traveling south on a two way highway through a construction zone. V1 drove into the median concrete barrier and damaged the front end of the vehicle. The vehicle was occupied by the driver only. He was hospitalized with an upper leg fracture. The vehicle was towed from the crash scene due to impact damage.



Vehicle	Body type	Make	Model	Year	Occ #	Age	Occupant's sex	Maximum known occupant ais
1	2DR SEDAN/HT/CPE	Cadillac	Deville/Fleetwood	1989	1	53	MALE	3 = SERIOUS INJURY

Occupant: 2000-73-167-1-1




Rollover Classification

Number of Harmful Events	1
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	33 -25 -21
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	1 F D E W 3
Run off Road	
Damage (C1-C6)	79 60 52 36 17 0
Crush (L and D)	162 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	16

Vehicle Factors

Make-Model	Cadillac Deville/Fleetwood
Year	1989
Class	PASSENGER CAR
Body Type	2DR SEDAN/HT/CPE
Weight	154

NASS Weighting Factor

Weighting factor	23.080756285

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	53	Height	168	Weight	83

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

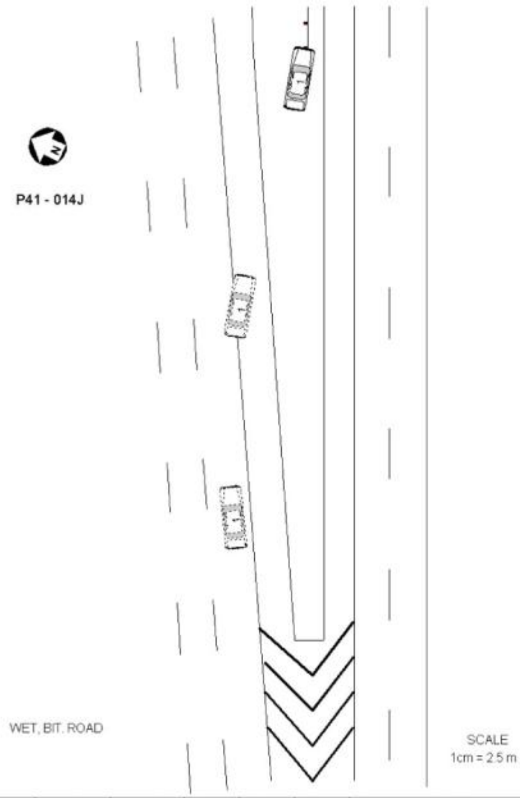
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	THIGH	LEFT HARDWARE

3 Case 1997-41-14

Summary:
VEHICLE 1 WAS TRAVELING NORTHEAST ON THREE LANE INTERSTATE ROADWAY,ROAD SURFACE BLACKTOP, LEVEL,WET DURING EVENING HOURS,VEHICLE 1 LEFT TRAFFIC LANE ON RIGHT SIDE AND COLLIDED WITH GUARD- RAIL WITH FRONT OF VEHICLE.VEHICLE 1 WAS TOWED FROM SCENE,DRIVER WAS TRANSPORTED TO A MEDICAL FACILITY..........



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Nissan	Sentra	1994	1	43	FEMALE-NOT PREG	3 = SERIOUS INJURY

Occupant: 1997-41-14-1-1

Rollover Classification

Number of Harmful Events	1
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	25 -25 2
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	12 F D E W 2
Run off Road	
Damage (C1-C6)	14 35 42 42 35 3
Crush (L and D)	96 0

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	WET
Light Conditions	DARK
Atmospheric Conditions	RAIN
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Nissan Sentra
Year	1994
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	106

NASS Weighting Factor

Weighting factor	28.99601527

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	NO DRIVER
Critical Pre-crash Event	0
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	43	Height	0	Weight	0

Gender	FEMALE-NOT PREG
Restrain	LAP BELT
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

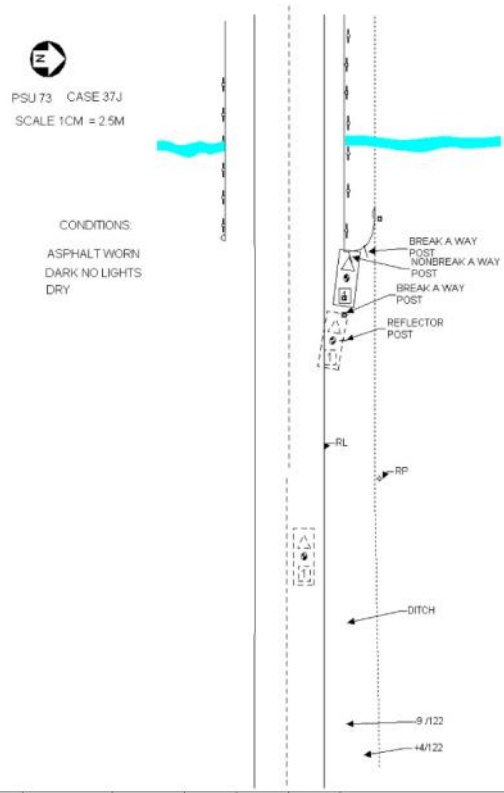
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	PELVIC - HIP	LEFT PANEL

7 Case 1997-73-37

Summary:
V1 WAS WESTBOUND ON A TWO LANE UNDIVIDED STATE HIGHWAY. V1 DEPARTED THE ROAD ON THE RIGHT SIDE. V1 STRUCK A STEEL POLE WHICH INDICATED THE BEGINNING OF THE GUARDRAIL. V1 CONTINUED FORWARD INTO THE GUARDRAIL AND SHEARED OFF THE NEXT TWO BREAKAWAY SUPPORTS. V1 THEN PROCEEDED TO PLOW UNDER TWO FIXED GUARDRAIL SUPPORTS. V1 CAME TO REST UP AGAINST THE GUARDRAIL FACING WEST. V1 SUSTAINED DAMAGE TO THE FRONT END AND THE UNDERCARRIAGE. V1 WAS TOWED DUE TO THE DAMAGE. THE DRIVER WAS TRANSPORTED TO A LOCAL HOSPITAL FOR TREATMENT. BOTH AIRBAGS IN V1 DEPLOYED DURING THE IMPACT. THE AIR BAG DEPLOYED AFTER THE INITICAL IMPACT WHICH ALLOWED THE DRIVER TO GET BEHIND AND BESIDE THE AIR BAG. AT THE TIME OF DEPLOYMENT THE DRIVER,S HEAD STRUCK THE W/S AND THE BAG THEN STRUCK THE DRIVER,S CHIN AND CHEST.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Mercury	Sable	1996	1	62	FEMALE-NOT PREG	4 = SEVERE INJURY

Occupant: 1997-73-37-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	MODERATE 2
CDC	12 F D A W 6
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	NOT DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	16

Vehicle Factors

Make-Model	Mercury Sable
Year	1996
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	154

NASS Weighting Factor

Weighting factor	26.645180035

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OVER LINE-RIGHT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	62	Height	155	Weight	54

Gender	FEMALE-NOT PREG
Restrain	NONE USED/AVAIL
Airbag Deployment	BAG DEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat PAS BAG DEPLY	DR
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

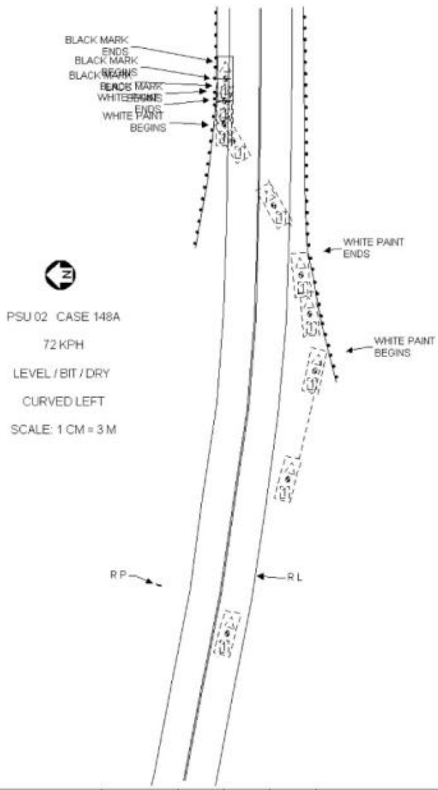
Occupant	1
MAIS	4 = SEVERE INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	HEAD - SKULL	WINDSHIELD
4 = SEVERE INJURY	HEAD - SKULL	WINDSHIELD

11 Case 1998-2-148

Summary:
VEHICLE 1 WAS TRAVELING EAST ON AN UNDIVIDED TWO LANE ROAD NEGOTIATING A LEFT CURVE. VEHICLE 1 WENT OFF THE RIGHT SIDE OF THE ROAD. THE FRONT OF VEHICLE 1 STRUCK A GUARDRAIL. VEHICLE 1 RICOCHETED OFF THE GUARDRAIL AND CROSSED THE ROADWAY TO THE LEFT. THE FRONT OF VEHICLE 1 STRUCK ANOTHER GUARDRAIL. VEHICLE 1 CONTINUED A SHORT DISTANCE AND CAME TO REST AGAINST THE GUARDRAIL VEHICLE 1 WAS TOWED TO DAMAGE. THE DRIVER WAS TRANSPORTED DUE TO INJURIES AND EXPIRED THE FOLLOWING DAY. THE WEATHER WAS CLEAR, THE ROAD WAS DRY, IT WAS DARK AND THE ROAD WAS LIGHTED AT THE TIME OF THE ACCIDENT.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Mitsubishi	Galant	1995	1	30	FEMALE-NOT PREG	5 = CRITICAL INJURY

Occupant: 1998-2-148-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	12 F R E E 9
Run off Road	
Damage (C1-C6)	11 7 4 1 0 5
Crush (L and D)	156 59

Pre-Crash Environment

Traffic Flow	NOT DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE LEFT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Mitsubishi Galant
Year	1995
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	125

NASS Weighting Factor

Weighting factor	21.865358689

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	30	Height	163	Weight	70

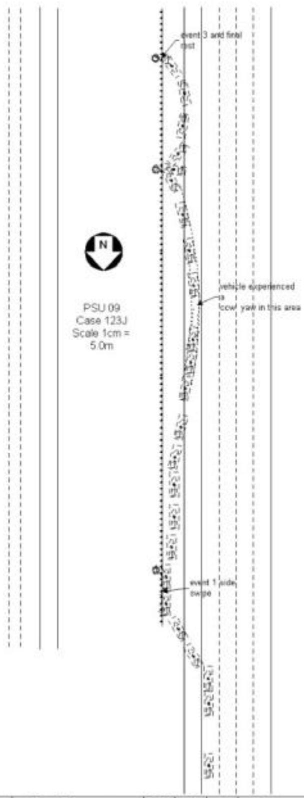
Gender	FEMALE-NOT PREG
Restrain	LAP AND SHOULDER
Airbag Deployment	BAG DEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	DR
PAS BAG DEPLY	
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	1
MAIS	5 = CRITICAL INJURY
Seat Position	FRONT LEFT SIDE

14 Case 1998-9-123

Summary:
Vehicle 1 was traveling south on a 4 lane divided major limited access highway. For an unknown reason the vehicle pulled to the left and left the roadway striking a gaurdrail on the left side of the vehicle in a sideswiping action the vehicle then returned to the paved shoulder of the road, left the roadway again striking the gaurdrail a second time in the front end. the vehicle then bounced off of the gaurdrail,rotated counterclockwise and struck the gaurdrail with the rear of the vehicle coming to a final rest in that position. The vehicle was equiped with redesigned air bags and the front seat passingers were wearing their lap and shoulder restraints, they were not injured in the incident. The left rear seat occupant was not restrained and suffered multiple fx of the neck additionally this occupant experienced a massive heart attack on the scene he was revived and transported to a local trauma center were he is still hospitalized as of this report. The right rear seat occupant suffered a fx nose, multiple lacerations, he was transported to a local trauma center due to mechanism of injury he was treated and released



Vehicle	Body type	Make	Model	Year	Occ.	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Oldsmobile	Cutlass RWD	1998	1	34	FEMALE-NOT PREG	1 = MINOR INJURY
1	4-DR SEDAN/HDTOP	Oldsmobile	Cutlass RWD	1998	2	31	MALE	0 = NOT INJURED
1	4-DR SEDAN/HDTOP	Oldsmobile	Cutlass RWD	1998	3	60	MALE	4 = SEVERE INJURY
1	4-DR SEDAN/HDTOP	Oldsmobile	Cutlass RWD	1998	4	64	MALE	1 = MINOR INJURY

Occupant: 1998-9-123-1-3

Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 2
CDC	91 F D E W 3
Run off Road	
Damage (C1-C6)	2 21 21 22 21 13
Crush (L and D)	162 -15

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Oldsmobile Cutlass RWD
Year	1998
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	135

NASS Weighting Factor

Weighting factor	16.678622322

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OTH CRIT EVENT
Attempted Avoidance Maneuver	BRAKE+STEER RT
Pre-impact Stability	LONGITUDINAL SKID
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	60	Height	165	Weight	64

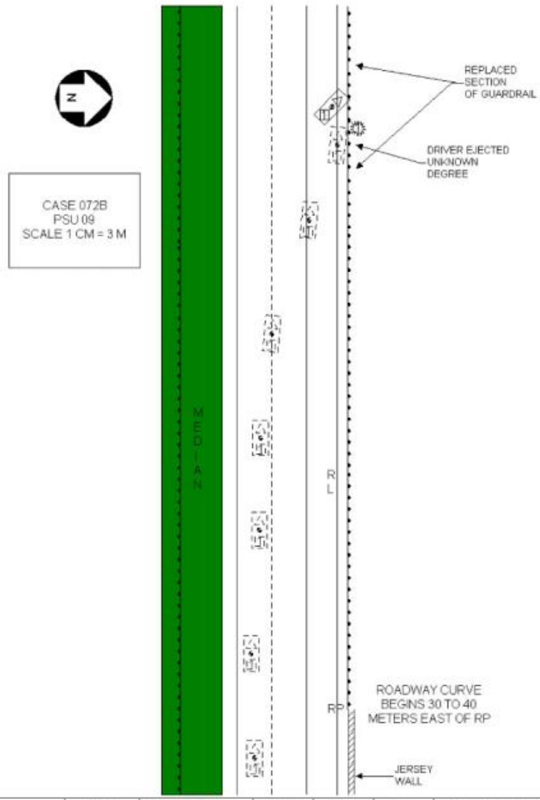
Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat PAS BAG DEPLY	DR
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	3
MAIS	4 = SEVERE INJURY
Seat Position	SECOND LEFT

15 Case 1998-9-72

Summary:
VEHICLE ONE WAS TRAVELING WEST BOUND ON A TWO LANE RAMP WITHIN AN INTERCHANGE AREA (POSITIVE BARRIERS BOTH SIDES). FOR UNKNOWN REASONS, VEHICLE ONE DEPARTS THE ROADWAY TO THE RIGHT AND STRIKES A GUARDRAIL WITH IT'S RIGHT SIDE PLANE. VEHICLE ONE PIVOTS CLOCKWISE ABOUT FORTY-FIVE DEGREES AND COMES TO REST. THE DRIVER AND SOLE OCCUPANT OF VEHICLE ONE WAS EJECTED TO AN UNKNOWN DEGREE AND WAS KILLED. THE VEHICLE WAS TOWED DUE TO DAMAGE. RESEARCHER NOTE: LT PAINT TRANSFER/DAMAGE TO LEFT FRONT FENDER/CORNER AREA. POSSIBLE CONTACT BY ANOTHER VEHICLE. HOWEVER, THIS ASPECT IS NOT CODED OR ASSIGNED AN EVENT DUE TO THE FACT THAT THE DAMAGE MAY HAVE BEEN PREVIOUS TO THIS "ACCIDENT."



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	3DR/2DR HATCHBAK	Honda	Civic/CRX	1986	1	35	MALE	6 = MAXIMUM INJURY

Occupant: 1998-9-72-1-1

Rollover Classification

Number of Harmful Events	1
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	2 R D E W 2
Run off Road	
Damage (C1-C6)	1 0 1 6 12 14
Crush (L and D)	380 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	DOWNHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	13

Vehicle Factors

Make-Model	Honda Civic/CRX
Year	1986
Class	PASSENGER CAR
Body Type	3DR/2DR HATCHBAK
Weight	86

NASS Weighting Factor

Weighting factor	26.229168251

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	35	Height	168	Weight	68

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	COMPLETE EJECT
Ejection Area	RIGHT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

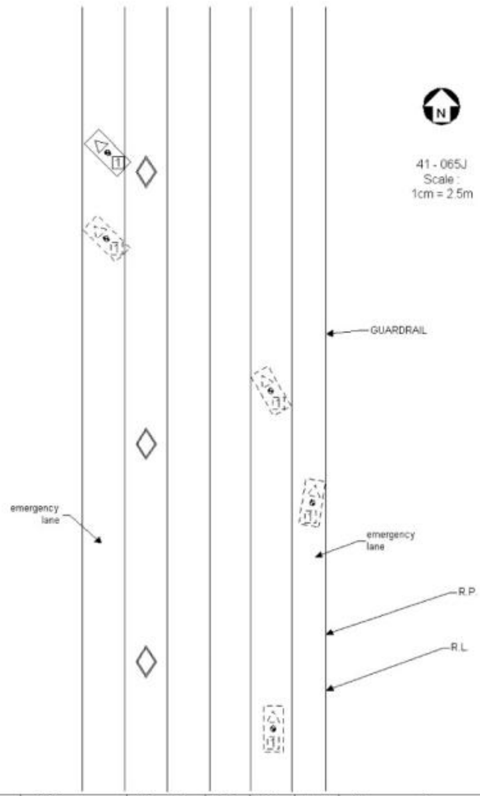
Occupant	1
MAIS	6 = MAXIMUM INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
6 = MAXIMUM INJURY	HEAD - SKULL	GROUND
3 = SERIOUS INJURY	HEAD - SKULL	GROUND
3 = SERIOUS INJURY	HEAD - SKULL	GROUND

19 Case 1999-41-65

Summary:
Vehicle one was N/bound in the right lane,of an eight lane, divided, dry, bituminous, interstate highway. Vehicle one veered out of her lane of traffic, to the right, sideswiped a guardrail with its right side. After the first event, vehicle one veered left across the northbound lanes of traffic, striking the concrete highway barrier/divider with its front, left of vehicle one. After striking the barrier, vehicle one caromed off the barrier, still traveling North, and struck the barrier again with the front left corner of vehicle one, overlapping the damage on the vehicle in events two and three, coming to final rest against the barrier facing northwest.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	3DR/2DR HATCHBAK	Mitsubishi	Eclipse	1996	1	38	FEMALE-NOT PREG	4 = SEVERE INJURY

Occupant: 1999-41-65-1-1




Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	SEVERE 2
CDC	12 F D E W 3
Run off Road	
Damage (C1-C6)	54 35 21 4 0 0
Crush (L and D)	144 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Mitsubishi Eclipse
Year	1996
Class	PASSENGER CAR
Body Type	3DR/2DR HATCHBAK
Weight	126

NASS Weighting Factor

Weighting factor	19.409371193

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	38	Height	0	Weight	0

Gender	FEMALE-NOT PREG
Restrain	NONE USED/AVAIL
Airbag Deployment	BAG DEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	DR
PAS BAG DEPLY	
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

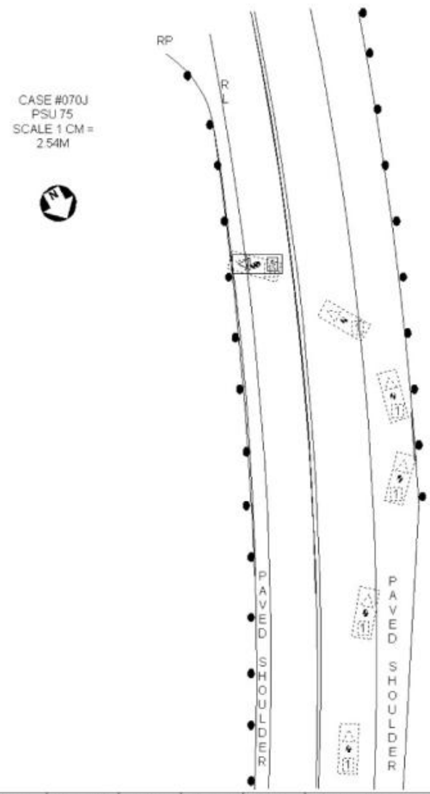
Occupant	1
MAIS	4 = SEVERE INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
4 = SEVERE INJURY	CHEST	STEERING COMB
3 = SERIOUS INJURY	HEAD - SKULL	MIRROR
4 = SEVERE INJURY	HEAD - SKULL	MIRROR
3 = SERIOUS INJURY	HEAD - SKULL	MIRROR

23 Case 1999-75-70

Summary:
Vehicle #1 was west bound on a two lane left curve State Highway. Vehicle #1 traveled off the right side of the road hitting a guardrail with its front, sideswipping all along the right side. Vehicle #1 re-entered the roadway and ran off the left side of the road hitting another guardrail head on. Vehicle #1 came to rest at the guardrail facing east. Vehicle #1 was towed from the scene. The Driver was transported and hospitalized for 14 days with injuries. Approximately 1-1/2 weeks after being discharged from the hospital, the driver died of a stroke.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	STATION WAGON	Saturn	SW	1996	1	76	FEMALE-NOT PREG	5 = CRITICAL INJURY

Occupant: 1999-75-70-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	MODERATE 2
CDC	12 F D E W 1
Run off Road	
Damage (C1-C6)	4 7 0 0 10 0
Crush (L and D)	145 0

Pre-Crash Environment

Traffic Flow	NOT DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE LEFT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Saturn SW
Year	1996
Class	PASSENGER CAR
Body Type	STATION WAGON
Weight	114

NASS Weighting Factor

Weighting factor	35.388297971

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	76	Height	163	Weight	66

Gender	FEMALE-NOT PREG
Restrain	NONE USED/AVAIL
Airbag Deployment	NONDEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

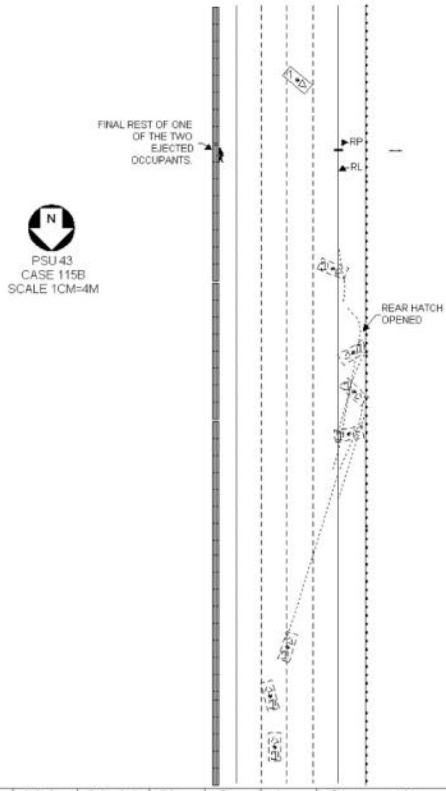
Occupant	1
MAIS	5 = CRITICAL INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
5 = CRITICAL INJURY	HEAD - SKULL	FRONT HEADER
3 = SERIOUS INJURY	HEAD - SKULL	FRONT HEADER

27 Case 2000-43-115

Summary:
V1 was traveling south in lane 3 of a 4 lane divided highway. V1 swerved to the left and lost control. V1 then swerved to the right and struck the metal guard rail with its front. V1 then spun clockwise off the guard rail and the left side struck the same guard rail. V1 continued to spin clockwise and came to rest in lane 2 of facing the guard rail. Occupant 1 recieved "B" injuries and was transported and released. Occupant 2 recieved "B" injuries and was transported and released. Occupant 3 was ejected from V1 and received "A" injuries and was transported and hospitalized. Occupant 3 died 2 weeks later from the injuries. Occupant 4 was ejected from the vehicle and recieved "K" injuries. V1 was towed due to damage.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	5DR/4DR HATCHBAK	VW	Golf	1994	1	21	MALE	1 = MINOR INJURY
1	5DR/4DR HATCHBAK	VW	Golf	1994	2	21	MALE	1 = MINOR INJURY
1	5DR/4DR HATCHBAK	VW	Golf	1994	3	23	FEMALE-NOT PREG	5 = CRITICAL INJURY
1	5DR/4DR HATCHBAK	VW	Golf	1994	4	17	FEMALE-NOT PREG	3 = SERIOUS INJURY

Occupant: 2000-43-115-1-3




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	71 F D E W 3
Run off Road	
Damage (C1-C6)	12 14 14 15 16 19
Crush (L and D)	152 32

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	VW Golf
Year	1994
Class	PASSENGER CAR
Body Type	5DR/4DR HATCHBAK
Weight	117

NASS Weighting Factor

Weighting factor	49.483087875

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	SAME DIR-LOSPEED
Attempted Avoidance Maneuver	STEERING LEFT
Pre-impact Stability	LAT SKID-CTR CLK
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age 23 Height 165 Weight 59

Gender	FEMALE-NOT PREG
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	COMPLETE EJECT
Ejection Area	REAR
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

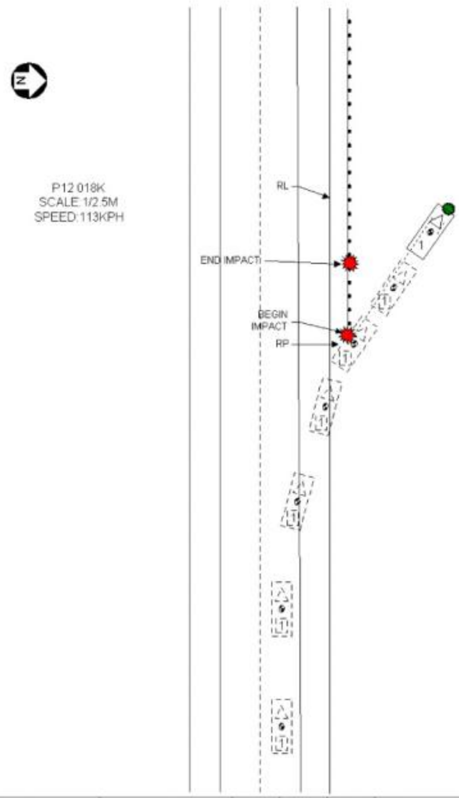
Occupant	3
MAIS	5 = CRITICAL INJURY
Seat Position	SECOND LEFT

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	CHEST	GROUND
3 = SERIOUS INJURY	PELVIC - HIP	GROUND
5 = CRITICAL INJURY	HEAD - SKULL	GROUND
4 = SEVERE INJURY	HEAD - SKULL	GROUND
3 = SERIOUS INJURY	HEAD - SKULL	GROUND
5 = CRITICAL INJURY	HEAD - SKULL	GROUND
5 = CRITICAL INJURY	HEAD - SKULL	GROUND
5 = CRITICAL INJURY	HEAD - SKULL	GROUND

10 Case 1998-12-18

Summary:
Vehicle 1 was traveling over the speed limit on a one way , 2 lane asphalt roadway under dry dark conditions. The driver fell asleep, and lost control leaving the right shoulder and contacting the front plane of the vehicle to the end of a guardrail peeling it back and breaking off 4 of the wooden posts. The vehicle continued a downward slope contacting a small sapling before coming to final rest. The vehicle was towed from the scene due to damage. The driver was transported to a local trauma center for treatment of injuries after losing consciousness. There was alcohol involved in the incident, and the driver states that he has lost a 3 hour time-slot and has been unable to recollect the accident except by what he's been told by relatives. The driver was wearing the seatbelt provided in the vehicle. The bumper cover was located at the scene jammed underneath the damaged guardrail.



VehiclBody type		Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Oldsmobile	Cutlass FWD	1986	1	42	MALE	3 = SERIOUS INJURY

Occupant: 1998-12-18-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	>39 AND <55 KMPH 1
CDC	1 F D E W 3
Run off Road	
Damage (C1-C6)	60 39 0 0 0 0
Crush (L and D)	154 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	19

Vehicle Factors

Make-Model	Oldsmobile Cutlass FWD
Year	1986
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	124

NASS Weighting Factor

Weighting factor	31.155384929

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	42	Height	168	Weight	67

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

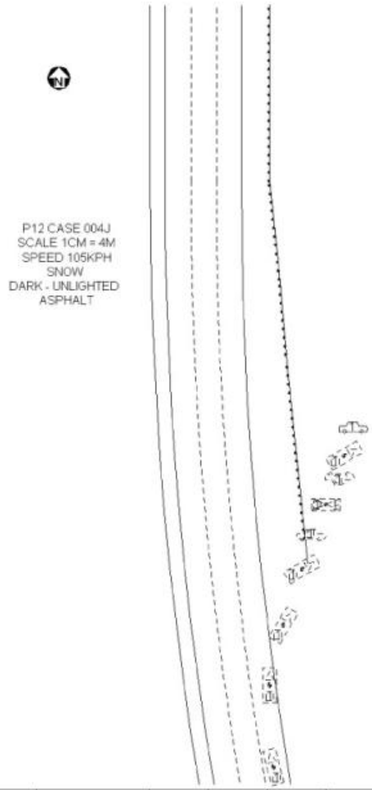
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	LEG	LEFT PANEL

25 Case 2000-12-4

Summary:
Vehicle 1 was headed north on a 3 lane, snowy, asphalt roadway after dark and with little or no artificial lighting. Traveling in lane 1, vehicle 1 lost control of his vehicle due to weather conditions and left the roadway to the right striking a guardrail prior to final rest on the left side of the vehicle off road. The vehicle was towed due to damage and the driver was transported to medical attention due to the severity of his injuries.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	2DR SEDAN/HT/CPE	Pontiac	Grand Prix	1997	1	32	MALE	3 = SERIOUS INJURY

Occupant: 2000-12-4-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	OTH FIXED OBJECT
Location on Vehicle where Principal	
Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	5 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	11 L D E W 3
Run off Road	
Damage (C1-C6)	29 15 13 23 7 4
Crush (L and D)	443 0

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	THREE
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	SNOW OR SLUSH
Light Conditions	DARK
Atmospheric Conditions	SNOW
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	16

Vehicle Factors

Make-Model	Pontiac Grand Prix
Year	1997
Class	PASSENGER CAR
Body Type	2DR SEDAN/HT/CPE
Weight	154

NASS Weighting Factor

Weighting factor	46.019742061

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	POOR ROAD CONDIT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	LATERAL SKID-CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	32	Height	180	Weight	86

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	NONDEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

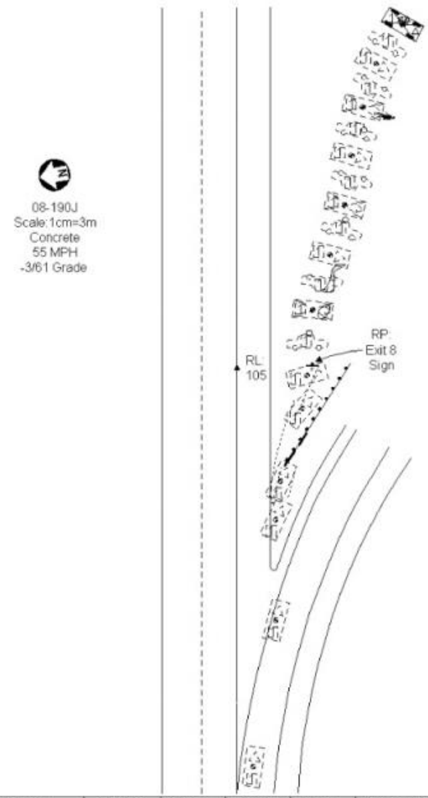
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	CHEST	BELT WEBB/BUCKLE

29 Case 2000-8-190

Summary:
V1 was travelling northeast on a two lane concrete roadway approaching an off ramp. V1 while attempting to exit onto the ramp began to rotate clockwise and departed the roadway to it's left. The left side of V1 struck a plastic marker and continued rotating clockwise. V1 ramped up a downturned guardrail end contacting the guardrail with it's undercarriage. V1 then began to roll towards it's left and while rolling, struck a wooden exit sign post with it's left side. V1 contiuned to roll left, and V101 was ejected from V1 through the lf glazing. V1 rolled three and a half times and came to rest on it's roof facing south west off the roadway. V1 was towed from the scene due to damage and V101 was transported to a medical facility.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	3DR/2DR HATCHBAK	Hyundai	Accent	1999	1	39	MALE	3 = SERIOUS INJURY

Occupant: 2000-8-190-1-1

Rollover Classification

Number of Harmful Events	4
Rollover Initiation Type	CLIMB-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	OTHER BARRIER
Location on Vehicle where Principal Tripping Force was Applied	UNDERCARRIAGE
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	14 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	MODERATE 3
CDC	0 T D D O 3
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	STRAIGHT
Roadway Profile	DOWNHILL GRADE
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	16

Vehicle Factors

Make-Model	Hyundai Accent
Year	1999
Class	PASSENGER CAR
Body Type	3DR/2DR HATCHBAK
Weight	95

NASS Weighting Factor

Weighting factor	113.01798209

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	LATERAL SKID-CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	39	Height	0	Weight	0

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	BAG DEPLOYED
Ejection	COMPLETE EJECT
Ejection Area	LEFT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat PAS BAG DEPLY	DR
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

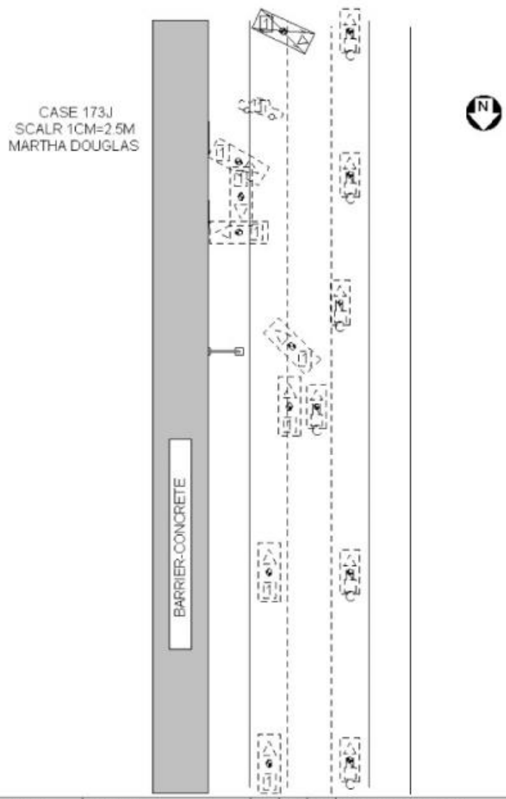
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	NECK	GROUND
3 = SERIOUS INJURY	CHEST	GROUND

2 Case 1997-12-173

Summary:
VEHICLE 1 WAS TRAVELING SOUTH IN LANE 3. AS SHE BEGAN TO CHANGE LANES TO THE RIGHT A NON CONTACT VEHICLE IN LANE 2 BEGAN TO CHANGE LANES TO THE LEFT. VEHICLE 1 TOOK EVASIVE ACTION AND HIT THE MEDIAN WALL WITH THE FRONT OF THE VEHICLE AND THEN THE BACK AND THEN ROLLED THE VEHICLE. ALL THREE OCCUPANTS WERE TRANSPORTED AND THE VEHICLE WAS TOWED. AIR BAGS DEPLOYED IN BOTH FRONT POSITIONS.



Veh	Body type	Make	Model	Year	Occ	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Cadillac	Deville/Fleetwood	1994	1	65	FEMALE-NOT PREG	5 = CRITICAL INJURY
1	4-DR SEDAN/HDTOP	Cadillac	Deville/Fleetwood	1994	2	70	MALE	1 = MINOR INJURY
1	4-DR SEDAN/HDTOP	Cadillac	Deville/Fleetwood	1994	3	88	FEMALE-NOT PREG	1 = MINOR INJURY

Occupant: 1997-12-173-1-1

Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	CONCRETE BARRIER
Location on Vehicle where Principal	
Tripping Force was Applied	END PLANE
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	998
Total, Longitudal, and Lateral delta-V	21 -18 -11
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	1 F Z E W 1
Run off Road	
Damage (C1-C6)	5 12 21 23 24 29
Crush (L and D)	180 51

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	THREE
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Cadillac Deville/Fleetwood
Year	1994
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	181

NASS Weighting Factor

Weighting factor	34.052922194

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	CHANGING LANES
Critical Pre-crash Event	0
Attempted Avoidance Maneuver	STEERING LEFT
Pre-impact Stability	LAT SKID-CTR CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	65	Height	160	Weight	73

Gender	FEMALE-NOT PREG
Restrain	LAP AND SHOULDER
Airbag Deployment	BAG DEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	DR
PAS BAG DEPLY	
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

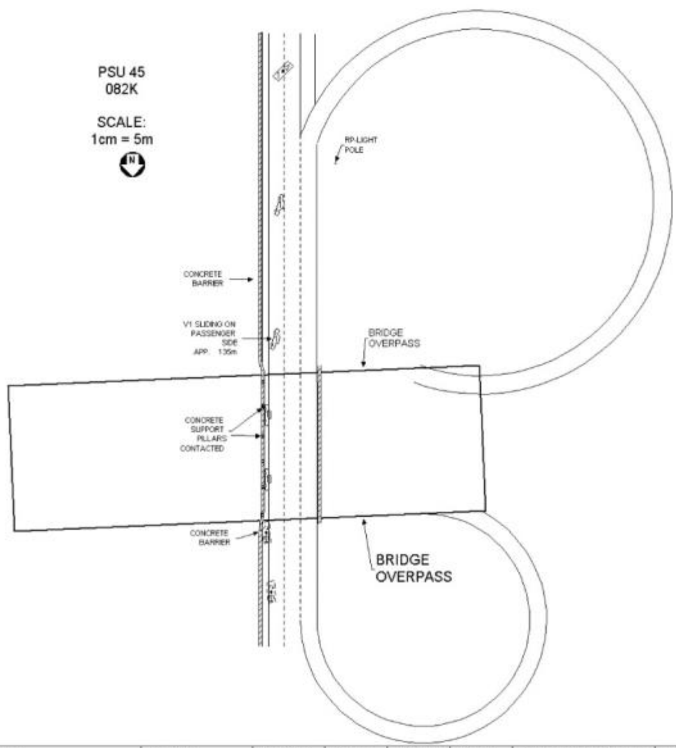
Occupant	1
MAIS	5 = CRITICAL INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
4 = SEVERE INJURY	HEAD - SKULL	ROOF
3 = SERIOUS INJURY	HEAD - SKULL	ROOF
3 = SERIOUS INJURY	HEAD - SKULL	ROOF
3 = SERIOUS INJURY	HEAD - SKULL	ROOF
4 = SEVERE INJURY	HEAD - SKULL	ROOF
5 = CRITICAL INJURY	HEAD - SKULL	ROOF

4 Case 1997-45-82

Summary:
V1 WAS TRAVELING SOUTH ON A BARRIER DIVIDED INTERSTATE WITH TWO SOUTHBOUND LANES. AS V1 WAS APPROACHING AN INTERCHANGE AREA THE DRIVER LOST CONTROL. V1 DEPARTED THE LEFT SIDE OF THE INTERSTATE AND STRUCK A CONCRETE BARRIER/BRIDGE SUPPORT WITH ITS LEFT FRONT CORNER. THE BARRIER ACTED AS A RAMP AND V1 RODE UP THE BARRIER AND ROLLED OVER ON TO ITS RIGHT SIDE. THE VEHICLE SLID APPROXIMATELY 400 ft ON ITS RIGHT SIDE BEFORE COMING TO REST BACK ON ITS WHEELS. THE DRIVER OF THE VEHICLE WAS PARTIALLY EJECTED OUT THE RIGHT FRONT GLAZING AREA.



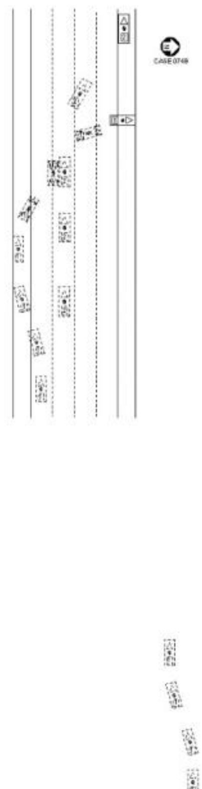
Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Oldsmobile	Ciera	1986	1	54	MALE	5 = CRITICAL INJURY

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
5 = CRITICAL INJURY	HEAD - SKULL	OTH RIGHT OBJ
3 = SERIOUS INJURY	HEAD - SKULL	RIGHT A PILLAR
4 = SEVERE INJURY	HEAD - SKULL	RIGHT A PILLAR
4 = SEVERE INJURY	HEAD - SKULL	RIGHT A PILLAR
3 = SERIOUS INJURY	HEAD - SKULL	RIGHT A PILLAR
4 = SEVERE INJURY	HEAD - SKULL	RIGHT A PILLAR
3 = SERIOUS INJURY	HEAD - SKULL	RIGHT A PILLAR
3 = SERIOUS INJURY	HEAD - SKULL	RIGHT A PILLAR
3 = SERIOUS INJURY	HEAD - SKULL	RIGHT A PILLAR

6 Case 1997-72-74

Summary:
VEHICLE 1 AND VEHICLE 2 WERE TRAVELING WESTBOUND WHEN V1 SWERVED ONTO THE LEFT SHOULDER STRIKING AND SLIDING ALONG THE CONCRETE WALL. V1 PROCEEDED TO ROLL INTO V2'S LANE OF TRAFFIC STRIKING THE LEFT SIDE OF V2. V1'S FINAL REST POSITION WAS FACING NORTH AND V2'S FINAL REST POSITION WAS FACING WEST. THE DRIVER OF V1 RECEIVED A "K" INJURY, PASSENGERS 2 AND 3 OF V1 BOTH RECEIVED "B" INJURIES AND WERE TRANSPORTED TO MEDICAL FACILITIES. PASSENGERS 2,3,4 ALSO RECEIVED "B" INJURIES. THERE IS NO INFORMATION ON THE PASSENGERS OF V2 BEING TRANSPORTED TO MEDICAL FACILITIES.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	3DR/2DR HATCHBAK	Ford	Escort/EXP	1989	1	20	MALE	4 = SEVERE INJURY
1	3DR/2DR HATCHBAK	Ford	Escort/EXP	1989	2	18	MALE	1 = MINOR INJURY
1	3DR/2DR HATCHBAK	Ford	Escort/EXP	1989	3	18	MALE	1 = MINOR INJURY

Occupant: 1997-72-74-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	$<$ 0.5KMPH
Total, Longitudal, and Lateral delta-V	$<$ 0.5 KMPH $<$ 0.5 KMPH $<$ 0.5 KMPH
Estimated delta-V with sequence number	MODERATE 1
CDC	12 F L E S 0
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	0
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NOT REPORTED
Alcohol Test ($<$ 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Ford Escort/EXP
Year	1989
Class	PASSENGER CAR
Body Type	3DR/2DR HATCHBAK
Weight	102

NASS Weighting Factor

Weighting factor	2.793564651

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	20	Height	173	Weight	73

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	PARTIAL EJECTION
Ejection Area	LEFT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

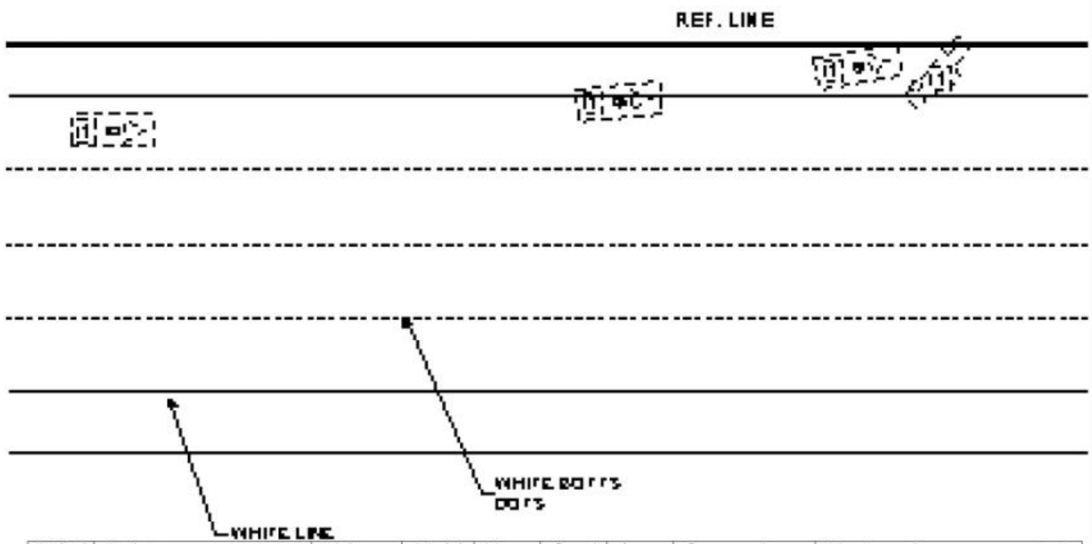
Occupant	1
MAIS	4 = SEVERE INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
4 = SEVERE INJURY	HEAD - SKULL	LEFT WINDOW FRAM
3 = SERIOUS INJURY	HEAD - SKULL	LEFT WINDOW FRAM

8 Case 1997-79-175

Summary:
V1 was heading south in the #4 lane of a 4-lane, physically divided, asphalt freeway with a slight downhill grade. V1 crossed left onto the median and impacted the concrete center divider with its front left corner then ramped up the divider with its left side. V1 then rolled right at least 6 quarter turns in a southerly direction over a distance of 100m. V1 came to rest on its roof in the #3 lane facing south. During the rollover sequence, the RF occupant (unrestrained) was fully ejected through the RF glazing area and came to rest with his head and hand(s) caught underneath the roof of V1 on the passenger side. He was transported and hospitalized with serious inuries. The driver (restrained) was transported and released with nonserious injuries. V1 was towed.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	3DR/2DR HATCHBAK	Hyundai	Excel	1987	1	24	MALE	1 = MINOR INJURY
1	3DR/2DR HATCHBAK	Hyundai	Excel	1987	2	25	MALE	3 = SERIOUS INJURY

Occupant: 1997-79-175-1-2




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	FLIP-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	CONCRETE BARRIER
Location on Vehicle where Principal	
Tripping Force was Applied	UNDERCARRIAGE
Direction of Initial Roll	ROLL RIGHT

Crash Severity

Nr. Quarter Turns	6 QUARTER TURNS
Impact Speed	998
Total, Longitudal, and Lateral delta-V	13 -13 $<$ 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	12 F L E E 2
Run off Road	
Damage (C1-C6)	3 1 1 1 1 1
Crush (L and D)	144 -68

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test ($<$ 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Hyundai Excel
Year	1987
Class	PASSENGER CAR
Body Type	3DR/2DR HATCHBAK
Weight	101

NASS Weighting Factor

Weighting factor	2.1276219825

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	25	Height	0	Weight	0

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	COMPLETE EJECT
Ejection Area	RIGHT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

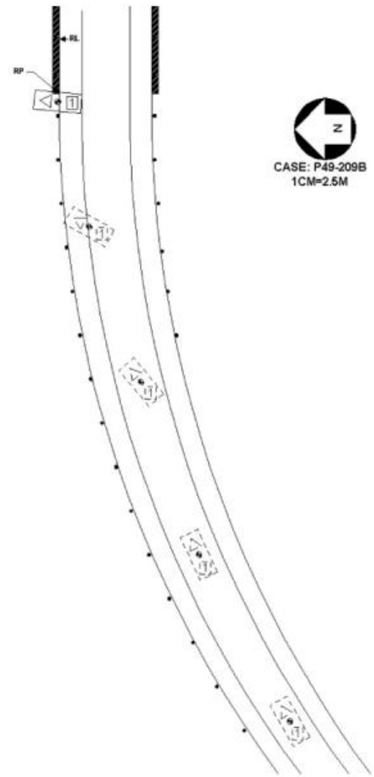
Occupant	2
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT RIGHT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	HEAD - SKULL	GROUND

20 Case 1999-49-209

Summary:
VEHICLE 1 WAS TAKING AN EXIT RAMP FROM A NORTHBOUND FREEWAY TO AN EASTBOUND FREEWAY WITH A WIDE RIGHT CURVE. VEHICLE 1 DEPARTED THE RAMP ON THE LEFT SIDE AND IMPACTED THE FRONT TO A METAL GAURDRAIL WHILE ROTATING COUNTERCLOCKWISE. THE FRONT OF VEHICLE 1 PENETRATED THE GAURDRAIL (WHICH SCRAPED ACROSS THE HOOD AND THE RIGHT SIDE IMPACTED THE END OF A CONCRETE BRIGE RAIL. VEHICLE 1 WAS TOWED AND THE DRIVER WAS TRANSPORTED. THE RIGHT FRONT PASSENGER WAS FATALLY INJURED. AT THE TIME OF THIS CRASH THE ROADWAY WAS DRY, AND THE ROADWAY SURFACE WAS MADE OF CONCRETE. IT WAS DARK BUT LIGHTED. VISIBILTY WAS CLEAR.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	3DR/2DR HATCHBAK	Nissan	"Z-car,ZX"	1991	1	24	MALE	2 = MODERATE INJURY
1	3DR/2DR HATCHBAK	Nissan	"Z-car,ZX"	1991	2	24	MALE	5 = CRITICAL INJURY

Occupant: 1999-49-209-1-2




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	54 < 0.5 KMPH -54
Estimated delta-V with sequence number	DELTA V CODED 2
CDC	3 R P E N 6
Run off Road	
Damage (C1-C6)	30 52 71 95 38 15
Crush (L and D)	145 -32

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	ONE
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	8

Vehicle Factors

Make-Model	Nissan "Z-car,ZX"
Year	1991
Class	PASSENGER CAR
Body Type	3DR/2DR HATCHBAK
Weight	158

NASS Weighting Factor

Weighting factor	13.663913125

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age 24 Height 168 Weight 71

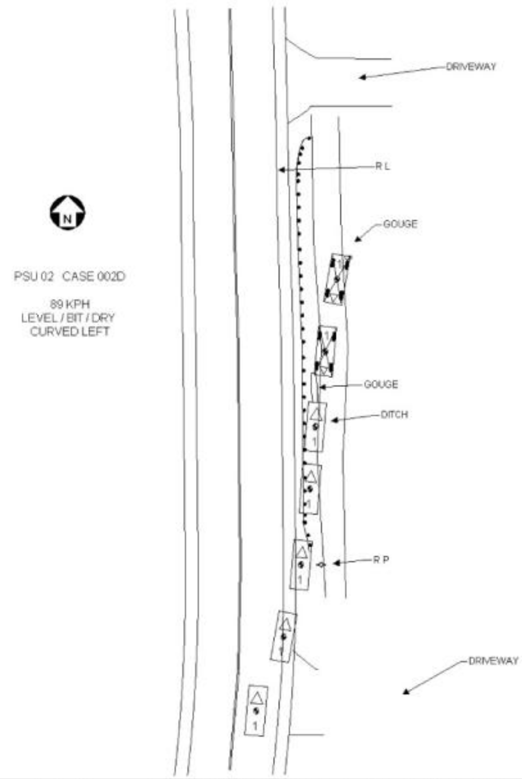
Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	JAMMED DOOR/FIRE
Airbag Deployment - 1st Seat	DR BAG DEPLOYED
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	2
MAIS	5 = CRITICAL INJURY
Seat Position	FRONT RIGHT SIDE

12 Case 1998-2-2

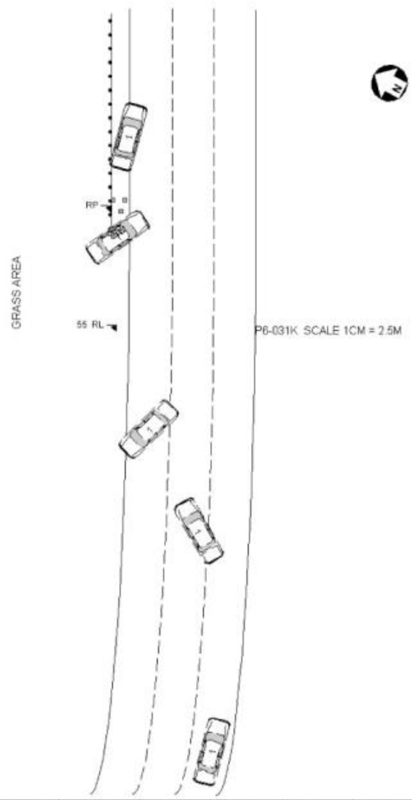
Summary:
VEHICLE 1 WAS TRAVELING NORTH ON AN UNDIVIDED TWO LANE ROAD NEGOTIATING A LEFT CURVE. VEHICLE 1 WENT OFF THE RIGHT SIDE OF THE ROAD AND STRUCK A GUARDRAIL. VEHICLE 1 MOUNTED THE GUARDRAIL AND TRAVELED ALONG THE GUARDRAIL. VEHICLE 1 THEN VAULTED THE GUARDRAIL AND STRUCK THE GOUND WITH THE FRONT. VEHICLE 1 THEN ROLLED END-OVER-END AND CAME TO REST ON ITS ROOF IN A DITCH FACING TO THE SOUTH. THE VEHICLE WAS TOWED DUE TO DAMAGE. THE DRIVER WAS TRANSPORTED DUE TO INJURIES. IT WAS CLOUDY , THE ROAD WAS DRY, IT WAS DARK AND THE ROAD WAS NOT LIGHTED AT THE TIME OF THE ACCIDENT.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Oldsmobile	Calais	1987	1	57	MALE	4 = SEVERE INJURY

13 Case 1998-6-31

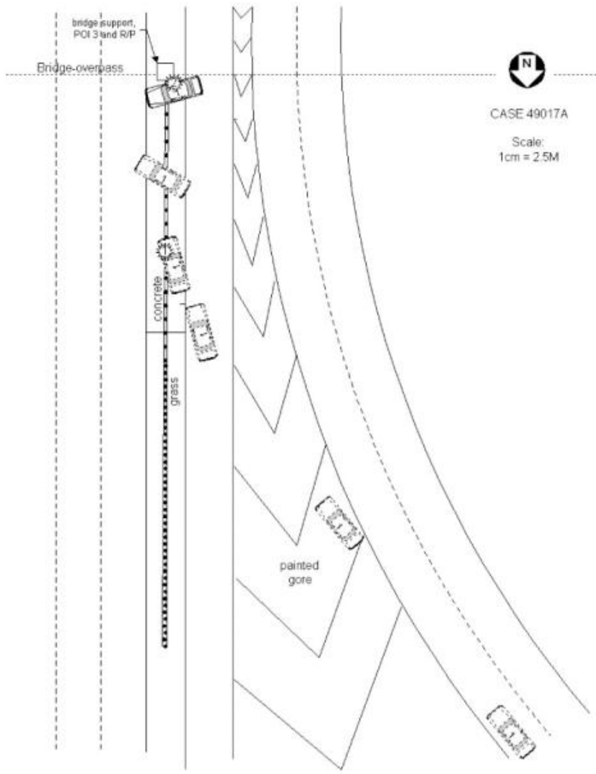
Summary:
VEHICLE 1 TRAVELING EAST ON A 3 LANE, 1 WAY HIGHWAY. THE BACK OF VEHICLE 1 WAS HIT BY AN UNKNOWN VEHICLE. VEHICLE 1 ROTATED COUNTERCLOCKWISE AND IMPACTED A GUARDRAIL WITH ITS LEFT SIDE. VEHICLE 1 CAME TO FINAL REST FACING EAST. A SERIOUS INJURY WAS REPORTED. THE VEHICLE WAS TOWED FROM THE SCENE.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Lexus	GS-300	1993	1	18	MALE	3 = SERIOUS INJURY

5 Case 1997-49-17

Summary:
Vehicle 1 was SB in the 2nd lane of a 2-lane one-way concrete onramp completing a curve to the right. V1 went left, crossing a painted divider, across another lane, impacting front left to a curb. The impact caused V1 to leave the road, jumping on top of a guardrail. V1 rotated to the left while on top of the guardrail, still traveling SB, impacted and came to rest against a bridge support. V1 was towed and the driver was transported to a hospital where he was pronounced dead.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Toyota	Camry	1996	1	23	MALE	6 = MAXIMUM INJURY

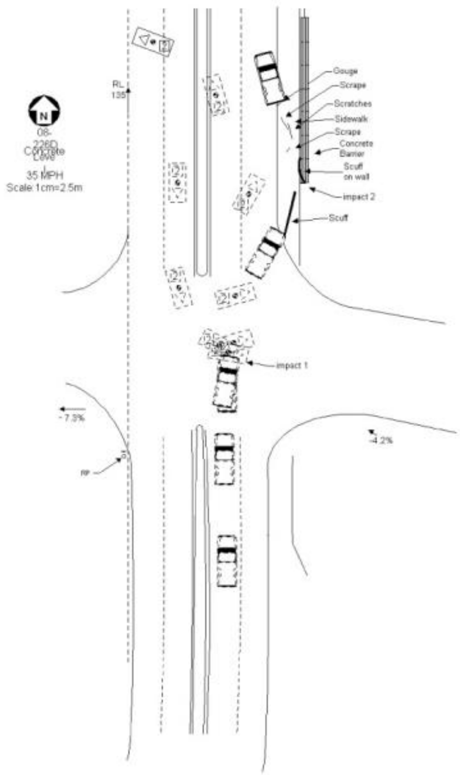
Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts	
6 = MAXIMUM INJURY	NECK	RIGHT PILLAR	B
3 = SERIOUS INJURY	HEAD - SKULL	RIGHT PILLAR	B
3 = SERIOUS INJURY	HEAD - SKULL	RIGHT PILLAR	B
3 = SERIOUS INJURY	HEAD - SKULL	RIGHT PILLAR	B
6 = MAXIMUM INJURY	HEAD - SKULL	RIGHT PILLAR	B

A.2 Truck/SUV - Roadside Hardware Crash Cases

20 Case 1999-8-226

Summary:
V1 was traveling in a southerly direction on a four lane, two way undivided roadway in lane two, approaching an intersection. V2 was traveling in a northerly direction in lane one of the same roadway. At the intersection, V2 attempted to turn to its left and travel west on an intersecting roadway. The front of V1 contacted the right side of V2 in the intersection, and in V1's original travel lane. V1 then traveled in a southwesterly direction after impacting V2, and the right front of V1 contacted a concrete retaining wall. V1 dragged down the wall for two meters, sliding along the sidewalk for another five meters, and eventually coming to rest facing in a southeasterly direction with the right rear of V1 still on the sidewalk and the front of V1 in lane one of southbound traffic. After the initial impact, V2 began to spin and yaw counterclockwise one-quarter turn, traveling 74 feet, sliding over the small concrete lane divider, and coming to rest facing in a southeasterly direction in lane one of northbound traffic. V1 and V2 towed due to damage. V2 airbags deployed. V201, V203 transported due to injury. V202 airlifted due to injury.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	LARGE PICKUP	Ford	F-series P/U	1997	1	33	MALE	0 = NOT INJURED
2	4-DR SEDAN/HDTOP	Saturn	SL	1995	1	20	MALE	2 = MODERATE INJURY
2	4-DR SEDAN/HDTOP	Saturn	SL	1995	2	17	MALE	3 = SERIOUS INJURY
2	4-DR SEDAN/HDTOP	Saturn	SL	1995	3	18	FEMALE-NOT PREG	1 = MINOR INJURY

Occupant: 1999-8-226-2-2

Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	32 -28 -16
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	1 R D E W 3
Run off Road	
Damage (C1-C6)	0 2 15 30 20 3
Crush (L and D)	436 0

Pre-Crash Environment

Traffic Flow	DVDED/NO BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	WET
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERSECTION REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Saturn SL
Year	1995
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	105

NASS Weighting Factor

Weighting factor	58.382260895

Pre-Crash Driver Data

Accident Type	68
Pre-event Movement	TURNING LEFT
Critical Pre-crash Event	OPP DIR-OVR RGHT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	STAYED IN LANE

PASSENGER Factors

Age	17	Height	183	Weight	77

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	BAG DEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	DR PAS BAG DEPLY
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

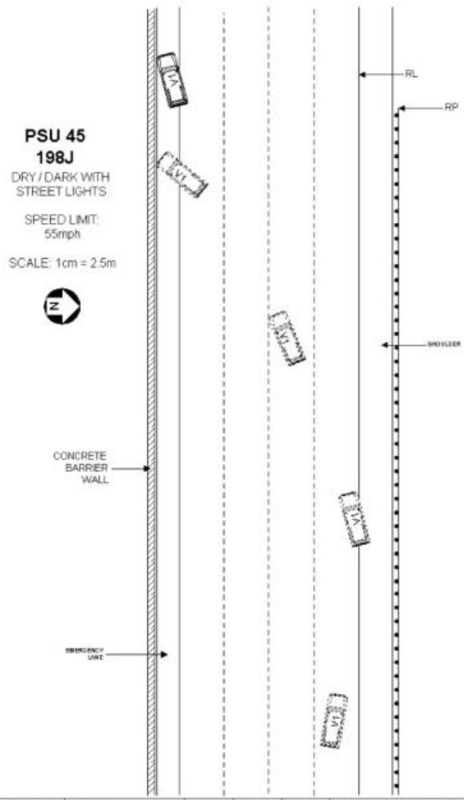
Occupant	2
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT RIGHT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	CHEST	RIGHT HARDWARE

3 Case 1997-45-198

Summary:
V1 WAS TRAVELING WEST ON A URBAN INTERSTATE WITH FOUR WESTBOUND LANES, FOUR EASTBOUND LANES WITH SHOULDERS AND DIVIDED BY A CONCRETE BARRIER WALL. V1 DRIFTED TO THE RIGHT OFF THE TRAVEL LANES AND ON TO THE RIGHT SHOULDER. THE DRIVER OVER-CORRECTED AND V1 CROSSED THE FOUR TRAVEL LANES AND CONTACTED THE CENTER CONCRETE MEDIAN WALL WITH ITS FRONT. THE VEHICLE CAME TO REST FACING WEST AGAINST THE WALL.



Vehicl	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Jeep	Cherokee84-	1994	1	37	FEMALE-NOT PREG	4 = SEVERE INJURY

Occupant: 1997-45-198-1-1

Rollover Classification

Number of Harmful Events	1
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	998
Total, Longitudal, and Lateral delta-V	51 -44 -25
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	1 F D E W 3
Run off Road	
Damage (C1-C6)	62 58 55 48 42 37
Crush (L and D)	146 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	WET
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	30

Vehicle Factors

Make-Model	Jeep Cherokee84-
Year	1994
Class	TRUCK
Body Type	COMPACT UTILITY
Weight	138

NASS Weighting Factor

Weighting factor	71.341103864

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	STEERING LEFT
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age 37 Height 168 Weight 58

Gender	FEMALE-NOT PREG
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

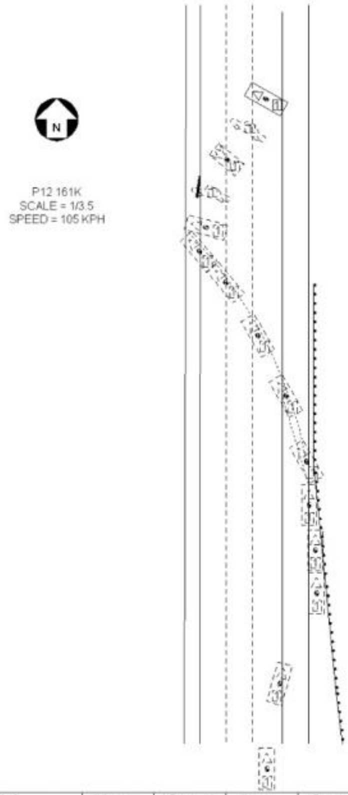
Occupant	1
MAIS	4 = SEVERE INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	CHEST	STEERING COMB
4 = SEVERE INJURY	ABDOMEN	STEERING RIM
7 = INJURY, UNK SEV	HEAD - SKULL	WINDSHIELD
3 = SERIOUS INJURY	FACE	CENTER PANEL

16 Case 1998-12-161

Summary:
VEHICLE ONE WAS HEADING NORTH ON A THREE LANE ONE WAY DRY ASPHALT ROADWAY. THE VEHICLE LEFT THE ROAD ON THE RIGHT STRIKING A GUARDRAIL ON THE RIGHT SIDE OF THE VEHICLE. THE VEHICLE CONTINUED ACROSS THE THREE LANES OF TRAFFIC AND STRUCK A CEMENT BARRIER BEFORE IT ROLLED OVER ONE COMPLETE TURN ENDING UP ON ITS WHEELS AT FINAL REST. THE VEHICLE WAS TOWED DUE TO DAMAGE AND THE ONLY OCCUPANT WAS TRANSPORTED TO A LOCAL TRAUMA CENTER FOR MEDICAL TREATMENT.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	LARGE PICKUP	Ford	F-series P/U	1993	1	46	MALE	3 = SERIOUS INJURY

Occupant: 1998-12-161-1-1




Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ON SHLDER-PAVED
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal	
Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL RIGHT

Crash Severity

Nr. Quarter Turns	4 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 2
CDC	32 F D E W 3
Run off Road	
Damage (C1-C6)	60 54 48 42 38 35
Crush (L and D)	176 0

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	THREE
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Ford F-series P/U
Year	1993
Class	TRUCK
Body Type	LARGE PICKUP
Weight	180

NASS Weighting Factor

Weighting factor	60.441446763

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	LEFT TRAVEL LANE

DRIVER Factors

Age	46	Height	183	Weight	108

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

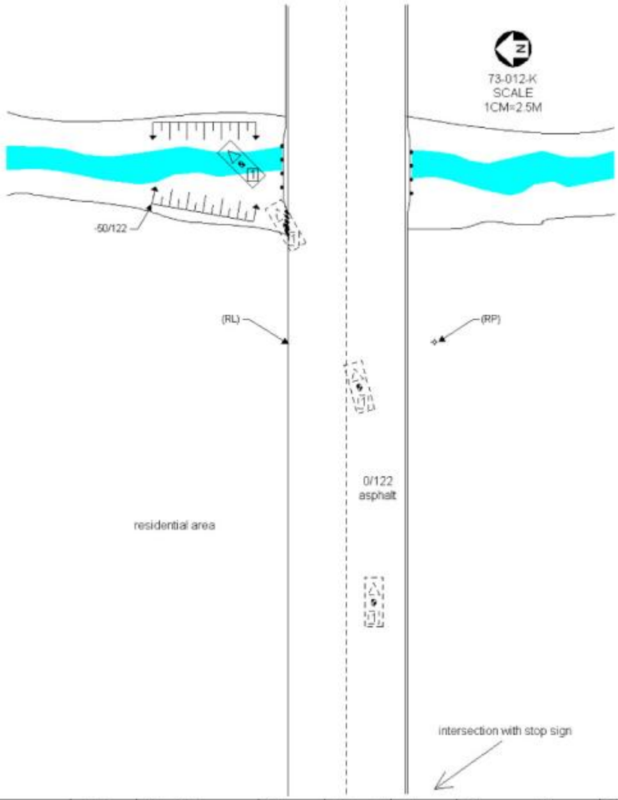
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	CHEST	CENTER PANEL

19 Case 1999-73-12

Summary:
V1 was traveling east on a two way, two lane roadway in the eastbound lane. V1 exited the roadway left in a counter-clockwise yaw, striking a guardrail with the right side passenger area of the vehicle. V1 continued down a ditch and struck the opposite side of the ditch with the front end. V1 came to final rest in the ditch. The vehicle was occupied by the driver only. He exited the vehicle unassisted and was transported to an area hospital for treatment and admitted. He was not restrained in the crash. The vehicle was towed from the crash scene due to damage.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT PICKUP	Isuzu	P'up Pickup	1985	1	29	MALE	3 = SERIOUS INJURY

Occupant: 1999-73-12-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	$<$ 0.5KMPH
Total, Longitudal, and Lateral delta-V	$<$ 0.5 KMPH $<$ 0.5 KMPH $<$ 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 2
CDC	12 F D E W 1
Run off Road	
Damage (C1-C6)	12 10 10 6 2 0
Crush (L and D)	150 0

Pre-Crash Environment

Traffic Flow	NOT DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	ICE
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test ($<$ 95 indicates BAC 0.xx)	28

Vehicle Factors

Make-Model	Isuzu P'up Pickup
Year	1985
Class	TRUCK
Body Type	COMPACT PICKUP
Weight	111

NASS Weighting Factor

Weighting factor	45.724943277

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	BRAKE W/ LOCKUP
Pre-impact Stability	LAT SKID-CTR CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	29	Height	175	Weight	75

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

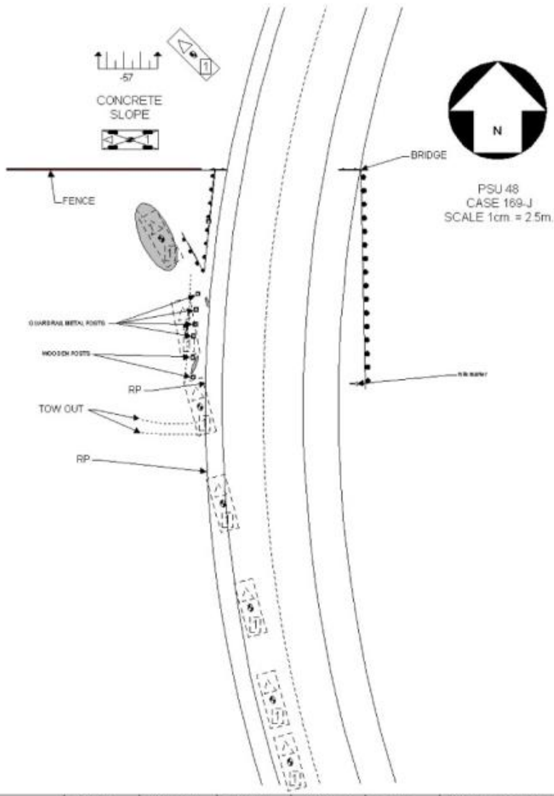
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	LEG	GLOVE DOOR

21 Case 2000-48-169

Summary:
Vehicle one was traveling north on a four lane, divided with positive barrier, dry, bituminous roadway. The front of vehicle one contacted a guardrail, the vehicle then rotated clock wise and the front, left side, and right side of the vehicle contacted a fence. Vehicle one then a concrete slope and rolled over. It's final rest position was on it's wheels facing north west. The restrained driver of vehicle one with a (redesigned) deployed airbag was hospitalized for liver laceration and lung contusion. The vehicle was towed due to disabling damage.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT PICKUP	Nissan	Pickup	1998	1	19	MALE	3 = SERIOUS INJURY

Occupant: 2000-48-169-1-1




Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	SEVERE 1
CDC	71 F D E W 2
Run off Road	
Damage (C1-C6)	0 32 37 44 50 64
Crush (L and D)	145 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	TWO
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Nissan Pickup
Year	1998
Class	TRUCK
Body Type	COMPACT PICKUP
Weight	168

NASS Weighting Factor

Weighting factor	477.36393496

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	NO AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	19	Height	196	Weight	104

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	BAG DEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	ONLY DR BAG DEPL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

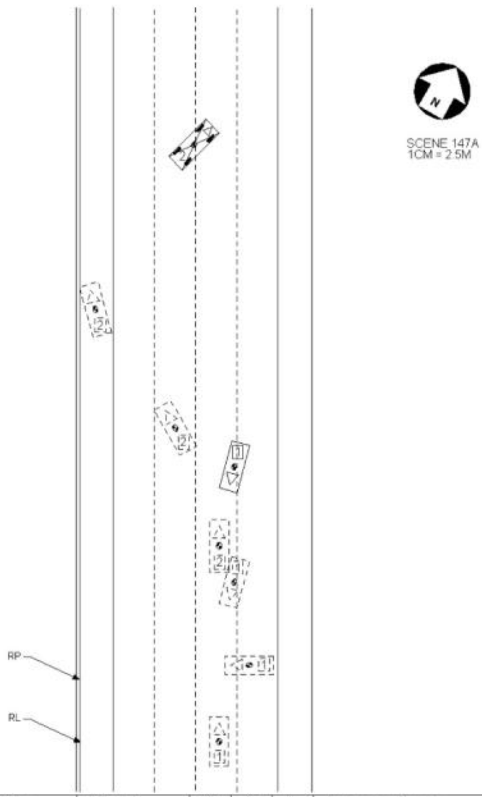
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	CHEST	BELT WEBB/BUCKLE
3 = SERIOUS INJURY	ABDOMEN	BELT WEBB/BUCKLE

5 Case 1997-72-147

Summary:
Vehicle one was traveling northwestbound on a four lane divided expressway in the second travel lane. Vehicle two was traveling on the same expressway, in the same direction, in the same travel lane. For unknown reasons, vehicle one rotated counterclockwise and impacted the right rear of vehicle two with its' own right side. This caused vehicle two to veer to the left and impact the left side concrete barrier with its' left side. Vehicle two rolled over and came to rest in the middle of lanes two and three on its' roof (per PAR). Vehicle one was driven from the scene with no reported injuries. Vehicle two was towed from the scene and the driver was transported to the hospital with "C" injuries. The front right occupant was totally ejected and later died from the injuries sustained in this crash.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
2	COMPACT UTILITY	Chevrolet	S-10 Blazer	1998	1	35	FEMALE-NOT PREG	1 = MINOR INJURY
2	COMPACT UTILITY	Chevrolet	S-10 Blazer	1998	2	39	FEMALE-NOT PREG	5 = CRITICAL INJURY

Occupant: 1997-72-147-2-2




Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	CONCRETE BARRIER
Location on Vehicle where Principal	
Tripping Force was Applied	SIDE PLANE
Direction of Initial Roll	ROLL RIGHT

Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	SEVERE 3
CDC	0 T D D O 4
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Chevrolet S-10 Blazer
Year	1998
Class	PASSENGER CAR
Body Type	COMPACT UTILITY
Weight	188

NASS Weighting Factor

Weighting factor	5.8944214137

Pre-Crash Driver Data

Accident Type	48
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	SAME DIR-OV RGHT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	STAYED IN LANE

PASSENGER Factors

Age 39 Height 155 Weight 77

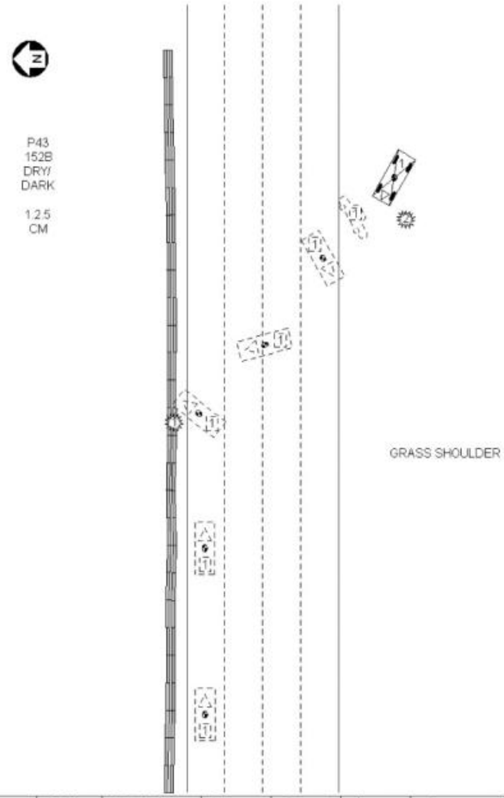
Gender	FEMALE-NOT PREG
Restrain	NONE USED/AVAIL
Airbag Deployment	NONDEPLOYED
Ejection	COMPLETE EJECT
Ejection Area	RIGHT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

Occupant	2
MAIS	5 = CRITICAL INJURY
Seat Position	FRONT RIGHT SIDE

10 Case 1999-43-152

Summary:
Vehicle one was traveling west on a 8 lane dry, bituminous, divided roadway in lane four entering a curve to the right. Vehicle one impacted the concrete divider with its front plane. Vehicle one traveled across four lanes and departed the road on the right rolling over an unknown number of times, coming to rest on its top plane. Vehicle one was towed due to damage. The driver of vehicle one was killed. All three occupants received "B" injuries.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Ford	Bronco II	1993	1	24	MALE	1 = MINOR INJURY
1	COMPACT UTILITY	Ford	Bronco II	1993	2	23	MALE	4 = SEVERE INJURY
1	COMPACT UTILITY	Ford	Bronco II	1993	3	20	MALE	1 = MINOR INJURY
1	COMPACT UTILITY	Ford	Bronco II	1993	4	22	MALE	1 = MINOR INJURY

Occupant: 1999-43-152-1-2

Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal	
Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	998
Total, Longitudal, and Lateral delta-V	30 -30 5
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	12 F D E W 2
Run off Road	
Damage (C1-C6)	31 35 32 20 13 13
Crush (L and D)	150 10

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	10

Vehicle Factors

Make-Model	Ford Bronco II
Year	1993
Class	PASSENGER CAR
Body Type	COMPACT UTILITY
Weight	176

NASS Weighting Factor

Weighting factor	42.608886833

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	23	Height	170	Weight	70

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

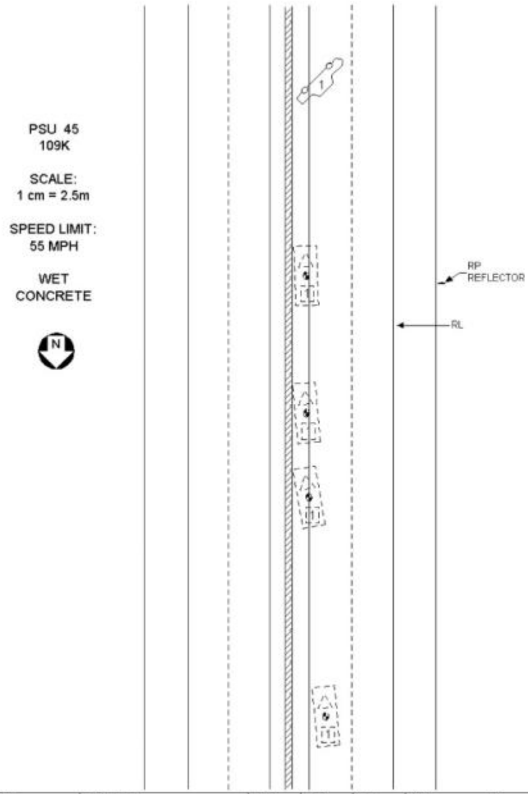
Occupant	2
MAIS	4 = SEVERE INJURY
Seat Position	FRONT RIGHT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
4 = SEVERE INJURY	ABDOMEN	BELT WEBB/BUCKLE

14 Case 1997-45-109

Summary:
V1 WAS SOUTHBOUND ON A FOUR LANE, MEDIAN DIVIDED INTERSTATE IN WET, DAYLIGHT CONDITIONS. THE DRIVER OF V1 LOST CONTROL ON THE WET ROADWAY AND DEPARTED THE LEFT SIDE OF THE INTERSTATE. V1 CONTACTED THE CENTER MEDIAN WALL WITH ITS FRONT LEFT. THE VEHICLE THEN ROLLED ONE QUARTER TURN TO ITS RIGHT WHERE IT CAME TO REST ON ITS RIGHT SIDE FACING SOUTHWEST.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	LARGE PICKUP	Chevrolet	C/K-series Pickup	1983	1	56	MALE	3 = SERIOUS INJURY

Occupant: 1997-45-109-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	CONCRETE BARRIER
Location on Vehicle where Principal	
Tripping Force was Applied	END PLANE
Direction of Initial Roll	ROLL RIGHT

Crash Severity

Nr. Quarter Turns	1 QUARTER TURN
Impact Speed	998
Total, Longitudal, and Lateral delta-V	14 -14 -3
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	12 F L E W 2
Run off Road	
Damage (C1-C6)	31 11 4 3 3 5
Crush (L and D)	184 -62

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	CONCRETE
Roadway Surface Condition	WET
Light Conditions	DAYLIGHT
Atmospheric Conditions	RAIN
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Chevrolet C/K-series Pickup
Year	1983
Class	TRUCK
Body Type	LARGE PICKUP
Weight	199

NASS Weighting Factor

Weighting factor	41.118978549

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	BRAKE W/ LOCKUP
Pre-impact Stability	LONGITUDINAL SKID
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	56	Height	183	Weight	75

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

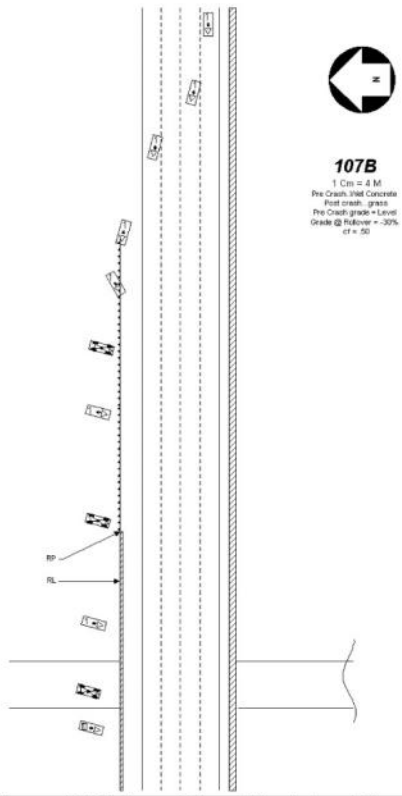
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	NECK	ROOF

12 Case 2000-49-107

Summary:
Vehicle 1 was traveling west in an unknown lane of a four lane divided expressway. The vehicle went off the roadway to the right and the front collided with a metal guard rail. From this point, the vehicle took out several wooden rail posts and continued moving away from the roadway. The vehicle rolled an undetermined number of times down an embankment, across a street going under the expressway, and came to rest on an uphill slope. The driver was fatally injured with brain and heart injuries and the passenger was hospitalized with internal injuries and fractures. The vehicle was towed.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Chevrolet	S-10 Blazer	1993	1	38	MALE	3 = SERIOUS INJURY
1	COMPACT UTILITY	Chevrolet	S-10 Blazer	1993	2	38	MALE	3 = SERIOUS INJURY

Occupant: 2000-49-107-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	0 U 9 9 9 0
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	DVDED/NO BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	WET
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	RAIN
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NOT REPORTED
Alcohol Test (< 95 indicates BAC 0.xx)	19

Vehicle Factors

Make-Model	Chevrolet S-10 Blazer
Year	1993
Class	PASSENGER CAR
Body Type	COMPACT UTILITY
Weight	154

NASS Weighting Factor

Weighting factor	11.264327125

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	NO DRIVER
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	38	Height	183	Weight	101

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	JAMMED DOOR/FIRE
Airbag Deployment - 1^{st} Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

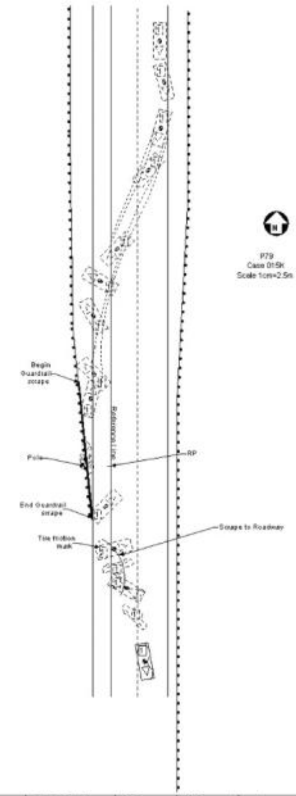
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	HEAD - SKULL	STEERING COMB
3 = SERIOUS INJURY	HEAD - SKULL	STEERING COMB
3 = SERIOUS INJURY	HEAD - SKULL	STEERING COMB

13 Case 2000-79-15

Summary:
V1 traveling S in the #2 lane of A 2 lane wet, level, grooved concrete, one way highway. As V1 attempted a lane change to the right driver swerved to avoid collision with another car in the #1 lane traveling faster than anticipated. As V1 turned the wheels traction was lost due to the wet road conditions. As the car skidded and started rotating CW the car then impacted a guardrail and rolled over an unknown number of times and entered the roadway again. The driver of V1 was transported for serious head injuries. Occupant 2 was transported and admitted for observation with complaint of pain injuries. Occupant 3 was transported and released with minor abrasions and contusions to scalp and right arm.V1 was towed from the scene.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Mitsubishi	Montero	1995	1	41	MALE	6 = MAXIMUM INJURY
1	COMPACT UTILITY	Mitsubishi	Montero	1995	2	35	MALE	0 = NOT INJURED
1	COMPACT UTILITY	Mitsubishi	Montero	1995	3	22	MALE	1 = MINOR INJURY

Occupant: 2000-79-15-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	SEVERE 2
CDC	0 T D D O 4
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	WET
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Mitsubishi Montero
Year	1995
Class	PASSENGER CAR
Body Type	COMPACT UTILITY
Weight	194

NASS Weighting Factor

Weighting factor	1.3288317962

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	CHANGING LANES
Critical Pre-crash Event	POOR ROAD CONDIT
Attempted Avoidance Maneuver	STEERING RIGHT
Pre-impact Stability	LATERAL SKID-CLK
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age 41 Height 183 Weight 109

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	NONDEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	ENTRAPPED
Airbag Deployment - 1st Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

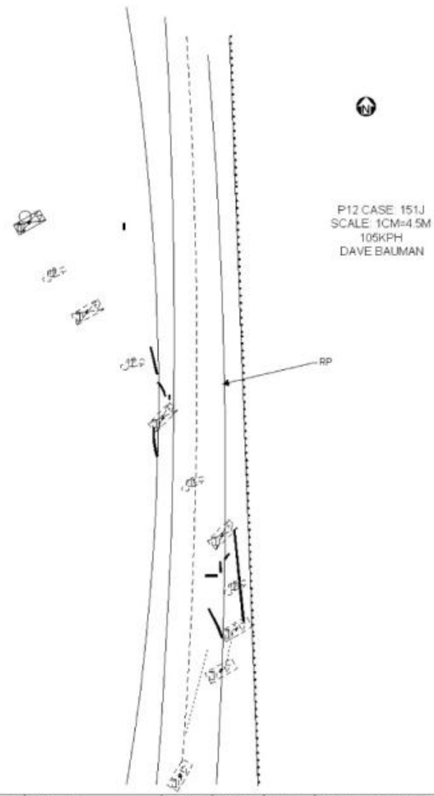
Occupant	1
MAIS	6 = MAXIMUM INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
6 = MAXIMUM INJURY	HEAD - SKULL	ROOF
4 = SEVERE INJURY	HEAD - SKULL	ROOF
4 = SEVERE INJURY	HEAD - SKULL	ROOF
3 = SERIOUS INJURY	ARM (UPPER)	ROOF LEFT RAIL
5 = CRITICAL INJURY	HEAD - SKULL	ROOF
5 = CRITICAL INJURY	HEAD - SKULL	ROOF
5 = CRITICAL INJURY	HEAD - SKULL	ROOF
4 = SEVERE INJURY	HEAD - SKULL	ROOF

1 Case 1997-12-151

Summary:
VEHICLE ONE WAS HEADING NORTH ON A TWO LANE ONE WAY EXPRESSWAY. THE VEHICLE LEFT THE ROAD ON THE RIGHT SIDE AND STRUCK A GUARDRAIL AND THEN BEGAN TO ROLLOVER THREE TIMES BEFORE COMING TO REST IN THE MEDIAN ON THE WEST SIDE OF THE ROAD. THE VEHICLE WAS TOWED DUE TO DAMAGE. ALL THREE OCCUPANTS WERE TRANSPORTED FOR TREATMENT. OCCUPANT THREE WAS TOTALLY EJECTED OUT OF THE LEFT REAR WINDOW.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	LARGE UTILITY	GMC	Jimmy fullsize	1997	1	45	MALE	3 = SERIOUS INJURY
1	LARGE UTILITY	GMC	Jimmy fullsize	1997	2	33	FEMALE-NOT PREG	1 = MINOR INJURY
1	LARGE UTILITY	GMC	Jimmy fullsize	1997	3	8	MALE	1 = MINOR INJURY

Occupant: 1997-12-151-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal	
Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	10 QUARTER TURNS
Impact Speed	$<$ 0.5KMPH
Total, Longitudal, and Lateral delta-V	$<$ 0.5 KMPH $<$ 0.5 KMPH $<$ 0.5 KMPH
Estimated delta-V with sequence number	MODERATE 2
CDC	0 T D D O 2
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	DVDED/NO BARRIER
Number of Travel Lanes	TWO
Roadway Alignment	CURVE LEFT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test ($<$ 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	GMC Jimmy fullsize
Year	1997
Class	TRUCK
Body Type	LARGE UTILITY
Weight	239

NASS Weighting Factor

Weighting factor	34.052922194

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OTH CRIT EVENT
Attempted Avoidance Maneuver	STEERING LEFT
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age 45 Height 173 Weight 75

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	NONDEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

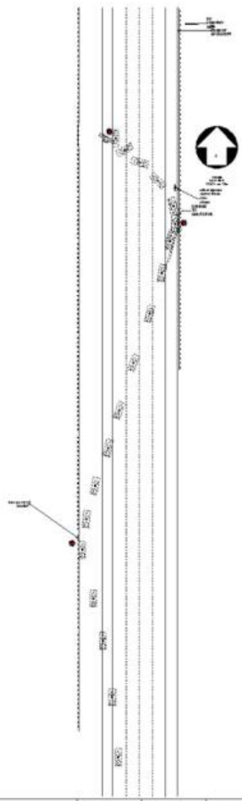
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	NECK	SEAT, BACK
3 = SERIOUS INJURY	NECK	SEAT, BACK

11 Case 1999-9-61

Summary:
Vehicle one, 1994 Jeep Grand Cherokee(4x4) was traveling north on a four lane divided highway in lane number four. For unknown reasons, vehicle one departs the roadway to the left, enters the median and sideswipes a guardrail with it's left side plane. Vehicle one steers right. Vehicle one re-enters the roadway, crosses all four travel lanes and departs the roadway to the right. Vehicle one strikes another guardrail with it's right side plane. Vehicle one steers left. As vehicle one re-enters the roadway, the driver and sole occupant is ejected thru the right front passenger window. The driver comes to rest on the right shoulder area of the roadway. Vehicle one crosses all four lanes again while rotating counter-clockwise. Vehicle one overturns, right side leading, one quarter turn. Vehicle one comes to rest on it's right side on the left shoulder area of the roadway. The vehicle is towed. The driver dies on scene and is not treated nor transported.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT UTILITY	Jeep	Cherokee84-	1994	1	20	MALE	3 = SERIOUS INJURY

Occupant: 1999-9-61-1-1

Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ON SHLDER-PAVED
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal	
Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL RIGHT

Crash Severity

Nr. Quarter Turns	1 QUARTER TURN
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 2
CDC	12 R D E W 2
Run off Road	
Damage (C1-C6)	2 14 10 10 11 8
Crush (L and D)	430 -18

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAWN
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	4

Vehicle Factors

Make-Model	Jeep Cherokee84-
Year	1994
Class	TRUCK
Body Type	COMPACT UTILITY
Weight	161

NASS Weighting Factor

Weighting factor	59.730454977

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	20	Height	196	Weight	98

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NONDEPLOYED
Ejection	COMPLETE EJECT
Ejection Area	RIGHT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

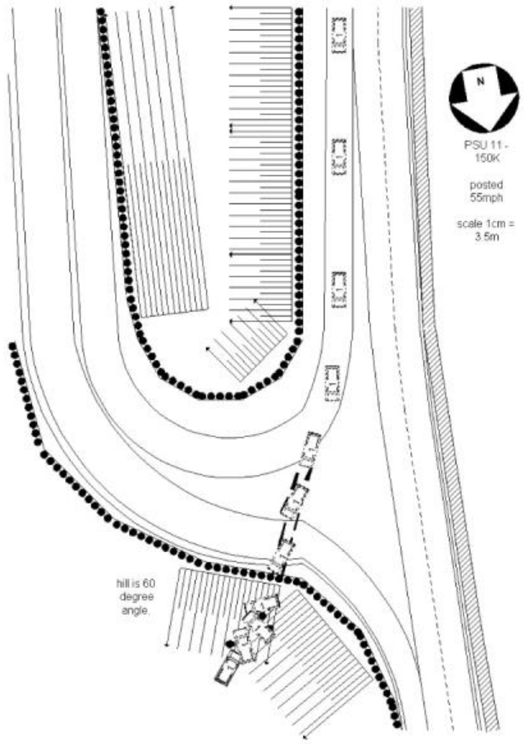
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	HEAD - SKULL	GROUND
3 = SERIOUS INJURY	NECK	GROUND
3 = SERIOUS INJURY	HEAD - SKULL	GROUND
3 = SERIOUS INJURY	HEAD - SKULL	GROUND

22 Case 1999-11-150

Summary:
Vehicle one, 1993 Mercury Villager, was travelling east in lane one of a Three lane urban express way, at an interchange. Vehicle one left the road way to the right, after lane one made a rapid turn to the right (off ramp). The driver of vehicle one had thought that there was three lanes of travel in her area. Vehicle one, left the road way and struck a guard rail with the front of the vehicle. V1 continued and began to rotate CW as the vehicle descended a 60degree hill. V1 struck three small trees, breaking them off, on the left side. Vehicle one came to rest at the bottom of the hill, after spinning 180 degrees. The driver of vehicle one was transported and hospitalized for 2 days. The passenger was transported and released. The vehicle was towed due to damage.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	MINIVAN	Mercury	Villager	1993	1	16	FEMALE-NOT PREG	3 = SERIOUS INJURY
1	MINIVAN	Mercury	Villager	1993	2	18	FEMALE-NOT PREG	1 = MINOR INJURY

Occupant: 1999-11-150-1-1

Rollover Classification

Number of Harmful Events	4
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	11 F D E W 2
Run off Road	
Damage (C1-C6)	23 21 18 16 15 18
Crush (L and D)	130 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	CURVE LEFT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Mercury Villager
Year	1993
Class	PASSENGER CAR
Body Type	MINIVAN
Weight	187

NASS Weighting Factor

Weighting factor	52.22696881

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	ACCELERATING
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	16	Height	173	Weight	48

Gender	FEMALE-NOT PREG
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1^{st} Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

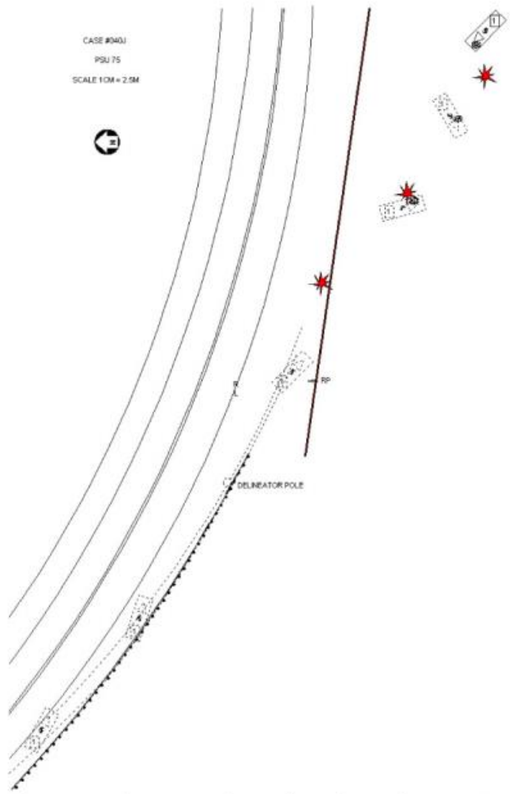
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	BACK	SEAT, BACK

9 Case 1998-75-40

Summary:
VEHICLE #1 WAS ROUNDING A LOCAL TWO LANE LEFT CURVE ROAD AND RAN OFF THE RIGHT SIDE OF THE ROAD. VEHICLE #1 ROTATED COUNTER CLOCKWISE AND HIT A GUARD RAIL WITH ITS RIGHT SIDE. VEHICLE #1 CONTINUED ALONG THE GUARD RAIL AND HIT A DELINEATOR POLE WITH ITS RIGHT SIDE. VEHICLE #1 BEGAN TO ROLLOVER AND IMPACTED A FENCE. VEHICLE #1 CONTINUED TO ROLLOVER EIGHT QUARTER TURNS AND CAME TO REST ON ITS WHEELS FACING NORTHWEST IN A FIELD. UNKNOWN LENGTH OF TIME FROM ACCIDENT TO FIRST ARRIVAL OF POLICE/EMS SINCE ENGINE BLOCK WAS COOL UPON ARRIVAL. VEHICLE #1 WAS TOWED FROM THE SCENE. THE DRIVER WAS HOSPITALIZED WITH INJURIES.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	UTILITY STAWAGON	Chevrolet	Suburban	1998	1	39	MALE	4 = SEVERE INJURY

Occupant: 1998-75-40-1-1

Rollover Classification

Number of Harmful Events	4
Rollover Initiation Type	CLIMB-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	OTHER BARRIER
Location on Vehicle where Principal	
Tripping Force was Applied	UNDERCARRIAGE
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	8 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	SEVERE 3
CDC	0 T D D O 4
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	NOT DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE LEFT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	10

Vehicle Factors

Make-Model	Chevrolet Suburban
Year	1998
Class	PASSENGER CAR
Body Type	UTILITY STAWAGON
Weight	240

NASS Weighting Factor

Weighting factor	40.069796108

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	39	Height	183	Weight	86

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NONDEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

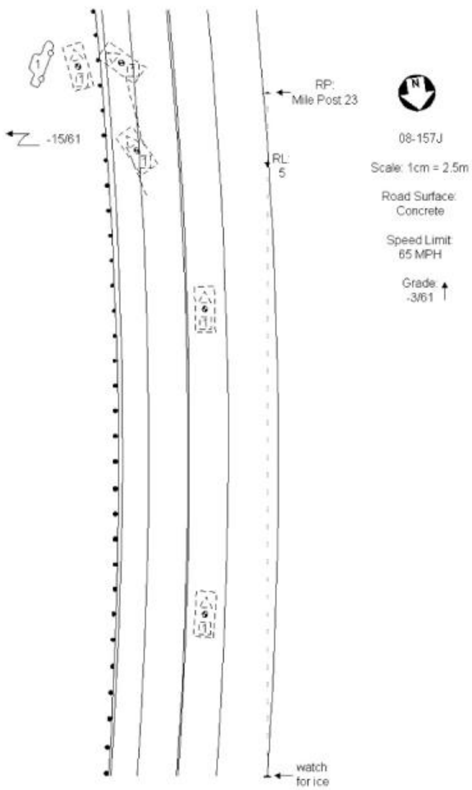
Occupant	1
MAIS	4 = SEVERE INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	NECK	GROUND
4 = SEVERE INJURY	CHEST	GROUND

17 Case 1998-8-157

Summary:
V1 was travelling south on a two lane concrete roadway in the curb lane. V1 departed the road to the left, striking a guardrail with its front. V1 after the guardrail impact rolled one quarter turn onto its driver's side and slid down an embankment coming to final rest on its left side. During the roll left, the driver was ejected through the LF window glazing. V1 was towed from the scene due to damage and V101 was transported to a medical facility. V101 airbag deployed.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT PICKUP	Dodge	Dakota	1997	1	24	MALE	3 = SERIOUS INJURY

Occupant: 1998-8-157-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	OTHER BARRIER
Location on Vehicle where Principal	
Tripping Force was Applied	END PLANE
Direction of Initial Roll	ROLL LEFT

Crash Severity

Nr. Quarter Turns	1 QUARTER TURN
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	DELTA V CODED 1
CDC	12 F D E W 2
Run off Road	
Damage (C1-C6)	30 17 10 5 0 0
Crush (L and D)	162 0

Pre-Crash Environment

Traffic Flow	DVDED/NO BARRIER
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	DOWNHILL GRADE
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	23

Vehicle Factors

Make-Model	Dodge Dakota
Year	1997
Class	TRUCK
Body Type	COMPACT PICKUP
Weight	139

NASS Weighting Factor

Weighting factor	111.2127492

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	STEERING RIGHT
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	24	Height	178	Weight	66

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	BAG DEPLOYED
Ejection	COMPLETE EJECT
Ejection Area	LEFT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat PAS BAG DEPLY	DR
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

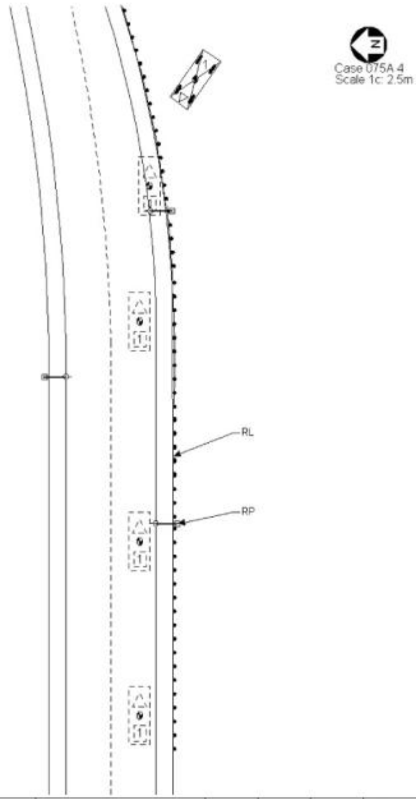
Occupant	1
MAIS	3 = SERIOUS INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
3 = SERIOUS INJURY	CHEST	LEFT INTERIOR

18 Case 1999-49-75

Summary:
Vehicle 1 was EB in the 1st lane of a dry 2-lane urban interstate elevated exit ramp to another dry interstate rounding a curve left. V1 impacted a concrete retaining wall/guardrail on the south side, sending a part ot the guardrail through the vehicle, and continued over the top and fell to the ground below, landing on it's top. The vehicle was towed due to damage and both occupants were transported. The driver was hospitalized and the passenger was pronounced dead.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	LARGE PICKUP	Chevrolet	C/K-series Pickup	1999	1	22	MALE	5 = CRITICAL INJURY
1	LARGE PICKUP	Chevrolet	C/K-series Pickup	1999	2	23	MALE	3 = SERIOUS INJURY

Occupant: 1999-49-75-1-1




Rollover Classification

Number of Harmful Events	2
Rollover Initiation Type	CLIMB-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	OTHER BARRIER
Location on Vehicle where Principal	
Tripping Force was Applied	UNDERCARRIAGE
Direction of Initial Roll	ROLL RIGHT

Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	SEVERE 1
CDC	12 F C E W 2
Run off Road	
Damage (C1-C6)	1 10 18 39 42 0
Crush (L and D)	180 -3

Pre-Crash Environment

Traffic Flow	ONE WAY
Number of Travel Lanes	TWO
Roadway Alignment	CURVE LEFT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	19

Vehicle Factors

Make-Model	Chevrolet C/K-series Pickup
Year	1999
Class	TRUCK
Body Type	LARGE PICKUP
Weight	177

NASS Weighting Factor

Weighting factor	10.216009813

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OVER LINE-RIGHT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	NO DRIVER
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	22	Height	185	Weight	106

Gender	MALE
Restrain	LAP AND SHOULDER
Airbag Deployment	BAG DEPLOYED
Ejection	NO EJECTION
Ejection Area	NO EJECTION
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	DR
PAS BAG DEPLY	
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	YES-RES DET

Injuries

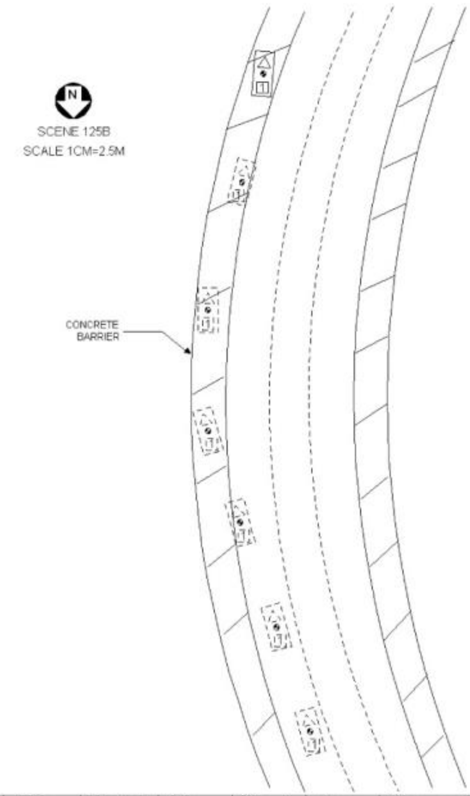
Occupant	1
MAIS	5 = CRITICAL INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
5 = CRITICAL INJURY	HEAD - SKULL	ROOF
3 = SERIOUS INJURY	HEAD - SKULL	ROOF
5 = CRITICAL INJURY	HEAD - SKULL	ROOF
3 = SERIOUS INJURY	NECK	ROOF
3 = SERIOUS INJURY	CHEST	STEERING COMB

15 Case 1997-72-125

Summary:
VEHICLE ONE WAS TRAVELING SOUTH IN THE LEFT LANE OF A THREE LANE HIGHWAY, IT PROCEEDED TO LEAVE THE ROADWAY TO THE LEFT AND STRIKE THE LEFT SHOULDER CONCRETE GUARDRAIL. VEHICLE ONE CONTINUED ON THE SHOULDER THEN STRUCK THE CONCRETE BRIDGE SUPPORT. VEHICLE ONE THEN CONTINUED TO TRAVEL ON THE SHOULDER BEFORE IT STRUCK THE LEFT GUARDRAIL AGAIN AND CAME TO REST. THE DRIVER SUSTAINED FATAL INJURIES AND THE VEHICLE WAS TOWED DUE TO DAMAGE.



Vehicle	Body type	Make	Model	Year	Occ.#	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT PICKUP	Toyota	Pickup	1988	1	30	MALE	6 = MAXIMUM INJURY

Occupant: 1997-72-125-1-1

Rollover Classification

Number of Harmful Events	3
Rollover Initiation Type	NO ROLLOVER
Location of Rollover Initiation	NO ROLLOVER
Rollover Initiation Object Contacted	NO ROLLOVER
Location on Vehicle where Principal	
Tripping Force was Applied	NO ROLLOVER
Direction of Initial Roll	NO ROLLOVER

Crash Severity

Nr. Quarter Turns	NO ROLLOVER
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral delta-V	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Estimated delta-V with sequence number	MODERATE 2
CDC	12 F L E E 9
Run off Road	
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0

Pre-Crash Environment

Traffic Flow	DVDED/W/BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	CURVE RIGHT
Roadway Profile	0
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	NO ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	NO ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Toyota Pickup
Year	1988
Class	TRUCK
Body Type	COMPACT PICKUP
Weight	147

NASS Weighting Factor

Weighting factor	3.9354342021

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	NO DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	30	Height	170	Weight	92

Gender	MALE
Restrain	NONE USED/AVAIL
Airbag Deployment	NOT EQUIP/AVAIL
Ejection	PARTIAL EJECTION
Ejection Area	LEFT FRONT
Entrapment	NOT ENTRAPPED
Airbag Deployment - 1st Seat	NOT EQUIP/AVAIL
Airbag Deployment - Oth Seat	NOT EQUIP W/ OTH
AOPS	NO

Injuries

Occupant	1
MAIS	6 = MAXIMUM INJURY
Seat Position	FRONT LEFT SIDE

Body Regions with MAIS 3+ Injuries

AIS Level	Region Injured	Contacts
6 = MAXIMUM INJURY	HEAD - SKULL	OTHER VEH OR OBJ

Appendix B
Vehicle Attributes

Selected Vehicle Measurements Adapted from the NHTSA Vehicle Characteristics Database and Research Team Measured Data

Nass Name and Model	Nass Code	Type	Class	Length (in)	Width (in)	Height (in)	Wheel base (in)	Crb wght (lb)	Front Overhang (in)	Rear Overhang (in)	Track Width (in)	Front Weight %	Rear Weight %
Acura CL/ TL	54035	CAR	MID	191.1	70.2	55.2	107.5	3227.4	39.9	44.1	60.4	62.0	38.0
Acura Integra	54031	CAR	COMPACT	172.4	67.2	52.5	101.2	2583.1	36.2	35.4	58.3	62.0	38.0
Acura NSX	54033	CAR	MID	174.4	71.3	46.1	99.6	3162.7	36.2	37.8	59.4	#N/A	#N/A
Acura SLX	54401	UTE	MID	187.8	72.2	72.2	108.7	4602.0	33.7	45.5	#N/A	#N/A	#N/A
AM General Hummer	3421	UTE	LARGE	182.3	86.6	75.7	129.9	6807.6	19.3	33.1	71.7	#N/A	#N/A
Audi 100/ A6	32032	CAR	MID	192.1	71.3	57.5	108.7	3728.4	39.8	44.1	60.6	57.7	42.3
Audi A4	32042	CAR	MID	178.0	68.1	55.9	103.0	3226.1	35.4	39.6	59.1	59.0	41.0
Audi A8	32044	CAR	LARGE	198.0	74.0	56.7	113.4	3901.1	40.2	45.3	62.6	61.0	39.0
BMW 3- series	34034	CAR	MID	173.9	67.5	54.4	106.6	3134.1	29.6	38.4	56.1	50.3	49.7
BMW 5- series	34035	CAR	MID	188.7	70.9	56.5	111.4	3797.5	33.9	43.9	59.1	52.0	48.0
BMW 7- series	34037	CAR	LARGE	199.7	73.2	56.4	119.0	4378.6	35.4	46.1	61.0	51.0	49.0
BMW Z3	34039	CAR	COMPACT	158.7	66.5	50.8	96.5	2782.6	31.5	30.7	55.5	51.0	49.0
Buick Century	18007	CAR	LARGE	194.5	72.7	56.7	109.0	3348.4	41.7	44.0	62.2	64.0	36.0
Buick Electra/ Park Avenue	18003	CAR	LARGE	206.7	74.8	57.4	113.8	3830.0	42.9	50.1	62.6	62.0	38.0
Buick Lesabre/ Wildcat/ Centurion	18002	CAR	LARGE	200.8	74.4	55.6	110.7	3448.2	44.1	45.6	60.6	65.0	35.0
Buick Regal	18010	CAR	LARGE	196.1	72.8	56.7	109.1	3442.6	42.9	44.5	62.2	63.0	37.0
Buick Regal FWD	18020	CAR	MID	196.2	72.6	56.6	109.0	3479.0	42.7	44.4	#N/A	#N/A	#N/A
Buick Riviera	18005	CAR	LARGE	207.2	75.0	54.6	113.8	3711.5	44.9	48.5	#N/A	#N/A	#N/A
Cadillac Catera	19017	CAR	LARGE	193.7	70.5	56.3	107.5	3768.8	39.0	46.5	58.7	54.0	46.0
Cadillac Deville/ Fleetwood	19003	CAR	LARGE	209.8	76.8	56.1	113.8	4060.9	44.5	51.2	60.2	62.0	38.0
Cadillac Eldorado	19005	CAR	LARGE	200.4	75.6	53.5	107.9	3812.9	45.7	47.6	61.0	64.0	36.0
Cadillac Escalade	19021	UTE	LARGE	201.2	77.2	74.4	117.7	5609.2	37.8	46.5	64.2	52.0	48.0
Cadillac Seville	19014	CAR	LARGE	201.2	74.8	55.5	112.2	3983.7	44.9	44.1	61.4	61.0	39.0
Chevrolet Astrovan	20441	VAN	MID	189.8	77.6	74.7	111.4	4322.0	33.1	45.7	65.0	53.0	47.0
Chevrolet C/ K- series Pickup	20481	TRU	LARGE	224.0	80.0	73.3	143.1	5305.3	36.8	43.9	65.3	#N/A	#N/A
Chevrolet Camaro	20009	CAR	MID	193.7	74.0	51.6	101.2	3447.1	45.3	46.9	60.6	56.0	44.0
Chevrolet Cavalier	20016	CAR	COMPACT	180.7	68.4	53.9	103.9	2703.6	38.7	38.1	57.5	65.0	35.0
Chevrolet Corvette	20004	CAR	MID	179.5	73.6	47.8	104.3	3203.1	38.6	37.0	62.2	52.0	48.0
Chevrolet Fullsize Blazer	20421	UTE	LARGE	193.9	77.0	73.0	114.6	4942.5	36.2	43.5	63.6	#N/A	#N/A
Chevrolet Geo Metro	20034	CAR	COMPACT	156.9	62.6	55.1	93.3	1856.9	32.7	31.7	54.7	#N/A	#N/A
Chevrolet Geo- Tracker	20402	UTE	COMPACT	159.4	68.7	67.4	94.9	2991.9	30.2	34.4	57.5	53.0	47.0
Chevrolet G- series Van	20461	VAN	LARGE	223.4	79.1	83.4	143.1	5426.0	34.6	45.7	66.5	#N/A	#N/A
Chevrolet Lumina	20020	CAR	MID	200.8	72.4	55.1	107.5	3299.4	46.5	47.6	59.4	64.0	36.0
Chevrolet Lumina APV	20442	VAN	MID	196.7	72.0	67.8	117.5	3798.6	37.0	42.0	61.4	58.5	41.5
Chevrolet Malibu/Chevelle	20001	CAR	MID	190.6	69.3	56.3	107.1	3050.3	39.8	44.1	59.1	64.0	36.0
Chevrolet Monte Carlo	20010	CAR	LARGE	200.8	72.4	53.9	107.5	3363.3	46.1	47.4	59.4	65.0	35.0
Chevrolet S- 10	20471	TRU	COMPACT	198.5	68.1	63.1	115.9	3430.4	35.4	47.2	56.0	#N/A	#N/A
Chevrolet S- 10 Blazer	20401	UTE	COMPACT	181.1	67.7	64.5	103.7	3876.3	36.2	41.5	55.7	#N/A	#N/A
Chevrolet Suburban	20431	UTE	LARGE	219.7	76.8	72.0	131.5	5463.2	36.2	52.8	65.6	#N/A	#N/A
Chrysler 300M	6051	CAR	LARGE	197.6	82.7	55.9	113.0	3566.1	42.1	43.3	61.8	64.0	36.0
Chrysler Cirrus	6044	CAR	MID	186.4	71.3	54.1	107.9	3146.2	37.6	41.2	60.2	64.0	36.0
Chrysler Concorde	6041	CAR	LARGE	209.1	74.4	55.9	113.0	3474.1	43.8	52.0	62.6	64.0	36.0
Chrysler LHS	6042	CAR	LARGE	205.3	74.4	56.0	113.0	3576.0	42.4	50.3	61.8	64.0	36.0
Chrysler Sebring	6043	CAR	MID	191.7	69.7	53.3	104.6	3223.2	40.7	46.4	59.7	63.3	36.7
Chrysler Town and Country	6441	VAN	LARGE	197.4	76.2	68.6	118.3	4246.7	36.4	42.6	63.0	58.0	42.0
Dodge Avenger	7042	CAR	MID	190.2	68.8	52.2	103.6	2975.4	40.7	45.8	59.4	64.0	36.0
Dodge Caravan	7442	VAN	MID	195.4	76.2	68.5	117.4	3967.8	36.5	41.6	63.0	58.5	41.5
Dodge Dakota	7472	TRU	COMPACT	202.1	71.7	66.5	122.0	3622.9	34.3	45.9	60.6	#N/A	#N/A
Dodge Durango	7402	UTE	LARGE	193.7	71.7	71.7	115.7	4405.8	35.0	43.3	61.4	59.0	41.0
Dodge Intrepid	7041	CAR	LARGE	203.6	74.6	55.9	113.0	3449.8	43.1	48.0	62.6	64.0	36.0
Dodge Neon	7020	CAR	COMPACT	171.7	67.4	54.8	104.0	2480.1	34.1	33.9	57.5	#N/A	#N/A
Dodge Ram 1500 P/U	7482	TRU	LARGE	219.3	81.1	76.9	134.5	4977.4	38.4	46.5	67.9	#N/A	#N/A
Dodge Stratus	7043	CAR	MID	185.9	71.3	54.1	107.9	3026.6	36.5	41.9	60.2	64.0	36.0
Dodge Viper	7004	CAR	MID	176.0	75.6	45.5	96.1	3429.4	34.8	44.9	59.6	#N/A	#N/A
Ferrari	69035	CAR	MID	177.6	75.6	49.2	99.1	3475.0	#N/A	#N/A	#N/A	48.0	52.0

Ford Bronco II	12401	UTE	MID	185.6	70.1	67.3	106.7	3458.6	35.0	44.1	58.7	#N/A	#N/A
Ford Contour	12035	CAR	MID	184.5	69.2	54.4	106.6	2931.3	37.5	40.9	59.1	63.0	37.0
Ford Crown Victoria	12016	CAR	LARGE	211.9	78.3	56.8	114.6	3854.2	42.5	54.8	63.4	56.0	44.0
Ford Escort/ EXP	12013	CAR	COMPACT	174.3	67.1	53.1	98.4	2496.4	36.1	39.9	56.7	64.0	36.0
Ford E- series Van	12461	VAN	LARGE	219.3	79.5	81.1	138.2	5294.6	30.0	51.5	70.1	#N/A	#N/A
Ford Expedition	12422	UTE	LARGE	204.7	78.7	76.4	119.3	4847.7	38.6	46.9	65.4	#N/A	#N/A
Ford F- series P/ U	12481	TRU	LARGE	230.9	81.2	73.6	146.9	4874.3	38.1	45.6	67.4	#N/A	#N/A
Ford Mustang/ Mustang II	12003	CAR	MID	183.2	73.2	53.3	101.2	3302.5	40.9	41.3	60.1	56.3	43.7
Ford Ranger	12471	TRU	COMPACT	196.1	69.7	66.3	118.6	3276.7	33.5	44.4	58.7	#N/A	#N/A
Ford Taurus	12017	CAR	MID	198.5	72.9	56.2	108.6	3401.9	41.8	48.3	61.4	64.0	36.0
Ford Windstar	12442	VAN	MID	201.0	75.9	65.8	120.8	3868.8	39.6	40.6	64.2	59.0	41.0
GMC CKRV- series P/ U	23481	TRU	LARGE	224.0	80.1	73.1	143.1	5315.2	36.8	44.0	65.2	#N/A	#N/A
GMC G- series Van	23461	VAN	LARGE	223.4	79.5	#N/A	143.1	5426.0	34.6	45.7	66.5	#N/A	#N/A
GMC Jimmy fullsize	23421	UTE	LARGE	200.3	77.4	74.9	117.7	5292.5	36.7	46.5	64.3	#N/A	#N/A
GMC Jimmy/S- 15 based	23401	UTE	COMPACT	181.7	67.7	65.6	104.4	3962.4	35.4	41.5	55.9	#N/A	#N/A
GMC S15	23471	TRU	COMPACT	198.9	68.1	63.1	116.0	3465.3	35.4	47.5	56.6	#N/A	#N/A
GMC Safari	23441	VAN	MID	189.8	77.6	74.7	111.4	4322.0	33.1	45.7	65.0	53.0	47.0
GMC Suburban	23431	UTE	LARGE	219.7	76.8	72.0	131.5	5463.2	36.2	52.8	65.6	#N/A	#N/A
Honda Accord	37032	CAR	COMPACT	188.2	70.5	56.4	106.3	3083.4	39.4	43.3	61.4	62.3	37.8
Honda Civic/ CRX	37031	CAR	COMPACT	173.0	67.3	54.4	103.1	2422.6	33.9	36.1	58.3	62.0	38.0
HONDAC- RV	37402	UTE	COMPACT	173.2	68.9	66.1	103.1	3200.2	33.1	37.0	60.2	55.0	45.0
Honda Odyssey	37441	VAN	MID	201.2	75.6	68.5	118.1	4209.6	39.4	44.5	66.1	58.0	42.0
Honda Prelude	37033	CAR	COMPACT	178.0	68.9	52.0	102.0	2997.4	38.2	38.6	60.2	63.0	37.0
Hyundai Accent	55036	CAR	COMPACT	161.8	63.8	54.7	94.5	2109.2	31.9	36.2	55.9	63.0	37.0
Hyundai Elantra	55035	CAR	COMPACT	175.4	66.9	56.3	100.4	2652.0	35.4	40.2	57.9	63.0	37.0
Hyundai Sonata	55033	CAR	MID	185.4	71.7	71.7	106.3	3105.4	37.4	42.5	60.6	62.0	38.0
Hyundai Tiburon	55037	CAR	COMPACT	170.9	68.1	51.2	97.6	2547.8	39.0	34.3	57.9	63.0	37.0
Infiniti G20	58033	CAR	COMPACT	177.5	66.8	54.3	102.4	2923.6	35.3	40.3	57.9	62.0	38.0
Infiniti I30	58035	CAR	MID	189.7	69.7	55.8	106.3	3147.3	39.3	43.8	59.8	63.0	37.0
Infiniti Q45	58032	CAR	MID	199.2	71.7	57.1	111.4	3931.9	38.6	49.1	60.6	56.0	44.0
Infiniti QX4	58401	UTE	MID	183.9	72.4	67.8	106.3	4275.8	32.2	45.0	59.8	55.0	45.0
Isuzu Rodeo	38402	UTE	MID	175.2	70.5	66.5	106.3	3812.9	30.3	38.6	59.8	54.0	46.0
Isuzu Trooper/ Trooper II	38401	UTE	MID	184.3	71.0	72.3	108.7	4446.6	33.6	42.4	59.8	51.0	49.0
Jeep Cherokee- 83	2421	UTE	LARGE	166.1	69.3	63.8	101.6	3078.4	27.6	36.2	57.9	54.5	45.5
Jeep Cherokee84-	2404	UTE	MID	181.5	72.4	69.3	105.9	3873.2	32.7	43.7	59.4	55.5	44.5
Lamborghini	69038	CAR	COMPACT	176.0	80.3	44.1	104.3	3581.5	35.4	35.4	60.2	41.0	59.0
Land Rover County LWB/ Classic	62421	UTE	MID	185.4	74.4	71.7	108.3	4963.4	33.9	43.7	60.6	53.0	47.0
Land Rover Discovery	62401	UTE	MID	182.1	72.4	77.0	100.0	4518.2	33.1	48.2	59.6	47.0	53.0
Lexus ES- 250/ 300	59031	CAR	MID	190.2	70.5	54.7	105.1	3333.6	39.8	45.5	61.0	62.0	38.0
Lexus GS- 300	59034	CAR	LARGE	189.3	70.9	56.3	110.2	3567.7	32.8	46.5	60.6	53.5	46.5
Lexus LS- 400	59032	CAR	LARGE	196.8	72.0	56.3	112.2	3901.1	35.4	49.3	62.2	55.0	45.0
Lexus LX 450/ 470	59421	UTE	LARGE	192.5	76.4	72.8	112.2	5327.1	35.1	45.2	63.8	51.0	49.0
Lexus Other Auto	59398	0	0	189.2	70.9	55.9	110.2	3691.7	32.9	46.1	#N/A	#N/A	#N/A
Lexus RX300	59401	UTE	MID	180.2	71.6	65.5	103.1	3796.4	36.6	40.8	61.8	57.0	43.0
Lexus SC- 300/ 400	59033	CAR	LARGE	192.9	70.9	52.6	105.9	3603.5	40.4	46.9	#N/A	#N/A	#N/A
Lincoln Continental	13005	CAR	LARGE	208.7	73.6	55.9	109.1	3868.0	45.3	54.7	63.0	63.0	37.0
Lincoln TownCar/ Continental	13001	CAR	LARGE	214.6	77.8	57.7	116.8	4028.5	49.2	48.6	63.4	56.0	44.0
Lincoln Navigator	13421	UTE	LARGE	204.7	79.9	76.8	118.9	5582.7	37.8	47.2	65.4	53.0	47.0
Lotus	69039	CAR	COMPACT	173.6	74.0	45.3	96.1	3041.5	42.1	35.0	60.2	43.0	57.0
Mazda 626	41037	CAR	COMPACT	186.9	69.3	55.1	105.1	2893.3	38.3	43.1	59.4	62.5	37.5
Mazda GLC/ 323/ Protege	41035	CAR	COMPACT	174.0	67.2	55.0	102.8	2491.6	33.4	37.9	57.9	62.0	38.0
Mazda Miata	41045	CAR	COMPACT	155.3	66.1	48.3	89.2	2298.8	#N/A	#N/A	#N/A	#N/A	#N/A
Mazda Millenia	41047	CAR	MID	189.8	69.7	55.0	108.3	3297.2	37.0	44.5	59.8	63.5	36.5
Mazda MPV	41441	VAN	MID	183.5	72.0	70.3	110.6	3895.0	35.8	37.8	60.6	#N/A	#N/A
Mazda MX- 3	41046	CAR	COMPACT	155.5	66.1	48.4	89.4	2274.5	31.5	34.6	55.9	53.0	47.0
Mazda Pickup	41471	TRU	COMPACT	196.1	69.6	65.6	119.7	3317.6	33.5	43.0	58.7	#N/A	#N/A
MERCEDES BENZ 220/280 C	42042	CAR	MID	177.6	67.7	55.9	105.9	3331.3	31.9	39.8	60.2	55.0	45.0
MERCEDES BENZ CL	42046	CAR	LARGE	199.6	75.2	57.1	116.1	4826.8	35.8	47.6	63.4	#N/A	#N/A
MERCEDES BENZ CLK	42047	CAR	MID	180.3	67.7	54.1	105.9	3416.2	33.9	40.2	59.4	53.0	47.0

MERCEDES BENZE	42048	CAR	MID	189.6	70.9	56.7	111.4	3657.1	32.6	45.2	60.4	53.3	46.8
MERCEDES BENZ M	42401	UTE	MID	180.7	72.0	70.1	111.0	4330.9	33.1	36.6	60.6	54.0	46.0
MERCEDES BENZ S	42043	CAR	LARGE	204.3	74.4	58.6	122.8	4654.8	34.3	47.6	63.4	51.0	49.0
MERCEDES BENZ SL	42044	CAR	MID	177.2	71.3	51.2	99.2	4286.8	37.4	41.3	60.6	#N/A	#N/A
MERCEDES BENZ SLK	42045	CAR	COMPACT	157.5	67.7	50.8	94.5	2971.0	31.5	31.5	58.7	54.0	46.0
Mercury Cougar	14038	CAR	MID	185.0	69.7	52.4	106.3	2883.9	39.0	40.6	59.4	63.0	35.0
Mercury Marquis/ Monterey	14006	CAR	LARGE	211.9	78.3	56.8	114.6	3861.4	42.5	54.8	63.4	56.0	44.0
Mercury Mystique	14037	CAR	MID	184.7	69.2	54.4	106.6	2813.4	37.8	40.7	59.1	65.0	35.0
Mercury Sable	14017	CAR	MID	199.4	72.9	56.5	108.6	3409.6	41.5	49.5	61.6	65.0	35.0
Nissan 810/ Maxima	35039	CAR	MID	189.4	69.7	55.8	106.3	3026.5	39.5	44.1	59.1	63.0	37.0
Nissan Altima	35047	CAR	COMPACT	183.5	69.2	56.0	103.1	2900.2	37.7	42.8	59.4	63.0	37.0
Nissan Pathfinder	35401	UTE	COMPACT	179.3	70.2	66.0	106.3	3965.2	31.1	41.6	59.3	#N/A	#N/A
Nissan Pickup	35471	TRU	COMPACT	192.5	69.2	64.0	111.2	3421.3	34.4	50.6	57.5	#N/A	#N/A
Nissan Quest	35443	VAN	MID	194.8	74.9	65.3	112.2	3907.1	39.7	43.1	63.4	58.0	42.0
Nissan Sentra	35043	CAR	COMPACT	171.3	66.6	54.3	99.9	2492.4	35.2	36.7	58.3	63.0	37.0
Oldsmobile Alero	21024	CAR	MID	186.6	70.1	54.3	107.1	2964.4	40.2	40.2	59.1	64.0	36.0
Oldsmobile Aurora	21022	CAR	LARGE	205.5	74.4	55.5	113.8	3965.0	45.7	46.1	62.6	63.0	37.0
Oldsmobile Delta 88	21002	CAR	LARGE	200.4	74.0	55.5	110.6	3449.3	45.7	44.9	61.0	#N/A	#N/A
Oldsmobile Intrigue	21023	CAR	LARGE	196.1	73.6	56.7	109.1	3460.3	42.1	44.1	61.8	64.0	36.0
Oldsmobile Silhouette	21441	VAN	MID	194.5	72.0	67.7	116.1	3846.0	37.4	40.6	61.4	58.5	41.5
Plymouth Breeze	9038	CAR	MID	186.5	71.3	54.1	107.9	2995.2	37.3	41.5	60.2	63.0	37.0
Plymouth Gran Fury	9004	CAR	LARGE	199.6	75.6	68.5	119.3	4024.5	36.6	43.7	63.0	58.0	42.0
Plymouth Neon	9020	CAR	COMPACT	171.7	67.3	54.7	103.9	2491.6	34.3	34.1	57.5	#N/A	#N/A
Plymouth Prowler	9039	CAR	COMPACT	165.4	76.4	51.2	113.4	2836.5	23.6	29.1	62.2	45.0	55.0
Plymouth Voyager Minivan	9442	VAN	MID	189.6	76.2	68.5	114.8	3737.7	36.5	38.5	63.0	59.0	41.0
Pontiac Bonneville/ Catalina	22002	CAR	LARGE	200.4	74.4	55.9	110.6	3515.4	43.7	46.9	60.8	64.0	36.0
Pontiac Firebird/ Trans AM	22009	CAR	MID	182.9	71.0	53.1	98.9	3011.6	41.7	42.5	58.9	56.0	44.0
Pontiac Grand AM	22018	CAR	LARGE	186.2	70.5	55.1	106.7	3081.2	40.2	40.2	59.1	64.0	36.0
Pontiac Grand Prix	22020	CAR	LARGE	196.5	72.8	54.7	110.6	3426.5	42.9	43.3	61.8	65.0	35.0
Pontiac Sunbird	22012	CAR	COMPACT	181.8	68.4	53.7	103.9	2750.0	39.4	38.5	57.5	65.0	35.0
Pontiac Trans Sport	22441	VAN	MID	194.3	72.8	67.7	116.1	3835.0	38.2	40.7	61.4	58.5	41.5
Porsche 911	45031	CAR	COMPACT	174.4	69.7	51.6	92.5	2909.3	40.6	41.7	57.5	39.0	61.0
Porsche Boxster	45040	CAR	COMPACT	170.9	70.1	50.8	95.3	2814.5	40.2	35.4	57.9	46.0	54.0
ROLLS ROYCE/ BENTLEY	69042	CAR	LARGE	209.4	79.4	58.4	119.9	4260.0	#N/A	#N/A	62.2	51.0	49.0
Saab 9-3	47035	CAR	MID	181.9	67.3	56.3	102.8	3070.9	39.4	40.2	57.1	62.3	37.7
Saab 9-5	47036	CAR	MID	189.4	70.5	57.7	106.3	3478.6	39.4	43.7	59.8	62.0	38.0
Saturn SC	24002	CAR	COMPACT	179.9	67.3	52.4	102.4	2406.8	40.2	37.4	56.7	61.0	39.0
Saturn SL	24001	CAR	COMPACT	176.8	66.9	54.7	102.4	2357.2	38.2	37.0	56.7	61.0	39.0
Saturn SW	24003	CAR	COMPACT	176.8	66.9	55.1	102.4	2420.0	38.2	37.0	56.7	#N/A	#N/A
Subaru Forester	48401	UTE	COMPACT	175.2	68.5	63.0	99.2	3081.2	35.8	40.9	57.5	55.0	45.0
Subaru Impreza	48038	CAR	COMPACT	172.4	67.3	56.6	99.2	2802.9	35.2	38.4	57.5	57.0	43.0
Subaru Legacy	48034	CAR	COMPACT	183.5	67.7	57.7	103.5	3064.3	37.5	42.1	57.2	56.0	44.0
Suzuki Esteem	53035	CAR	COMPACT	167.6	66.4	54.9	97.6	2292.2	33.9	38.1	56.7	62.0	38.0
Suzuki Sidekick	53402	UTE	COMPACT	156.1	67.7	67.5	92.1	2887.2	30.1	33.8	57.9	54.0	46.0
Suzuki Swift	53034	CAR	COMPACT	149.5	62.6	54.7	93.2	1895.4	32.5	24.1	54.7	#N/A	#N/A
Toyota 4- Runner	49401	UTE	COMPACT	181.0	69.0	68.1	105.4	3801.8	34.5	41.5	59.4	55.0	45.0
Toyota Avalon	49043	CAR	MID	192.0	70.5	56.4	107.1	3432.7	39.1	46.3	61.0	62.0	38.0
Toyota Camry	49040	CAR	COMPACT	189.1	70.5	55.2	105.0	3132.4	38.7	45.6	61.0	62.3	37.8
Toyota Celica	49033	CAR	COMPACT	175.0	68.9	51.4	100.0	3431.9	39.0	36.0	59.8	63.0	37.0
Toyota Corolla	49032	CAR	COMPACT	174.0	66.8	54.2	97.1	2447.8	35.2	42.0	57.5	61.0	39.0
Toyota Landcruiser	49421	UTE	MID	192.5	76.4	73.2	112.2	5113.3	35.2	45.1	#N/A	#N/A	#N/A
Toyota Paseo	49042	CAR	COMPACT	163.7	65.4	50.6	93.7	2735.2	36.5	33.4	55.5	#N/A	#N/A
Toyota RAV- 4	49402	UTE	COMPACT	150.8	66.8	64.7	90.1	2692.6	29.2	31.5	57.5	56.0	44.0
Toyota Sienna	49442	VAN	MID	193.6	73.5	67.1	114.2	3722.9	37.7	41.9	61.8	58.0	42.0
Toyota Tacoma	49472	TRU	COMPACT	195.2	66.9	65.7	115.5	2964.0	32.0	47.7	57.1	#N/A	#N/A
Toyota Tercel	49038	CAR	COMPACT	162.6	65.4	53.7	93.7	2102.1	31.9	37.1	55.1	#N/A	#N/A
VOLKSWAGEN Beetle	30032	CAR	COMPACT	161.0	68.1	59.4	98.8	2816.7	32.3	29.1	59.4	63.0	37.0
VOLKSWAGEN Eurovan	30442	VAN	LARGE	193.8	72.4	77.6	120.2	4599.7	38.6	35.8	62.6	63.0	37.0
VOLKSWAGEN Golf	30042	CAR	COMPACT	162.8	68.1	56.5	98.5	2854.6	34.6	30.5	59.1	59.3	40.8
VOLKSWAGEN Jetta	30040	CAR	COMPACT	172.4	68.5	57.1	98.8	2879.9	34.6	39.0	59.4	60.3	39.7
VOLKSWAGEN Passat	30046	CAR	COMPACT	184.1	68.5	58.3	106.4	3350.5	37.4	40.6	59.1	60.3	46.3

Appendix C
NASS Case Investigation Forms

Figure C.01

U. S. Department of Transportation National
Highway Traffic Safety Administration

COLLISION DIAGRAM

National Automotive Sampling System
Crash Causation Special Study

PSU No. ____ ____ Case Number--Stratum ____ ____ ____ ____ Indica North

Scale: 1 centimeter=_______meters

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Figure C.01: Collision Diagram Form Page 1

Figure C.02

U.S. Department of Transportation
National Highway Traffic Safety Administration

COLLISION DIAGRAM MEASUREMENT TABLE

National Automotive Sampling System
Crash Causation Special Study

Primary Sampling Unit Number ____ ____ Case Number -- Stratum ____ ____ ____ ____

Collision Diagram

Document the physical plant:

- all road/roadway delineation (e.g., curbs/edge lines, lane markings, median markings, pavement markings, parked vehicles, poles, signs, etc.)
- all traffic controls (e.g., signs/signals, etc.)
- north arrow placed on diagram
- roadway surface type and condition of applicable roadways
- grade measurements for all applicable roadways and at location of rollover initiation
- roadway curvature (include measurement of pre-crash superelevation for each vehicle if applicable

Document vehicle dynamics including:

- reference point and reference line relative to physical features present at the scene
- scaled documentation of all crash induced physical evidence
- scaled documentation of all roadside objects contacted
- scaled representations of the vehicle(s) at pre-impact, impact, and final rest based upon either:
  - a) physical evidence, or
  - b) reconstructed crash dynamics

CRASH DATA

	Veh. #1	Veh. #2	Veh. #3
Heading Angle	____	____	____
Surface Type	____	____	____
Surface Condition	____	____	____
Coefficient of Friction	____	____	____
Grade (v/h) Measurement (between impact and final rest)	____	____	____
Grade (v/h) Measurement (at location of rollover initiation)	____	____	____
Grade (v/h) Measurement (at pre-crash location)	____	____	____

Reference Point: ______________________________

Reference Line: ______________________________

Item	Distance and Direction From Reference Point	Distance and Direction From Reference Line

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Figure C.02: Collision Diagram Measurement Form Page 1

Figure C.03

Item	Distance and Direction From Reference Point	Distance and Direction From Reference Line

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Figure C.03: Collision Diagram Measurement Form Page 2

Figure C.04

U.S. Department of Transportation
National Highway Traffic Safety Administration

GENERAL VEHICLE FORM

National Automotive Sampling System
Crash Causation Special Study

1. Primary Sampling Unit Number ___ ___

2. Case Number - Stratum ___ ___ ___ ___

3. Vehicle Number ___ ___

VEHICLE IDENTIFICATION

4. Vehicle Model Year ___ ___ ___ ___
Code all four digits of the model year
(9999) Unknown

5. Vehicle Make (specify): ___ ___
____
Applicable codes are found in your NASS Data Collection, Coding and Editing Manual.
(999) Unknown

6. Vehicle Model (specify): ___ ___ ___
____
Applicable codes are found in your NASS Data Collection, Coding and Editing Manual.
(999) Unknown

7. Body Type ___ ___
NOTE: Applicable codes may be found on the back of this page.

8. Vehicle Identification Number
__ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Left justify; Slash zeros and letter Z (0and Z)
No VIN – Code all zeros
Unknown – Code all nines

9. Vehicle Special Use (This Trip) ___
(0) No special use
(1) Taxi
(2) Vehicle used as school bus
(3) Vehicle used as other bus
(4) Military
(5) Police
(6) Ambulance
(7) Fire truck or car
(8) Other (specify): ________
(9) Unknown

OFFICIAL RECORDS

10. Police Reported Vehicle Disposition ___
(0) Not towed due to vehicle damage
(1) Towed due to vehicle damage
(9) Unknown

11. Police Reported Travel Speed ___ ___ ___
Code to the nearest kmph (NOTE: 000 means Less than 0.5 kmph)
(200) 199.5 kmph and above
(999) Unknown
___ ___mph X 1.6093 = ___ ___ ___kmph

12. Speed Limit ___ ___ ___
(000) No statutory limit
Code posted or statutory speed limit in kmph
(000) No statutory limit
(999) Unknown
___ ___mph X 1.6093 = ___ ___ ___kmph

13. Reported Alcohol Presence For Driver ___
(0) No alcohol present
(1) Yes alcohol present
(7) Not reported
(8) No driver present
(9) Unknown

Source of Alcohol Report ___
(1) Police
(2) Company
(8) Other (specify): ________________
____
(9) Unknown

Time Delay (between crash and alcohol test)
___ ___ : ___ ___ (hours/minutes)
97:97 Not applicable
99:99 Unknown

14. Alcohol Test Result For Driver ___ ___
Code actual value (decimal implied before first digit – 0.xx)
(94) Test refused
(95) None given
(96) AC test performed, results unknown
(97) Not applicable
(98) No driver present
(99) Unknown

15. Police Reported Other Drug Presence For Driver ___
(0) No other drug(s) present
(1) Yes other drug(s) present
(7) Not reported
(8) No driver present
(9) Unknown

16. Other Drug specimen Test Result For Driver ___
(0) No specimen test given
(1) Drug(s) not found in specimen
(2) Drug(s) found in specimen
(specify): ________________
(3) Specimen test given, results unknown or not obtained
(8) No driver present
(9) Unknown if specimen test given

17. Violations Charged ___ ___ ___ ___ ___ ___
As A Result Of This Crash (Code up to three.):
(00) None

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Figure C.04: General Vehicle Form Page 1

Figure C.05

National Automotive Sampling System – Crash Causation Special Study: General Vehicle Form Page 2

CODES FOR BODY TYPE

CDS APPLICABLE VEHICLES

Automobiles
- (01) Convertible (excludes sun-roof, t-bar)
- (02) 2-door sedan, hardtop, coupe
- (03) 3-door/2-door hatchback
- (04) 4-door sedan, hardtop
- (05) 5-door/4-door hatchback
- (06) Station wagon (excluding van and truck based)
- (07) Hatchback, number of doors unknown
- (08) Other automobile type (specify): ____________
- (09) Unknown automobile type

Automobile Derivatives
- (10) Auto based pickup (includes El Camino, Caballero, Ranchero, Brat, and Rabbit (pickup)
- (11) Auto based panel (cargo station wagon, auto based ambulance/hearse)
- (12) Large limousine - more than four side doors or stretched chassis
- (13) Three-wheel automobile or automobile derivative

Utility Vehicles (≤ 4,536 kgs GVWR)
- (14) Compact utility (Jeep- CJ-2-7, Scrambler, Golden Eagle, Renegade, Laredo, Wrangler, Cherokee (84 and after), Dispatcher, Raider, Bronco II, Bronco (76 and before), Explorer, S-10 Blazer, Geo Tracker, Bravada, S-15 Jimmy, Thing, Pathfinder, Trooper, Trooper II, Roadeo, Amigo, Navajo, 4-Runner, Montero, Passport, Samurai, Sidekick, Rocky)
- (15) Large utility (includes Jeep Cherokee [83 and before], Ramcharger, Trailduster, Bronco-fullsize, Jimmy, Hummer, Landcruiser, Rover, Scout, Yukon)
- (16) Utility station wagon (Chevy Suburban, GMC Suburban, Travelall, Grand Wagoneer, includes suburban limousine)
- (19) Utility, unknown body type

Van Based Light Trucks (≤ 4,536 kgs GVWR)
- (20) Minivan (Town and Country, Caravan, Grand Caravan, Voyager, Grand Voyager, Mini-Ram, Vista, Aerostar, Windstar, Villager, Lumina APV, Trans Sport, Silhouette, Astro, Safari, Toyota Van, Toyota Minivan, Previa, Nissan Minivan, Quest, Mitsubishi Minivan, Expo Wagon, Vanagon/Camper.)
- (21) Large van (B150-B350, Sportsman, Royal, Maxiwagon, Ram, Tradesman, Voyager (83 and before), E150-E350, Econline, Clubwagon, Chateau, G10-G30, Chevy Van, Beauville, Sport Van, G15-G35, Rally Van, Vandura.)
- (22) Step van or walk-in van (≤ 4,536 kgs GVWR)
- (23) Van based motorhome (≤ 4,536 kgs GVWR)
- (24) Van based school bus (≤ 4,536 kgs GVWR)
- (25) Van based other bus (≤ 4,536 kgs GVWR)
- (28) Other van type (Hi-Cube Van, Kary) (specify): ____________
- (29) Unknown van type

Light Conventional Trucks (Pickup style cab, ≤ 4,356 kgs GVWR)
- (30) Compact pickup (D50, Colt P/U, Ram 50, Dakota, Arro Pickup ([foreign], Ranger, Courier, S-10, T-10, LUV, S-15, T-15, Sonoma, Datsun/Nissan Pickup, P'up,
- (31) Large Pickup (Jeep Pickup, Comanche, Ram Pickup, D100-D350, W100-W350, F100-F350, C10-C35, K10-K35, R10-R35, V10-V35, Silverado, Sierra, R100-R500, T100)
- (32) Pickup with slide-in camper
- (33) Convertible pickup
- (39) Unknown pickup style light conventional truck type

Other Light Trucks (≤ 4,356 kgs GVWR)
- (40) Cab chassis based (includes rescue vehicles, light stake, dump, and tow truck)
- (41) Truck based panel
- (42) Light truck based motorhome (chassis mounted)
- (45) Other light conventional truck type
- (48) Unknown light truck type
- (49) Unknown light vehicle type (automobile, utility, van,
- (49) Unknown light vehicle type (automobile, utility, van, or light truck)

OTHER VEHICLES

Buses (Excluded Van Based)
- (50) School bus (designed to carry students, not cross country or transit)
- (58) Other bus type (e.g., transit, intercity, bus based motorhome) (specify) ____________
- (59) Unknown bus type

Medium/Heavy Trucks (> 4,536 kgs GVWR)
- (60) Step van (> 4,536 kgs GVWR)
- (61) Single unit straight truck (4,536 kgs < GVWR ≤ 8,845 kgs GVWR)
- (62) Single unit straight truck (8,845 kgs < GVWR ≤ 11,793 kgs)
- (63) Single unit straight truck (> 11,793 kgs GVWR)
- (64) Single unit straight truck, GVWR unknown
- (65) Medium/heavy truck based motorhome
- (67) Truck-tractor with no cargo trailer
- (68) Truck-tractor pulling one trailer
- (69) Truck-tractor pulling two or more trailers
- (70) Truck-tractor (unknown if pulling trailer)
- (78) Unknown medium/heavy truck type
- (79) Unknown truck type (light/medium/heavy)

Motor Cycles (Does Not Include All-Terrain Vehicles/Cycles)
- (80) Motorcycle
- (81) Moped (motorized bicycle)
- (82) Three-wheel motorcycle or moped
- (88) Other motored cycle (minibike, motorscooter) (specify): ____________
- (89) Unknown motored cycle type

Other Vehicles
- (90) ATV (All-Terrain Vehicle) and ATC (All-Terrain Cycle)
- (91) Snowmobile
- (92) Farm equipment other than trucks
- (93) Construction equipment other than trucks
- (97) Other vehicle type
- (99) Unknown body type

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Figure C.05: General Vehicle Form Page 2

Figure C.06

National Automotive Sampling System – Crash Causation Special Study: General Vehicle Form Page 3

Reckless/Careless/Hit-and-Run Type Offenses
(01) Manslaughter or homicide
(02) Willful reckless driving; driving to endanger, negligent driving
(03) Unsafe reckless (not willful, wanton reckless) driving
(04) Inattentive, careless, improper driving
(05) Fleeing or eluding police
(06) Failure to obey police, fireman, authorized person directing traffic
(07) Hit-and-run, failure to stop after accident
(08) Failure to give aid, info, wait for police after accident
(09) Serious violation resulting in death

Impairment Offenses
(11) Driving while intoxicated (alcohol or drugs) or BAC above limit (any detectable BAC for CDLs)
(12) Driving while impaired
(13) Driving under influence of substance not intended to intoxicate
(14) Drinking while operating
(15) Illegal possession of alcohol or drugs
(16) Driving with detectable alcohol
(18) Refusal to submit to chemical test
(19) Alcohol, drug or impairment violations generally

Speed-Related Offenses
(21) Racing
(22) Speeding (above the speed limit)
(23) Speed greater than reasonable & prudent (not necessarily over the limit)
(24) Exceeding special speed limit (e.g.: for trucks, buses, cycles, or on bridge, in school zone, etc.)
(25) Energy speed (exceeding 55 mph, non-pointable)
(26) Driving too slowly
(29) Speed related violations, generally

Rules of the Road - Traffic Sign & Signals
(31) Failure to stop for red signal
(32) Failure to stop for flashing red
(33) Violation of turn on red (failure to stop & yield, yield to pedestrians before turning)
(34) Failure to obey flashing signal (yellow or red)
(35) Failure to obey signal, generally

Rules of the Road - Traffic Sign & Signals
(36) Violate RR grade crossing device/regulations
(37) Failure to obey stop sign
(38) Failure to obey yield sign
(39) Failure to obey traffic control device, generally

Rules of the Road - Turning, Yielding, Signaling
(41) Turn in violation of traffic control (disobey signs, turn arrow or pavement markings; this is not a right-on red violation)
(42) Improper method & position of turn (too wide, wrong lane)
(43) Failure to signal for turn or stop
(45) Failure to yield to emergency vehicle
(46) Failure to yield, generally
(48) Enter intersection when space insufficient
(49) Turn, yield, signaling violations, generally

Rules of the Road - Wrong Side, Passing & Following
(51) Driving wrong way on one-way road
(52) Driving on left, wrong side of road, generally
(53) Improper, unsafe passing
(54) Pass on right (drive off pavement to pass)
(55) Pass stopped school bus
(56) Failure to give way when overtaken
(58) Following too closely
(59) Wrong side, passing, following violations, generally

Rules of the Road - Lane Usage
(61) Unsafe or prohibited lane change
(62) Improper use of lane (center of 3-lane road, HOV designated lane)
(63) Certain traffic to use right lane (trucks, slow-moving, etc.)
(66) Motorcycle lane violations (more than two per lane, riding between lanes, etc.)
(67) Motorcyclist attached to another vehicle

Non-Moving - License and Registration Violations
(71) Driving while license withdrawn (including violation of provisions of work permit)
(72) Other driver license violations
(73) Commercial driver violations (log book, hours, permits carried)
(74) Vehicle registration violations
(75) Failure to carry insurance card
(76) Driving uninsured vehicle
(79) Non-moving violations, generally

Equipment
(81) Lamp violations
(82) Brake violations
(83) Failure to require restraint use (by self or passengers)
(84) Motorcycle equipment violations (helmet, special equipment)
(85) Violation of hazardous cargo regulations
(86) Size, weight, load violations
(89) Equipment violations, generally

License, Registration & Other Violations
(91) Parking
(92) Theft, unauthorized use of motor vehicle
(93) Driving where prohibited (sidewalk, limited access, off truck route)
(98) Other moving violation (coasting, backing, opening door)
(99) Unknown VIOLATION/Unknown if violation occurred

18. Driver's Zip Code ___ ___ ___ ___ ___

(00001) Driver not a resident of U.S. or territories

______ Code actual 5-digit zip code
(99998) No driver present
(99999) Unknown

19. Driver's Race/Ethnic Origin _____
(1) White (non-Hispanic)
(2) Black (non-Hispanic)
(3) White (Hispanic)
(4) Black (Hispanic)
(5) American Indian, Eskimo or Aleut
(6) Asian or Pacific Islander
(7) Other (specify): ____________
(8) No driver present
(9) Unknown

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Figure C.06: General Vehicle Form Page 3

Figure C.07

National Automotive Sampling System – Crash Causation Special Study: General Vehicle Form **Page 4**

PRECRASH ENVIRONMENTAL DATA

20. Relation To Roadway ____
    (1) On roadway
    (2) Shoulder
    (3) Median
    (4) Roadside
    (5) Outside right-of-way
    (6) Off roadway - location unknown
    (7) In parking lane
    (8) Gore
    (9) Unknown

21. Relation To Junction ____ ____
    Noninterchange:
    (01) Nonjunction
    (02) Intersection
    (03) Intersection related
    (04) Driveway, alley access, etc.
    (05) Entrance/exit ramp related
    (06) Rail grade crossing
    (07) In crossover
    (09) Unknown, noninterchange
    Interchange area:
    (10) Intersection
    (11) Intersection related
    (12) Driveway, alley access, etc.
    (13) Entrance/exit ramp related
    (14) In crossover
    (15) Other location in interchange
    (19) Unknown, interchange area
    (99) Unknown

22. Intersection Type ____ ____
    (00) Nonintersection (and not intersection related)
    (01) Signalized cross intersection
    (02) Cross intersection with right turn lane(s) and stop control on minor street
    (03) Cross intersection with left turn Lane(s) and stop control on minor street
    (04) Cross intersection with left/right turn lanes and stop control on minor street
    (05) Cross intersection with no turning lanes and stop control on minor street
    (06) Signalized Tee intersection
    (07) Tee intersection with turn lanes and stop control on minor street
    (08) Tee intersection with no turn lanes and stop control on minor street
    (98) Other (specify): ____________________
    (99) Unknown

23. Trafficway Flow ____
    (0) Not physically divided (two way traffic)
    (1) Divided trafficway-median strip without positive barrier
    (2) Divided trafficway-median strip with positive barrier
    (3) One way traffic
    (9) Unknown

24. Trafficway Flow Restrictions ____
    (0) No restrictions
    (1) Work zone
    (2) Roadway immersed
    (3) Prior crash
    (4) Congestion
    (5) Dust storm
    (8) Other (specify): ____________________
    (9) Unknown

25. Number of Travel Lanes ____
    (1) One
    (2) Two
    (3) Three
    (4) Four
    (5) Five
    (6) Six
    (7) Seven or More
    (9) Unknown

26. Access Control ____
    (1) Full control
    (2) No control
    (3) Other
    (9) Unknown

27. Route Signing ____
    (1) Interstate
    (2) U.S. highway
    (3) State highway
    (4) County road
    (5) Township
    (6) Municipality
    (7) Frontage road
    (8) Other
    (9) Unknown

28. Trafficway Functional Class ____ ____
    (01) Rural principal arterial - Interstate
    (02) Rural principal arterial - other
    (03) Rural minor arterial
    (04) Rural major collector
    (05) Rural minor collector
    (06) Rural local
    (09) Rural unknown
    (11) Urban principal arterial – Interstate
    (12) Urban principle arterial – Freeways and Expressways
    (13) Urban principal arterial - other
    (14) Urban minor arterial
    (15) Urban collector
    (16) Urban local
    (19) Urban unknown
    (99) Unknown

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Figure C.07: General Vehicle Form Page 4

Figure C.08

National Automotive Sampling System – Crash Causation Special Study: General Vehicle Form **Page 5**

PRECRASH ENVIRONMENTAL DATA

29. Roadway Class ____ ____
    - (01) Rural Freeway (> four lanes)
    - (02) Rural Freeway (≤ four lanes)
    - (03) Rural multi-lane divided, non-Freeway
    - (04) Rural multi-lane undivided, non-Freeway
    - (05) Rural two-lane road
    - (09) Rural unknown
    - (11) Urban Freeway (> four lanes)
    - (12) Urban Freeway (≤ four lanes)
    - (13) Urban multi-lane divided, non-Freeway
    - (14) Urban multi-lane undivided, non-Freeway
    - (15) Urban two-lane road
    - (19) Urban unknown
    - (99) Unknown

30. Roadway Alignment ____
    - (1) Straight
    - (2) Curve right
    - (3) Curve left
    - (9) Unknown

31. Roadway Profile ____
    - (1) Level
    - (2) Uphill grade (> 2%)
    - (3) Hill crest
    - (4) Downhill grade (> 2%)
    - (5) Sag
    - (9) Unknown

32. Roadway Surface Type ____
    - (1) Concrete
    - (2) Bituminous (asphalt)
    - (3) Brick or block
    - (4) Slag, gravel, or stone
    - (5) Dirt
    - (8) Other (specify): ____________
    - (9) Unknown

33. Roadway Surface Condition ____
    - (1) Dry
    - (2) Wet
    - (3) Snow or slush
    - (4) Ice
    - (5) Sand, dirt, or oil
    - (8) Other (specify): ____________
    - (9) Unknown

34. Roadway Surface Defects ____
    - (0) No defects noted
    - (1) Defect noted (specify): : ____________
    - (9) Unknown

35. Shoulder Surface Type ____
    - (0) No stabilized shoulder
    - (1) Concrete
    - (2) Bituminous (asphalt)
    - (3) Brick or block
    - (4) Slag, gravel, or stone
    - (5) Dirt
    - (8) Other (specify): ____________
    - (9) Unknown

36. Shoulder Width ____
    - (0) No stabilized shoulder
    - (1) < 1 meter
    - (2) > 1 ≤ 2 meters
    - (3) > 2 ≤ 3 meters
    - (4) > 3 meters
    - (9) Unknown

    ___ ___ ___ ft. x 0.3048 = ___ ___ . ___ m

37. Rumble Strip Type/Involvement ____
    - (0) No rumble strip present
    - (1) Raised rumble strip/no precrash departure
    - (2) Raised rumble strip/partial precrash departure
    - (3) Raised rumble strip/full precrash departure
    - (4) Depressed rumble strip/no precrash departure
    - (5) Depressed rumble strip/partial precrash departure
    - (6) Depressed rumble strip/full precrash departure
    - (8) Other (specify): ____________
    - (9) Unknown

38. Roadway Design Deficiencies ____
    - (0) No deficiencies noted
    - (1) Inappropriate signage speeds (i.e., appropriate for autos, not heavy trucks)
    - (2) Insufficient crown
    - (3) Excessive crown
    - (4) Insufficient superelevation
    - (5) Excessive superelevation
    - (6) Excessive curvature (i.e., short radius)
    - (7) No shoulder/Breakdown lane
    - (8) Other (specify): ____________
    - (9) Unknown

39. Sight Line Restriction (this vehicle) ____
    - (1) Yes (specify location; e.g., straight ahead, to left, etc.) ____________
    - (2) No
    - (9) Unknown

    Record, measured sight distance ___ ___ ___ ___ . ___ m
    ___ ___ ___ ___ . ___ ft x 0.3048 ___ ___ ___ ___ . ___ m

    AASHTO Recommended Sight Distance ___ ___ ___ ___ . ___ m
    ___ ___ ___ ___ . ___ ft x 0.3048 ___ ___ ___ ___ . ___ m

40. Light Conditions ____
    - (1) Daylight
    - (2) Dark
    - (3) Dark, but lighted
    - (4) Dawn
    - (5) Dusk
    - (9) Unknown

41. Atmospheric Conditions ____ ____ ____
    (Code up to three conditions.)
    - (0) No adverse atmospheric-related driving conditions
    - (1) Rain
    - (2) Snow
    - (3) Fog
    - (4) Wind gust
    - (5) Hail
    - (6) Sleet
    - (7) Dust
    - (8) Other (specify): ____________
    - (9) Unknown

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Figure C.08: General Vehicle Form Page 5

Figure C.09

National Automotive Sampling System – Crash Causation Special Study: General Vehicle Form Page 6

PRECRASH ENVIRONMENTAL DATA

42. Traffic Control Device ____ ____
    - (00) No traffic control device
    - (01) Traffic control signal (on colors) without pedestrian signal
    - (02) Traffic control signal (on colors) with pedestrian signal
    - (03) Traffic control signal (on colors) not known whether or not pedestrian signal
    - (04) Flashing traffic control signal
    - (05) Flashing beacon
    - (06) Flashing highway traffic signal, type unknown or other than traffic control or beacon
    - (07) Lane use control signal
    - (08) Other highway traffic signal
    - (09) Unknown highway traffic signal

Regulatory signs
- (20) Stop sign
- (21) Yield sign
- (28) Other regulatory sign
- (29) Unknown type regulatory sign

School zone signs
- (30) School speed limit sign
- (31) School advance or crossing sign
- (38) Other school related sign
- (39) Unknown type school zone sign

Warning signs
- (40) Warning sign

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

At Railroad Grade Crossing

Active devices
- (60) Gates
- (61) Flashing lights
- (62) Traffic control signal
- (63) Wigwags
- (64) Bells
- (68) Other train activated device
- (69) Active device, type unknown

Passive devices
- (70) Cross-bucks
- (71) Stop sign
- (72) Other railroad crossing sign
- (73) Special warning device - watchman, flagged by crew
- (78) Other passive device
- (79) Passive device, type unknown

Miscellaneous devices at railroad crossing
- (80) Grade crossing controlled, type unknown

Whether Or Not At Railroad Grade Crossing
- (98) Other (specify): ____________________
- (99) Unknown

43. Traffic Control Device Functioning ____
    - (0) No traffic control device
    - (1) Traffic control device not functioning (specify): ____________________
    - (2) Traffic control device functioning properly
    - (9) Unknown

44. Manner Of Collision ____
    - (0) Not a collision with a motor-vehicle in transit
    - (1) Rear-end
    - (2) Head-on
    - (3) Rear-to-rear
    - (4) Angle
    - (5) Sideswipe - same direction
    - (6) Sideswipe - opposite direction
    - (8) Other (specify): ____________________
    - (9) Unknown

45. First Harmful Event (Choose One): ____ ____
    - (01) Overturn)
    - (02) Fire/explosion
    - (03) Immersion
    - (04) Gas inhalation
    - (05) Fell from vehicle
    - (06) Injured in vehicle
    - (07) Other noncollision
    - (08) Pedestrian
    - (09) Pedalcycle
    - (10) Railway train
    - (11) Animal
    - (12) Motor vehicle in transport
    - (13) Motor vehicle in transport in other roadway
    - (14) Parked motor vehicle
    - (15) Other type nonmotorist
    - (16) Thrown or falling object
    - (17) Boulder
    - (18) Other object (not fixed)
    - (19) Building
    - (20) Impact attenuator/crash cushion
    - (21) Bridge pier or abutment
    - (22) Bridge parapet end
    - (23) Bridge rail
    - (24) Guardrail
    - (25) Concrete traffic barrier
    - (26) Other longitudinal barrier type
    - (27) Highway/traffic sign post
    - (28) Overhead sign support
    - (29) Luminaire/light support
    - (30) Utility pole
    - (31) Other post, pole or supports
    - (32) Culvert
    - (33) Curb
    - (34) Ditch
    - (35) Embankment - earth
    - (36) Embankment - rock, stone or concrete
    - (37) Embankment - material type unknown
    - (38) Fence
    - (39) Wall
    - (40) Fire hydrant
    - (41) Shrubbery
    - (42) Tree
    - (43) Other fixed object
    - (44) Pavement surface irregularity (pothole, grooved, grates)
    - (45) Transport device used as equipment
    - (46) Traffic signal support
    - (99) Unknown

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Figure C.09: General Vehicle Form Page 6

Figure C.10

National Automotive Sampling System – Crash Causation Special Study: General Vehicle Form Page 7

VEHICLE WEIGHT ITEMS

46. Vehicle Curb Weight ____ ____ , ____ ____0
____ Code weight to nearest 10 kilograms.
(0000) Less than 5 kilograms
(9999) Unknown
__ __ , __ __ __lbs x .4536= __ __ , __ __ __kgs
Source:____

47. Vehicle Cargo Weight ____ ____ , ____ ____0
____ Code weight to nearest 10 kilograms.
(0000) Less than 5 kilograms
(9999) Unknown
__ __ , __ __ __lbs x .4536= __ __ , __ __ __kgs
Source:____

52. Location on Vehicle Where Initial Principal Tripping Force is Applied (cont.)
(5) Other location on vehicle (specify):
____
(6) Non-contact rollover forces (specify):
____
(8) Rollover - - end-over-end
(9) Unknown

53. Direction of Initial Roll ____
(0) No rollover
(1) Roll right - primarily about the longitudinal axis
(2) Roll left - primarily about the longitudinal axis
(8) Rollover - - end-over-end
(9) Unknown roll direction

ROLLOVER DATA

48. Rollover ____ ____
(00) No rollover (no overturning)
Rollover (primarily about the longitudinal axis)
(01-16) Code the number of quarter turns
(17) Rollover, 17 or more quarter turns (specify):____
(98) Rollover - -end-over-end (i.e., primarily about the lateral axis)
(99) Rollover (overturn), details unknown

49. Rollover Initiation Type ____ ____
(00) No rollover
(01) Trip-over
(02) Flip-over
(03) Turn-over
(04) Climb-over
(05) Fall-over
(06) Bounce-over
(07) Collision with another vehicle
(08) Other rollover initiation type (specify):
____
(98) Rollover - -end-over-end
(99) Unknown rollover initiation type

50. Location of Rollover Initiation ____
(0) No rollover
(1) On roadway
(2) On shoulder - paved
(3) On shoulder - unpaved
(4) On roadside or divided trafficway median
(8) Rollover - - end-over-end
(9) Unknown

51. Rollover Initiation Object Contacted ____ ____
(Note: Applicable codes on back of page)

52. Location on Vehicle Where Initial Principal Tripping Force is Applied ____
(0) No rollover
(1) Wheels/tires
(2) Side plane
(3) End plane
(4) Undercarriage

FIRE OCCURRENCE

54. Fire Occurrence ____
(0) No fire
Yes, fire occurred
(1) Minor
(2) Major
(9) Unknown

55. Origin of Fire ____
(0) No fire
(1) Vehicle exterior (front, side, back, top)
(2) Exhaust system
(3) Fuel tank (and other fuel retention system parts)
(4) Engine compartment
(5) Cargo/trunk compartment/trailer
(6) Instrument panel
(7) Passenger compartment/cab area
(8) Other location (specify):
____
(9) Unknown

UNDERRIDE/OVERRIDE OCCURRENCE

56. Underride/Override (This Vehicle) ____
(0) No underride or override
With Motor Vehicle in Transport
(1) Underride, compartment intrusion
(2) Underride, no compartment intrusion
(3) Underride, compartment intrusion unknown
With Other Vehicle Not In Transport
(4) Underride, compartment intrusion
(5) Underride, no compartment intrusion
(6) Underride, compartment intrusion unknown

(7) Override, motor vehicle in transport
(8) Override, other vehicle not in transport
(9) Unknown if underride or override

Underride/Override Occurrence Notes:

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Figure C.10: General Vehicle Form Page 7

Figure C.11

National Automotive Sampling System – Crash Causation Special Study: General Vehicle Form Page 8

CODES FOR ROLLOVER INITIATION OBJECT CONTACTED

(00) No rollover
(01-30) - Vehicle Number

Noncollision
(31) Turn-over fall-over
(32) No rollover impact initiation (end-over-end)
(34) Jackknife

Collision With Fixed Object
(41) Tree (≤ 10 cm in diameter)
(42) Tree (> 10 cm in diameter)
(43) Shrubbery or bush
(44) Embankment
(45) Breakaway pole or post (any diameter)

Nonbreakaway Pole or Post
(50) Pole or post (≤ 10 cm in diameter)
(51) Pole or post (> 10 cm in diameter
(52) Pole or post (>30 cm in diameter)
(53) Pole or post (diameter unknown)
(54) Concrete traffic barrier
(55) Impact attenuator
(56) Other traffic barrier (includes guardrail) (specify):________________________
(57) Fence
(58) Wall
(59) Building
(60) Ditch or culvert
(61) Ground
(62) Fire hydrant
(63) Curb
(64) Bridge
(68) Other fixed object (specify): ________________________
(69) Unknown fixed object

Collision With Nonfixed Object
(70) Passenger car, light truck, van, or other vehicle not in-transport
(71) Medium/heavy truck or bus not in-transport
(76) Animal
(77) Train
(78) Trailer, disconnected in-transport
(79) Object fell from vehicle in-transport
(88) Other nonfixed object (specify): ________________________
(89) Unknown nonfixed object
(98) Other event (specify): ________________________
(99) Unknown event or object

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Figure C.11: General Vehicle Form Page 8

Figure C.12

EXTERIOR VEHICLE FORM NATIONAL AUTOMOTIVE SAMPLING SYSTEM CRASH CAUSATION SPECIAL STUDY

1. Primary Sampling Unit Number ___ ___
2. Case Number - Stratum ___ ___ ___ ___
3. Vehicle Number ___ ___

VIN ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ Model Year ___ ___

Vehicle Make (specify): ____________ Vehicle Model (specify): ____________

Locate the end of the damage with respect to the vehicle's damaged center point or bumper corner for end impacts or an undamaged axle for side impacts.

Specific Impact No.	Location of Direct Damage	Location of Field L	Location of Max Crush

NOTES: Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, etc.) and label adjustments (e.g., free space).

Measure C1 to C6 from driver to passenger side in front or rear impacts and rear to front in side impacts.

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

Use as many lines/columns as necessary to describe each damage profile.

Specific Impact Number	Plane of Impact C-Measurements	Direct Damage Width (CDC)	Direct Damage Max Crush	Field L	C_1	C_2	C_3	C_4	C_5	C_6	±D

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Figure C.12: Exterior Vehicle Form Page 1

Figure C.13

National Automotive Sampling System-Crash Causation Special Study: Exterior Vehicle Form **Page 2**

Wheelbase	___ ___ ___.___	inches	x	2.54	=	___ ___ ___cm
Overall Length	___ ___ ___.___	inches	x	2.54	=	___ ___ ___cm
Maximum Width	___ ___ ___.___	inches	x	2.54	=	___ ___ ___cm
Curb Weight	___ ___,___ ___ ___	pounds	x	.4536	=	___,___ ___ ___ kg
Average Track	___ ___ ___.___	inches	x	2.54	=	___ ___ ___cm
Front Overhang	___ ___ ___.___	inches	x	2.54	=	___ ___ ___cm
Rear Overhang	___ ___ ___.___	inches	x	2.54	=	___ ___ ___cm
Undeformed End Width	___ ___ ___.___	inches	x	2.54	=	___ ___ ___cm
Engine Size: cyl./displ.	___ ___ ___ ___	cc	x	.001	=	___.___ L
	___ ___ ___	CID	x	.0164	=	___.___ L

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Figure C.13: Exterior Vehicle Form Page 2

Figure C.14

National Automotive Sampling System-Crash Causation Special Study: Exterior Vehicle Form **Page 4**

CODES FOR OBJECT CONTACTED

(01-30) — Vehicle Number

Noncollision
- (31) Overturn — rollover (excludes end-over-end)
- (32) Rollover—end-over-end
- (33) Fire or explosion
- (34) Jackknife
- (35) Other intraunit damage (specify): ____________
- (36) Noncollision injury
- (38) Other noncollision (specify): ____________
- (39) Noncollision — details unknown

Collision With Fixed Object
- (41) Tree (≤ 10 cm in diameter)
- (42) Tree (> 10 cm in diameter)
- (43) Shrubbery or bush
- (44) Embankment
- (45) Breakaway pole or post (any diameter)

Nonbreakaway Pole or Post
- (50) Pole or post (≤ 10 cm in diameter)
- (51) Pole or post (> 10 cm but ≤ 30 cm in diameter)
- (52) Pole or post (> 30 cm in diameter)
- (53) Pole or post (diameter unknown)
- (54) Concrete traffic barrier
- (55) Impact attenuator
- (56) Other traffic barrier (includes guardrail) (specify):____________
- (57) Fence
- (58) Wall
- (59) Building
- (60) Ditch or culvert
- (61) Ground
- (62) Fire hydrant
- (63) Curb
- (64) Bridge
- (68) Other fixed object (specify): ____________
- (69) Unknown fixed object

Collision with Nonfixed Object
- (70) Passenger car, light truck, van, or other vehicle not in-transport
- (71) Medium/heavy truck or bus not in-transport
- (72) Pedestrian
- (73) Cyclist or cycle
- (74) Other nonmotorist or conveyance ____________
- (75) Vehicle occupant
- (76) Animal
- (77) Train
- (78) Trailer, disconnected in transport
- (79) Object fell from vehicle in-transport
- (88) Other nonfixed object (specify): ____________
- (89) Unknown nonfixed object
- (98) Other event (specify): ____________
- (99) Unknown event or object

DEFORMATION CLASSIFICATION BY EVENT NUMBER

Accident Event Sequence Number	Object Contacted	(1) (2) Direction of Force (degrees)	Incremental Value of Shift	(3) Deformation Location	(4) Specific Longitudinal or Lateral Location	(5) Specific Vertical or Lateral Location	(6) Type of Damage Distribution	(7) Deformation Extent
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __

Figure C.14: Exterior Vehicle Form Page 3

Figure C.15

National Automotive Sampling System-Crash Causation Special Study: Exterior Vehicle Form Page 4

CODES FOR OBJECT CONTACTED

(01-30) — Vehicle Number

Noncollision
- (31) Overturn — rollover (excludes end-over-end)
- (32) Rollover—end-over-end
- (33) Fire or explosion
- (34) Jackknife
- (35) Other intraunit damage (specify): ____
- (36) Noncollision injury
- (38) Other noncollision (specify): ____
- (39) Noncollision — details unknown

Collision With Fixed Object
- (41) Tree (≤ 10 cm in diameter)
- (42) Tree (> 10 cm in diameter)
- (43) Shrubbery or bush
- (44) Embankment
- (45) Breakaway pole or post (any diameter)

Nonbreakaway Pole or Post
- (50) Pole or post (≤ 10 cm in diameter)
- (51) Pole or post (> 10 cm but ≤ 30 cm in diameter)
- (52) Pole or post (> 30 cm in diameter)
- (53) Pole or post (diameter unknown)
- (54) Concrete traffic barrier
- (55) Impact attenuator
- (56) Other traffic barrier (includes guardrail) (specify): ____
- (57) Fence
- (58) Wall
- (59) Building
- (60) Ditch or culvert
- (61) Ground
- (62) Fire hydrant
- (63) Curb
- (64) Bridge
- (68) Other fixed object (specify): ____
- (69) Unknown fixed object

Collision with Nonfixed Object
- (70) Passenger car, light truck, van, or other vehicle not in-transport
- (71) Medium/heavy truck or bus not in-transport
- (72) Pedestrian
- (73) Cyclist or cycle
- (74) Other nonmotorist or conveyance ____
- (75) Vehicle occupant
- (76) Animal
- (77) Train
- (78) Trailer, disconnected in transport
- (79) Object fell from vehicle in-transport
- (88) Other nonfixed object (specify): ____
- (89) Unknown nonfixed object
- (98) Other event (specify): ____
- (99) Unknown event or object

DEFORMATION CLASSIFICATION BY EVENT NUMBER

Accident Event Sequence Number	Object Contacted	(1) (2) Direction of Force (degrees)	Incremental Value of Shift	(3) Deformation Location	(4) Specific Longitudinal or Lateral Location	(5) Specific Vertical or Lateral Location	(6) Type of Damage Distribution	(7) Deformation Extent
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __
__ __	__ __	__ __ __	__ __	__	__	__	__	__ __

Figure C.15: Exterior Vehicle Form Page 4

Figure C.16

National Automotive Sampling System-Crash Causation Special Study: Exterior Vehicle Form — Page 5

CODES FOR VEHICLE COMPONENTS/SUBSYSTEMS

(00) No components in a degraded condition
(01) Tires
(02) Wheels
(03) Suspension components
(04) Braking system components
(05) Engine
(06) Transmission
(07) Other drive line components (specify): ____________
(11) Cooling system
(12) Fuel system
(13) Exterior lighting system
(14) Wiring (specify): ____________
(15) Windshield
(16) Window glazing
(17) Backlight
(97) Other components (specify): ____________
(98) Not Applicable
(99) Unknown

LIST ALL VEHICLE COMPONENTS WHICH WERE IN A SUBSTANDARD OR DEGRADED CONDITION AT THE TIME OF THE CRASH	___ ___ ___ ___ ___
LIST ALL VEHICLE COMPONENTS WHICH, IN YOUR OPINION, MAY HAVE CONTRIBUTED TO CRASH OCCURRENCE	___ ___ ___ ___ ___

DESCRIBE ALL COMPONENT CONDITIONS RECORDED ABOVE

Figure C.16: Exterior Vehicle Form Page 5

Figure C.17

U. S. Department of Transportation National Highway Traffic Safety Administration

OCCUPANT ASSESSMENT FORM

National Automotive Sampling System
Crash Causation Special Study

1. Primary Sampling Unit Number ___ ___
2. Case Number - Stratum ___ ___ ___ ___
3. Vehicle Number ___ ___
4. Occupant Number ___ ___

OCCUPANT'S CHARACTERISTICS

5. Occupant's Age ___ ___
   Code actual age at time of crash.
   (00) Less than one year old (specify by month): ________________
   (97) 97 years and older
   (99) Unknown

6. Occupant's Sex ___
   (1) Male
   (2) Female - not reported pregnant
   (3) Female - pregnant - 1st trimester (1st-3rd month)
   (4) Female - pregnant 2nd trimester (4th-6th month)
   (5) Female - pregnant - 3rd trimester (7th-9th month)
   (6) Female - pregnant term unknown
   (9) Unknown

7. Occupant's Height ___ ___ ___
   Code actual height to the nearest centimeter.
   (999) Unknown

   ___ ___inches x 2.54 = ___ ___ ___centimeters

8. Occupant's Weight ___ ___ ___
   Code actual weight to the nearest kilogram.
   (999) Unknown

   ___ ___ ___pounds x .4536 = ___ ___ ___kilograms

9. Occupant's Role ___
   (1) Driver
   (2) Passenger
   (9) Unknown

OCCUPANT'S SEATING

10. Occupant's Seat Position ___ ___

    Front Seat
    (11) Left side
    (12) Middle
    (13) Right side
    (14) Other (specify): ________________
    (15) On or in the lap of another occupant

    Second Seat
    (21) Left side
    (22) Middle
    (23) Right side
    (24) Other (specify): ________________
    (25) On or in the lap of another occupant

    Third Seat
    (31) Left side
    (32) Middle
    (33) Right side
    (34) Other (specify): ________________
    (35) On or in the lap of another occupant

    Fourth Seat
    (41) Left side
    (42) Middle
    (43) Right side
    (44) Other (specify): ________________
    (45) On or in the lap of another occupant

    (96) In sleeper berth
    (98) Other seat (specify): ________________
    (99) Unknown

11. Occupant's Posture ___
    (0) Normal posture

    Abnormal posture
    (1) Kneeling or standing on seat
    (2) Lying on or across seat/sleeper mattress
    (3) Kneeling, standing or sitting in front of seat
    (4) Sitting sideways or turned to talk with another occupant or to look out a rear window
    (5) Sitting on a console
    (6) Lying back in a reclined seat position
    (7) Bracing with feet or hands on a surface in front of seat
    (8) Other abnormal posture (specify): ________________
    (9) Unknown

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Figure C.17: Occupant Assessment Form Page 1

Figure C.18

National Automotive Sampling System – Crash Causation Special Study: Occupant Assessment Form 2

EJECTION/ENTRAPMENT

12. Ejection ____
    - (0) No ejection
    - (1) Complete ejection
    - (2) Partial ejection
    - (3) Ejection, unknown degree
    - (9) Unknown

13. Ejection Area ____
    - (0) No ejection
    - (1) Windshield
    - (2) Left front
    - (3) Right front
    - (4) Left rear
    - (5) Right rear
    - (6) Rear
    - (7) Roof
    - (8) Other area (e.g., back of pickup, etc.) (specify): __________
    - (9) Unknown

14. Ejection Medium ____
    - (0) No ejection
    - (1) Door/hatch//tailgate
    - (2) Nonfixed roof structure
    - (3) Fixed glazing
    - (4) Nonfixed glazing (specify): __________
    - (5) Integral structure
    - (8) Other medium (specify): __________
    - (9) Unknown

15. Medium Status (Immediately Prior To Impact) ____
    - (0) No ejection
    - (1) Open
    - (2) Closed
    - (3) Integral structure
    - (9) Unknown

16. Entrapment ____
    - (0) Not entrapped/exit not inhibited
    - (1) Entrapped/pinned - mechanically restrained
    - (2) Could not exit vehicle due to jammed doors, fire, etc. (specify): __________
    - (9) Unknown

17. Occupant Mobility ____
    - (0) Occupant fatal before removed from vehicle
    - (1) Removed from vehicle while unconscious or not oriented to time or place
    - (2) Removed from vehicle due to perceived serious injuries
    - (3) Exited vehicle with some assistance
    - (4) Exited vehicle under own power
    - (5) Occupant fully ejected
    - (8) Removed from vehicle for other reasons (specify): __________
    - (9) Unknown

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Figure C.18: Occupant Assessment Form Page 2

Figure C.19

National Automotive Sampling System – Crash Causation Special Study: Occupant Assessment Form 3

BELT SYSTEM FUNCTION

18. Manual (Active Belt System Availability) ____
    - (0) None available
    - (1) Belt removed/destroyed
    - (2) Shoulder belt
    - (3) Lap belt
    - (4) Lap and shoulder belt
    - (5) Belt available - type unknown

Integral Belt Partially Destroyed
- (6) Shoulder belt (lap belt destroyed/removed)
- (7) Lap belt (shoulder belt destroyed/removed)
- (8) Other belt (specify): ____________
- (9) Unknown

19. Manual (Active Belt System Use) ____ ____
    - (00) Not used, not available, or belt removed/destroyed
    - (01) Inoperative (specify): ____________
    - (02) Shoulder belt
    - (03) Lap belt
    - (04) Lap and shoulder belt
    - (05) Belt used - type unknown
    - (08) Other belt used (specify): ____________
    - (12) Shoulder belt used with child safety seat
    - (13) Lap belt used with child safety seat
    - (14) Lap and shoulder belt used with child safety seat
    - (15) Belt used with child safety seat - type unknown
    - (18) Other belt used with child safety seat (specify): ____________
    - (99) Unknown if belt used

20. Proper Use of Manual (Active) Belts ____
    - (0) None used or available
    - (1) Belt used properly
    - (2) Belt used properly with child safety seat

Belt Used Improperly
- (3) Shoulder belt worn under arm
- (4) Shoulder belt worn behind back or seat
- (5) Belt worn around more than one person
- (6) Lap belt worn on abdomen
- (7) Lap belt or lap and shoulder belt used improperly with child safety seat (specify): ____________
- (8) Other improper use of manual belt system (specify): ____________
- (9) Unknown

21. Manual (Active Belt Failure Modes During Crashes) ____
    - (0) No manual belt used or not available
    - (1) No manual belt failure(s)
    - (2) Torn webbing (stretched webbing not included)
    - (3) Broken buckle or latch plate
    - (4) Upper anchorage separated
    - (5) Other anchorage separated (specify): ____________
    - (6) Broken retractor
    - (7) Combination of above (specify): ____________
    - (8) Other manual belt failure (specify): ____________
    - (9) Unknown

22. Manual Shoulder Belt Upper Anchorage Adjustment ____
    - (0) No manual shoulder belt
    - (1) No upper anchorage adjustment for manual shoulder belt

Adjustable shoulder Belt Upper Anchorage
- (2) In full up position
- (3) In mid position
- (4) In full down position
- (6) Lap belt worn on abdomen
- (5) Position unknown
- (9) Unknown if position has adjustable upper anchorage adjustment

23. Automatic (Passive) Belt System Availability/Function ____
    - (0) Not equipped/not available
    - (1) 2-point automatic belts
    - (2) 3-point automatic belts
    - (3) Automatic belts - type unknown

Non-functional
- (4) Automatic belts destroyed or rendered inoperative
- (9) Unknown

24. Automatic (Passive) Belt System Use ____
    - (0) Not equipped/not available/destroyed or rendered inoperative
    - (1) Automatic belt in use
    - (2) Automatic belt not in use (manually disconnected, motorized track inoperative) (specify): ____________
    - (9) Unknown

25. Automatic (Passive) Belt System Type ____
    - (0) Not equipped/not available
    - (1) Non-motorized system
    - (2) Motorized system
    - (9) Unknown

26. Proper Use of Automatic (Passive) Belt System ____
    - (0) Not equipped/not available/not used
    - (1) Automatic belt used properly
    - (2) Automatic belt used properly with child safety seat

Automatic Belt Used Improperly
- (3) Automatic shoulder belt worn under arm
- (4) Automatic shoulder belt worn behind back
- (5) Automatic belt worn around more than one person
- (6) Lap portion of automatic belt worn on abdomen
- (7) Automatic lap and shoulder belt or automatic shoulder belt used improperly with child safety seat (specify): ____________
- (8) Other improper use of automatic belt system (specify): ____________
- (9) Unknown

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Figure C.19: Occupant Assessment Form Page 3

Figure C.20

National Automotive Sampling System – Crash Causation Special Study: Occupant Assessment Form 4

POLICE REPORTED RESTRAINT USE

27. Automatic (Passive) Belt Failure Modes During Crash ____
 - (0) Not equipped/not available/not in use
 - (1) No automatic belt failures
 - (2) Torn webbing (stretched webbing not included)
 - (3) Broken buckle or latch plate
 - (4) Upper anchorage separated
 - (5) Other anchorage separated (specify): ____________
 - (6) Broken retractor
 - (7) Combination of above (specify): ____________
 - (8) Other automatic belt failure (specify): ____________
 - (9) Unknown

28. Police Reported Belt Use ____
 - (0) None used
 - (1) Police did not indicate belt use
 - (2) Shoulder belt
 - (3) Lap belt
 - (4) Lap and shoulder belt
 - (5) Belt used, type not specified
 - (6) Child safety seat
 - (7) Automatic belt
 - (8) Other type belt, (specify): ____________
 - (9) Police indicated "unknown"

29. Police Reported Air Bag Availability/Function ____
 - (0) No air bag available
 - (1) Police did not indicate air bag
 - (2) Deployed
 - (3) Not deployed
 - (4) Unknown if deployed
 - (9) Police indicated "unknown"

Check the Primary Source Used In Determining Belt Use.

- [ ] Vehicle inspection
- [ ] Official injury data
- [ ] Driver/occupant interview
- [ ] Other (specify): ____________
- [ ] Unknown if belt used

____

____

____

____

AIR BAG SYSTEM FUNCTION

30. Frontal Air Bag System Availability/Function ____
 (This Occupant Position)
 - (0) Not equipped/not available
 - (1) Air bag

 Non-functional
 - (2) Air bag disconnected (specify): ____________
 - (3) Air bag not reinstalled
 - (9) Unknown

31. Frontal Air Bag System Deployment ____
 (This Occupant Position)
 - (0) Not equipped/not available
 - (1) Deployed during crash (as a result of impact)
 - (2) Deployed inadvertently just prior to crash
 - (3) Deployed, details unknown
 - (4) Deployed as a result of a noncollision event during crash sequence (e.g., fire, explosion, electrical)
 - (5) Unknown if deployed
 - (7) Non-deployed
 - (9) Unknown

32. Other Than First Seat Frontal Air Bag Availability/Function ____
 (This Occupant Position)
 - (0) Not equipped/not available
 - (1) Air bag

 Non-functional
 - (2) Air bag disconnected (specify): ____________
 - (3) Air bag not installed
 - (9) Unknown

 Specify type of "other" air bag present: ____________

33. Air Bag(s) Deployment, Other Than First Seat Frontal (This Occupant Position) ____
 - (0) Not equipped with an "other" air bag
 - (1) Deployed during crash (as a result of impact)
 - (2) Deployed inadvertently just prior to crash
 - (3) Deployed, details unknown
 - (4) Deployed as a result of a noncollision event during crash sequence (e.g., fire, explosion, electrical)
 - (5) Unknown if deployed
 - (7) Non-deployed
 - (9) Unknown

34. Are There Indications of Air Bag System Failure? ____
 (This Occupant Position)
 - (0) Not equipped/not available
 - (1) No
 - (2) Yes (specify): ____________

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Figure C.20: Occupant Assessment Form Page 4

Figure C.21

National Automotive Sampling System – Crash Causation Special Study: Occupant Assessment Form 5

INJURY CONSEQUENCES

35. Injury Severity (Police Rating) ____
    - (0) O - No injury
    - (1) C - Possible injury
    - (2) B - Non-incapacitating injury
    - (3) A - Incapacitating injury
    - (4) K - Killed
    - (5) U - Injury, severity unknown
    - (6) Died prior to crash
    - (9) Unknown

36. Treatment - Mortality ____
    - (0) No treatment
    - (1) Fatal
    - (2) Fatal - ruled disease (specify): ____________________

    Nonfatal
    - (3) Hospitalization
    - (4) Transported and released
    - (5) Treatment at scene - non-transported
    - (6) Treatment later
    - (7) Treatment - other (specify): ____________________
    - (8) Transported to a medical facility-unknown if treated
    - (9) Unknown

37. Type Of Medical Facility (For Initial Treatment) ____
    - (0) Not treated at a medical facility
    - (1) Trauma center
    - (2) Hospital
    - (3) Medical clinic
    - (4) Physician's office
    - (5) Treatment later at medical facility
    - (8) Other (specify): ____________________
    - (9) Unknown

38. Hospital Stay ____ ____
    - (00) Not Hospitalized
    - Code the number of days (up through 60) that the occupant stayed in hospital
    - (61) 61 days or more
    - (99) Unknown

39. Working Days Lost ____ ____
    - Code the number of days (up through 60) that the occupant lost from work due to the crash
    - (00) No working days lost
    - (61) 61 days or more
    - (97) Not working prior to crash
    - (99) Unknown

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Figure C.21: Occupant Assessment Form Page 5

Figure C.22

National Automotive Sampling System – Crash Causation Special Study: Occupant Assessment Form 6

TO BE CODED BY THE ZONE CENTER

INJURY CONSEQUENCES

40. Time To Death ____ ____
    ____ Code the number of hours from time of crash to time of death up through **24** hours. If time of death is greater than 24 hours, code number of days = 32, …n days = 30 + n up through 30 days = 60)
    (00) Not fatal
    (96) Fatal - ruled disease
    (99) Unknown

41. 1st Medically Reported Cause of Death ____ ____

42. 2nd Medically Reported Cause of Death ____ ____

43. 3rd Medically Reported Cause of Death ____ ____
    ____ Code the Occupant Injury from line number(s) for the medically reported injury(s) which reportedly contributed to this occupant's death.
    (00) Not fatal or no additional causes
    (96) Mode of death given but specific injuries are not linked to cause of death. (specify): ____________
    (97) Other result (includes fatal ruled disease) (specify): ____________
    (99) Unknown

44. Number of Recorded Injuries For This Occupant ____ ____
    ____ Code the actual number of injuries recorded for this occupant.
    (00) No recorded injuries
    (97) Injured, details unknown
    (99) Unknown if injured

45. Highest AIS Severity Level Sustained ____
    (0) Not injured
    (1) AIS - 1
    (2) AIS - 2
    (3) AIS - 3
    (4) AIS - 4
    (5) AIS - 5
    (6) AIS - 6
    (7) AIS - 7
    (9) Unknown

TRAUMA DATA

46. Glasgow Coma Scale (GCS) Score ____ ____
    (At Medical Facility)
    (00) Not injured
    (01) Injured - not treated at medical facility
    (02) No GCS Score at medical facility
    (03-15) Code the actual value of the initial GCS Score recorded at medical facility.
    (97) Injured, details unknown
    (99) Unknown if injured

47. Was the Occupant Given Blood? ____
    (1) No - blood not given
    (2) Yes - blood given (specify units): ____________
    (9) Unknown if blood given

48. Arterial Blood Gases (ABG) - HC_3 ____ ____
    (00) Not injured
    (01) Injured - ABGs not measured or reported
    (02-50) Code the actual value of the HCO_3
    (96) ABGs reported, HCO_3 unknown
    (97) Injured, details unknown
    (99) Unknown if injured

BELT USE DETERMINATION

49. Primary Source of Belt Use Determination ____
    (0) Not equipped/not available/destroyed or rendered inoperative
    (1) Vehicle inspection
    (2) Official injury data
    (3) Driver/occupant interview
    (4) Police accident report
    (8) Other (specify): ____________
    (9) Unknown if belt used

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Figure C.22: Occupant Assessment Form Page 6

Figure C.23

1. Primary Sampling Unit Number _____ _____	3. Vehicle Number _____ _____
2. Case Number - Stratum _____ _____ _____ _____	4. Occupant Number _____ _____

OCCUPANT INJURY DATA

Record below the actual injuries sustained by this occupant that were identified from the official and unofficial data sources. Remember not to double count an injury just because it was identified from two different sources. If greater than ten injuries have been documented, encode the balance on the Occupant Injury Supplement.

		A.I.S. – 90									
	Source of Injury Data	Body Region	Type of Anatomic Structure	Specific Anatomic Structure	Level of Injury	A.I.S. Severity	Aspect	Injury Source	Injury Source Confidence Level	Direct/ Indirect Injury	Injury Intrusion Related 1- Yes 2-No 3-Unknown
1st	5.___	6.___	7.___	8.__ __	9.__ __	10.___	11.___	12.__ __ __	13.___	14.___	15.___
2nd	16.___	17.___	18.___	19.__ __	20.__ __	21.___	22.___	23.__ __ __	24.___	25.___	26.___
3rd	27.___	28.___	29.___	30.__ __	31.__ __	32.___	33.___	34.__ __ __	35.___	36.___	37.___
4th	38.___	39.___	40.___	41.__ __	42.__ __	43.___	44.___	45.__ __ __	46.___	47.___	48.___
5th	49.___	50.___	51.___	52.__ __	53.__ __	54.___	55.___	56.__ __ __	57.___	58.___	59.___
6th	60.___	61.___	62.___	63.__ __	64.__ __	65.___	66.___	67.__ __ __	68.___	69.___	70.___
7th	71.___	72.___	73.___	74.__ __	75.__ __	76.___	77.___	78.__ __ __	79.___	80.___	81.___
8th	82.___	83.___	84.___	85.__ __	86.__ __	87.___	88.___	89.__ __ __	90.___	91.___	92.___
9th	93.___	94.___	95.___	96.__ __	97.__ __	98.___	99.___	100.__ __ _	101.___	102.__	103.___
10th	104.__	105.__	106.___	107.__ __	108.__ __	109.___	110.__	111.__ __ _	112.___	113.__	114.___

HS Form 433B (1/96) This report is authorized by P.L. 80-563, Title 1, Section 106, 108, and 112. While you are not required to respond, your cooperation is needed to make the results of this data collection effort comprehensive, accurate, and timely

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Figure C.23: Occupant Injury Forms Page 1

Figure C.24

OCCUPANT INJURY DATA											
		A.I.S. - 90									
	Source of Injury Data	Body Region	Type of Anatomic Structure	Specific Anatomic Structure	Level of Injury	A.I.S. Severity	Aspect	Injury Source	Injury Source Confidence Level	Direct/ Indirect Injury	Injury Intrusion Related 1- Yes 2-No 3-Unknown
11th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
12th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
13th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
14th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
15th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
16th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
17th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
18th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
19th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
20th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
21st	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
22nd	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
23rd	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
24th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__
25th	__	__	__	_ _	_ _	__	__	_ _ _	__	__	__

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Figure C.24: Occupant Injury Forms Page 2

Figure C.25

U.S. Department of Transportation National Highway Traffic Safety Administration

GENERAL CRASH FORM

National Automotive Sampling System
Crash Causation Special Stud

1. Primary Sampling Unit Number _____ _____ 2. Case Number - Stratum _____ _____ _____ _____	

CRASH DESCRIPTION

Describe the crash sequence in detail including events/driver actions which resulted in crash occurrence.

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Figure C.25: General Crash Event Form Page 1

Figure C.26

U.S. Department of Transportation
National Highway Traffic Safety Administration

GENERAL CRASH FORM

National Automotive Sampling System
Crash Causation Special Study

1. Primary Sampling Unit Number ____ ____

Case Number - Stratum ____ ____ ____ ____

IDENTIFICATION

3. Number of General Vehicle Forms Submitted ____ ____

4. Date of Accident (Month/Day/Year) __ __/__ __/__ __ __ __

5. Time of Accident ____ ____ ____ ____

Code reported military time of accident.

NOTE: Midnight = 2400
Unknown = 9999

SPECIAL STUDIES SPECIAL

Check (√) each special study that has been completed; code 1 for the checked special studies and 0 for the special studies not checked.

6. ____ Heavy Truck Causation ____

NUMBER OF EVENTS

11. Number of Recorded Events in This Crash ____ ____
Code the number of events which occurred in this crash.

CRASH EVENTS

For each event that occurred in the crash, code the lowest numbered vehicle in the left columns and the other involved vehicle or object in the right columns.

Accident Event Sequence Number	Vehicle Number	Class Of Vehicle	General Area Of Damage	Vehicle Number Or Object Contacted	Class Of Vehicle	General Area Of Damage
12. 0 1	13. __ __	14. __ __	15. __ __	16. __ __	17. __ __	18. ____
19. 0 2	20. __ __	21. __ __	22. __ __	23. __ __	24. __ __	25. ____
26. 0 3	27.__ __	28.__ __	29.__ __	30.__ __	31.__ __	32. ____
33. 0 4	34__ __	35__ __	36__ __	37__ __	38__ __	39. ____
40. 0 5	41__ __	42__ __	43__ __	44__ __	45__ __	46. ____

IF GREATER THAN FIVE EVENTS, CONTINUE CODING ON THE CRASH EVENT SUPPLEMENT.

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Figure C.26: General Crash Event Form Page 2

Figure C.27

CODES FOR CLASS OF VEHICLE

(00)	Not a motor vehicle	(31)	Large pickup truck (< 4,536 kgs GVWR)
(01)	Subcompact/mini (wheelbase < 254 cm)	(38)	Other pickup truck (< 4,536 kgs GVWR)
(02)	Compact (wheelbase > 254 but< 265 cm)	(39)	Unknown pickup truck type (<4,536 kgs GVWR)
(03)	Intermediate (wheelbase>265 but <278 cm)	(45)	Other light truck (< 4,536 kgs GVWR)
(04)	Full size (wheelbase > 278 but< 291 cm)	(48)	Unknown light truck type (< 4,536 kgs GVWR)
(05)	Largest (wheelbase > 291 cm)	(49)	Unknown light vehicle type
(09)	Unknown passenger car size	(50)	School bus (excludes van based)
(14)	Compact utility vehicle	(58)	Other bus (> 4,536 kgs GVWR)
(15)	Large utility vehicle (< 4,536 kgs GVWR)	(59)	Unknown bus type
(16)	Utility station wagon (< 4,536 kgs GVWR)	(60)	Truck (> 4,536 kgs GVWR)
(19)	Unknown utility type	(67)	Tractor without trailer
(20)	Minivan (< 4,536 kgs GVWR)	(68)	Tractor-trailer(s)
(21)	Large van (< 4,536 kgs GVWR)	(78)	Unknown medium/heavy truck type
(24)	Van based school bus (<4,536 kgs GVWR)	(79)	Unknown light/medium/heavy truck type
(28)	Other van type (< 4,536 kgs GVWR)	(80)	Motored cycle
(29)	Unknown van type (< 4,536 kgs GVWR)	(90)	Other vehicle
(30)	Compact pickup truck (<4,536kgs GVWR)	(99)	Unknown

CODES FOR GENERAL AREA OF DAMAGE (GAD)

CDS	(0)	Not a motor vehicle	(R)	Right side	(T)	Top
APPLICABLE	(N)	Noncollision	(L)	Left side	(U)	Undercarriage
AND OTHER	(F)	Front	(B)	Back	(9)	Unknown
VEHICLES						

TDC	(0)	Not a motor vehicle	(L)	Left side	(C)	Rear of cab
APPLICABLE	(N)	Noncollision	(B)	Back of unit with cargo area (rear	(V)	Front of cargo area
VEHICLES	(F)	Front		of trailer or straight truck)	(T)	Top
	(R)	Right side		Back (rear of tractor)	(U)	Undercarriage
			(D)		(9)	Unknown

CODES FOR VEHICLE NUMBER OR OBJECT CONTACTED

(01-30) - Vehicle Number

Noncollision

- (31) Overturn - rollover (excludes end-over-end)
- (32) Rollover - end-over-end
- (33) Fire or explosion
- (34) Jackknife
- (35) Other intraunit damage (specify): ______________________________
- (36) Noncollision injury
- (38) Other noncollision (specify): ______________________________
- (39) Noncollision - details unknown

Collision With Fixed Object

- (41) Tree (< 10 cm in diameter)
- (42) Tree (> 10 cm in diameter)
- (43) Shrubbery or bush
- (44) Embankment
- (45) Breakaway pole or post (any diameter)

Nonbreakaway Pole or Post

- (50) Pole or post (< 10cm in diameter)
- (51) Pole or post (>10cm but < 30cm in diameter)
- (52) Pole or post (>30cm in diameter)
- (53) Pole or post (diameter unknown)
- (54) Concrete traffic barrier
- (55) Impact attenuator
- (56) Other traffic barrier (includes guardrail) (specify):__________________________
- (57) Fence
- (58) Wall
- (59) Building
- (60) Ditch or culvert
- (61) Ground
- (62) Fire hydrant
- (63) Curb
- (64) Bridge
- (68) Other fixed object (specify): ______________________________
- (69) Unknown fixed object

Collision With Nonfixed Object

- (70) Passenger car, light truck, van, or other vehicle not in-transport
- (71) Medium/heavy truck or bus not in-transport
- (72) Pedestrian
- (73) Cyclist or cycle
- (74) Other nonmotorist or conveyance ______________________________
- (75) Vehicle occupant
- (76) Animal
- (77) Train
- (78) Trailer, disconnected in-transport
- (79) Object fell from vehicle in-transport
- (88) Other nonfixed object (specify): ______________________________
- (89) Unknown nonfixed object
- (98) Other event (specify): ______________________________
- (99) Other event (specify): ______________________________

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Figure C.27: General Crash Event Form Page 3

Figure C.28

U.S. Department of Transportation National Highway Traffic Safety Administration

CRASH EVENT ACCESSMENT FORM

National Automotive Sampling System
Crash Causation Special Study

1. Primary Sampling Unit Number ___ ___
2. Case Number - Stratum ___ ___ ___ ___
3. Vehicle Number ___ ___

PRECRASH EVENT RELATED DATA

4. Pre-Event Movement ___ ___
   (Prior to Recognition of Critical Event)
   (00) No driver present
   (01) Going straight
   (02) Decelerating in traffic lane
   (03) Accelerating in traffic lane
   (04) Starting in traffic lane
   (05) Stopped in traffic lane
   (06) Passing or overtaking another vehicle
   (07) Disabled or parked in travel lane
   (08) Leaving a parking position
   (09) Entering a parking position
   (10) Turning right
   (11) Turning left
   (12) Making a U-turn
   (13) Backing up (other than for parking position)
   (14) Negotiating a curve
   (15) Changing lanes
   (16) Merging
   (17) Successful avoidance maneuver to a previous critical event
   (98) Other (specify): ___
   (99) Unknown

5. Critical Precrash Event ___ ___

THIS VEHICLE LOSS OF CONTROL DUE TO:
(01) Blow out or flat tire
(02) Stalled engine
(03) Disabling vehicle failure (e.g., wheel fell off)
(specify): ___
(04) Non-disabling vehicle problem (e.g., hood flew up)
(specify): ___
(05) Poor road conditions (puddle, pot hole, ice, etc.)
(specify): ___
(06) Traveling too fast for conditions
(07) Jackknife event
(08) Cargo shift
(18) Other cause of control loss
(specify): ___
(19) Unknown cause of control loss

THIS VEHICLE TRAVELING
(20) Over the lane line on left side of travel lane
(21) Over the lane line on right side of travel lane
(22) Off the edge of the road on the left side
(23) Off the edge of the road on the right side
(24) End departure
(25) Turning left at intersection
(26) Turning right at intersection
(27) Crossing over (passing through) intersection
(28) This vehicle decelerating
(29) Unknown travel direction

OTHER MOTOR VEHICLE IN LANE
(50) Other vehicle stopped
(51) Traveling in same direction with lower steady speed
(52) Traveling in same direction while decelerating
(53) Traveling in same direction with higher speed
(54) Traveling in opposite direction
(55) In crossover
(56) Backing
(59) Unknown travel direction of other motor vehicle in lane

OTHER MOTOR VEHICLE ENCROACHING INTO LANE
(60) From adjacent lane (same direction) – over left lane line
(61) From adjacent lane (same direction) – over right lane line
(62) From opposite direction - over left lane line
(63) From opposite direction - over right lane line
(64) From parking lane
(65) From crossing street, turning into same direction
(66) From crossing street, across path
(67) From crossing street, turning into opposite direction
(68) From crossing street, intended path not known
(70) From driveway, turning into same direction
(71) From driveway, across path
(72) From driveway, turning into opposite direction
(73) From driveway, intended path not known
(74) From entrance to limited access highway
(78) Encroachment by other vehicle - details unknown

PEDESTRIAN, PEDALCYCLIST, OR OTHER NONMOTORIST
(80) Pedestrian in roadway
(81) Pedestrian approaching roadway
(82) Pedestrian - unknown location
(83) Pedalcyclist or other nonmotorist in roadway
(specify): ___
(84) Pedalcyclist or other nonmotorist approaching roadway
(specify): ___
(85) Pedalcyclist or other nonmotorist - unknown location
(specify): ___

OBJECT OR ANIMAL
(87) Animal in roadway
(88) Animal approaching roadway
(89) Animal - unknown location
(90) Object in roadway
(91) Object approaching roadway
(92) Object - unknown location

OTHER
(93) This vehicle not involved in first harmful event
(98) Other critical precrash event
(specify): ___
(99) Unknown

6. Critical Reason For The Critical Event ___ ___ ___
   (000) Critical event not coded to this vehicle

DRIVER RELATED FACTOR
Critical Non-Performance Errors
(100) Sleep, that is, actually asleep
(101) Heart attack or other physical impairment of the ability to act
(108) Other critical non-performance (specify): ___
(109) Unknown critical non-performance

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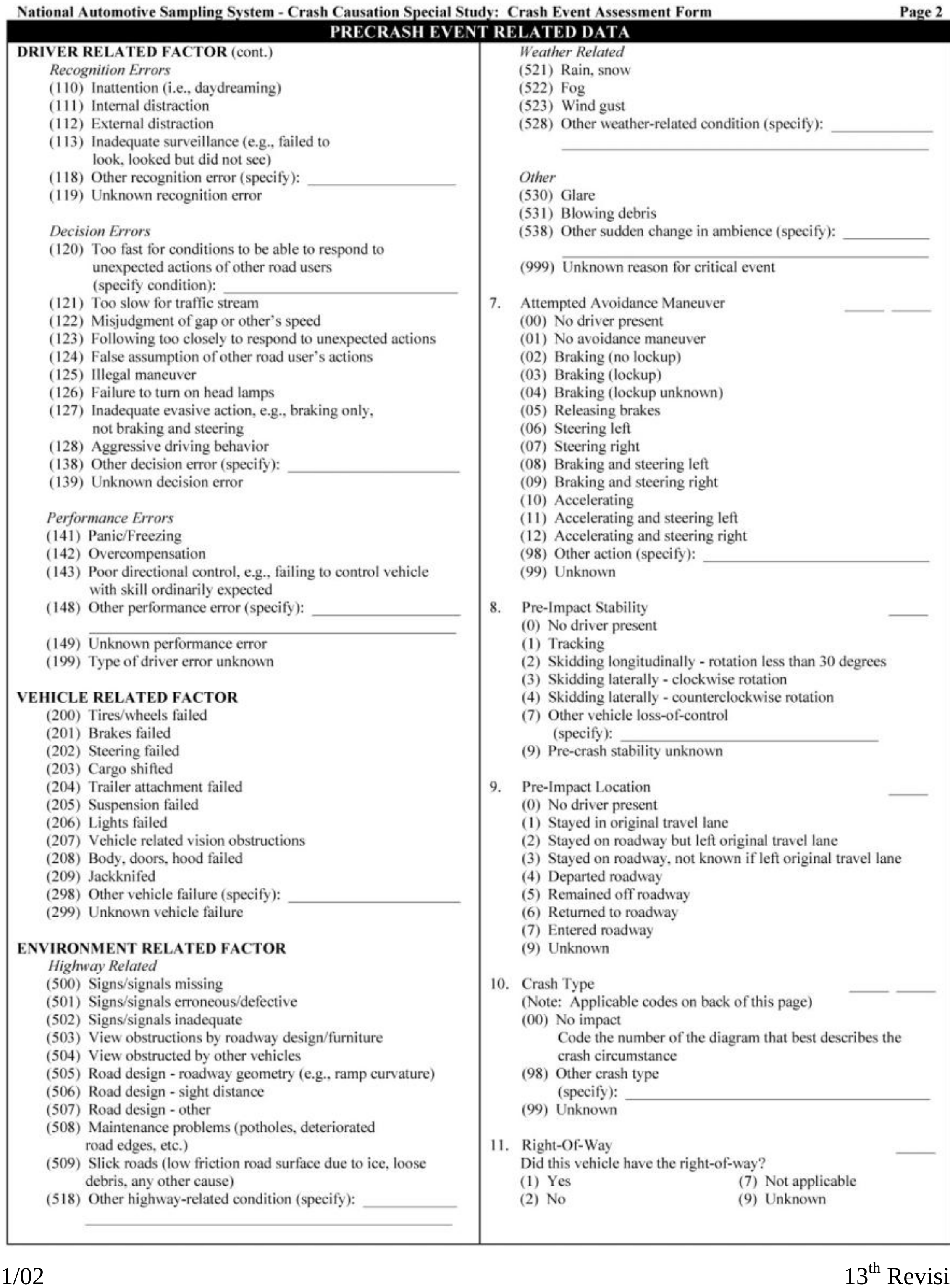
Figure C.28: Crash Event Form Page 1

Figure C.29



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PRECRASH EVENT RELATED DATA

DRIVER RELATED FACTOR (cont.)

Recognition Errors
(110) Inattention (i.e., daydreaming)
(111) Internal distraction
(112) External distraction
(113) Inadequate surveillance (e.g., failed to look, looked but did not see)
(118) Other recognition error (specify): ________
(119) Unknown recognition error

Decision Errors
(120) Too fast for conditions to be able to respond to unexpected actions of other road users (specify condition): ________
(121) Too slow for traffic stream
(122) Misjudgment of gap or other's speed
(123) Following too closely to respond to unexpected actions
(124) False assumption of other road user's actions
(125) Illegal maneuver
(126) Failure to turn on head lamps
(127) Inadequate evasive action, e.g., braking only, not braking and steering
(128) Aggressive driving behavior
(138) Other decision error (specify): ________
(139) Unknown decision error

Performance Errors
(141) Panic/Freezing
(142) Overcompensation
(143) Poor directional control, e.g., failing to control vehicle with skill ordinarily expected
(148) Other performance error (specify): ________
(149) Unknown performance error
(199) Type of driver error unknown

VEHICLE RELATED FACTOR
(200) Tires/wheels failed
(201) Brakes failed
(202) Steering failed
(203) Cargo shifted
(204) Trailer attachment failed
(205) Suspension failed
(206) Lights failed
(207) Vehicle related vision obstructions
(208) Body, doors, hood failed
(209) Jackknifed
(298) Other vehicle failure (specify): ________
(299) Unknown vehicle failure

ENVIRONMENT RELATED FACTOR

Highway Related
(500) Signs/signals missing
(501) Signs/signals erroneous/defective
(502) Signs/signals inadequate
(503) View obstructions by roadway design/furniture
(504) View obstructed by other vehicles
(505) Road design - roadway geometry (e.g., ramp curvature)
(506) Road design - sight distance
(507) Road design - other
(508) Maintenance problems (potholes, deteriorated road edges, etc.)
(509) Slick roads (low friction road surface due to ice, loose debris, any other cause)
(518) Other highway-related condition (specify): ________

Weather Related
(521) Rain, snow
(522) Fog
(523) Wind gust
(528) Other weather-related condition (specify): ________

Other
(530) Glare
(531) Blowing debris
(538) Other sudden change in ambience (specify): ________

(999) Unknown reason for critical event

7. Attempted Avoidance Maneuver ___ ___
(00) No driver present
(01) No avoidance maneuver
(02) Braking (no lockup)
(03) Braking (lockup)
(04) Braking (lockup unknown)
(05) Releasing brakes
(06) Steering left
(07) Steering right
(08) Braking and steering left
(09) Braking and steering right
(10) Accelerating
(11) Accelerating and steering left
(12) Accelerating and steering right
(98) Other action (specify): ________
(99) Unknown

8. Pre-Impact Stability ___
(0) No driver present
(1) Tracking
(2) Skidding longitudinally - rotation less than 30 degrees
(3) Skidding laterally - clockwise rotation
(4) Skidding laterally - counterclockwise rotation
(7) Other vehicle loss-of-control (specify): ________
(9) Pre-crash stability unknown

9. Pre-Impact Location ___
(0) No driver present
(1) Stayed in original travel lane
(2) Stayed on roadway but left original travel lane
(3) Stayed on roadway, not known if left original travel lane
(4) Departed roadway
(5) Remained off roadway
(6) Returned to roadway
(7) Entered roadway
(9) Unknown

10. Crash Type ___ ___
(Note: Applicable codes on back of this page)
(00) No impact
Code the number of the diagram that best describes the crash circumstance
(98) Other crash type (specify): ________
(99) Unknown

11. Right-Of-Way ___
Did this vehicle have the right-of-way?
(1) Yes — (7) Not applicable
(2) No — (9) Unknown

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Figure C.29: Crash Event Form Page 2

Figure C.30

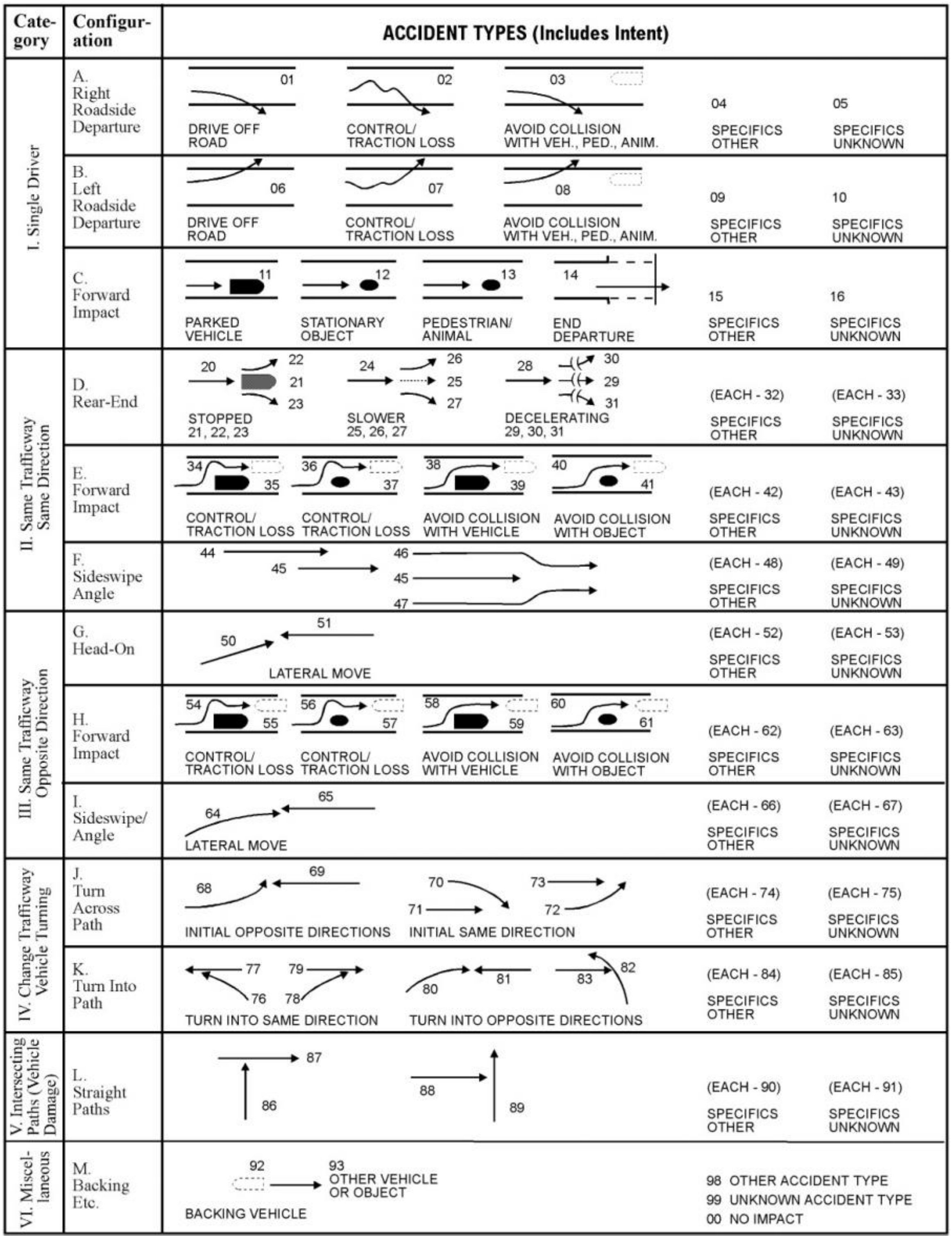

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Figure C.30: Crash Event Form Page 3

Figure C.31

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KEY PRECRASH EVENT CHARACTERISTICS

Jackknife Event

12. Type Of Jackknife Event ____
    (0) No precrash jackknife
    (1) Tractor jackknife
    (2) Trailer swing
    (7) Not applicable
    (9) Unknown

13. Circumstances In Which Event Occurred ___ ___/___ ___/___ ___/___ ___
    (Code up to four circumstances)
    (00) No precrash jackknife
    (01) Traversing a curve
    (02) Completing turn
    (03) Traversing a straight section
    (04) Completing avoidance maneuver
    (05) Driving at constant velocity
    (06) Accelerating
    Decelerating:
    (07) Throttle input only
    (08) Light braking
    (09) Moderate braking
    (10) Heavy braking

    (97) Not applicable
    (98) Other (specify) ______________________
    (99) Unknown

14. Source Of Jackknife Impetus ____
    (0) No precrash jackknife
    (1) Steering input
    (2) Braking input
    (3) Steering and braking input
    (4) Environmental condition (specify): ______________
    (5) Vehicle condition (specify): ______________
    (7) Not applicable
    (8) Combination of sources (specify): ______________
    ____
    (9) Unknown

15. Vehicle Location (At Start Of Jackknife) ____
    (0) No precrash jackknife
    (1) On roadway
    (2) On shoulder
    (3) On roadside
    (4) On median
    (7) Not applicable
    (9) Unknown

16. Direction Of Rotation ____
    (0) No precrash jackknife
    (1) Clockwise
    (2) Counterclockwise
    (7) Not applicable
    (9) Unknown

Cargo Shift Event

17. Type Of Cargo Shift Event ____
    (0) No precrash cargo shift
    (1) Boxed general freight (solids)
    (2) Bulk freight (containerized)
    (3) Bulk freight (not containerized)
    (4) Large objects (solids)

Cargo Shift Event (cont.)

17. Type Of Cargo Shift Event (cont.)
    (5) Tank - solids
    (6) Tank - liquids
    (7) Not applicable
    (8) Other (specify): ______________________
    (9) Unknown

18. Circumstances In Which Event Occurred ___ ___/___ ___/___ ___/___ ___
    (Code up to four circumstances)
    (00) No precrash cargo shift
    (01) Traversing a curve
    (02) Completing turn
    (03) Traversing a straight section
    (04) Completing avoidance maneuver
    (05) Driving at constant velocity
    (06) Accelerating
    Decelerating:
    (07) Throttle input only
    (08) Light braking
    (09) Moderate braking
    (10) Heavy braking

    (97) Not applicable
    (98) Other (specify) ______________________
    (99) Unknown

19. Cargo Shift Associated With ___ ___/___ ___/___ ___/___ ___
    (Code up to four factors))
    (00) No precrash cargo shift
    Solids
    (01) Improper loading (general freight)
    (02) Improper loading (bulk freight)
    (03) Inadequate securement (no. of tie downs)
    (04) Inadequate securement (strength of tie downs)
    (08) Other source (specify): ______________
    Liquids (Tanks)
    (11) Less than full load (slosh)
    (12) Baffle failure (specify): ______________
    (13) Compartment partition failure (specify): ______________
    (14) Tank failure (specify): ______________
    (18) Other (specify): ______________
    Other Cargo Types
    (21) Specify shift source: ______________
    (97) Not applicable
    (99) Unknown

20. Vehicle Location At Start Of Cargo Shift ____
    (0) No precrash cargo shift
    (1) On roadway
    (2) On shoulder
    (3) On roadside
    (4) On median
    (7) Not applicable
    (9) Unknown

21. Precrash Cargo Spillage ____
    (0) No precrash cargo shift
    (1) Yes (specify): ______________
    (7) Not applicable
    (9) Unknown

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Figure C.31: Crash Event Form Page 4

Figure C.32

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CRITICAL EVENT ASSOCIATED FACTOR SUPPORT DATA

22. Driver's Current Sleep Condition
Hours of last sleep:
_____ _____ : _____ _____ (hours : minutes)

Start time of sleep interval (Military Time)
_____ _____ : _____ _____ (hours : minutes)

End of sleep interval (Military Time)
_____ _____ : _____ _____ (hours : minutes)

If hours of last sleep were less than four hours, record hours of last main sleep (i.e., > four hours)
_____ _____ : _____ _____ (hours : minutes)

Start of main sleep interval (Military Time)
_____ _____ : _____ _____ (hours : minutes)

End of main sleep interval (Military Time)
_____ _____ : _____ _____ (hours : minutes)

Hours since last sleep:
_____ _____ : _____ _____ (hours : minutes)

Hours driving since last 8-hour break:
_____ _____ : _____ _____ (hours : minutes)

Hours on duty since last 8-hour break:
_____ _____ : _____ _____ (hours : minutes)
97:97 No driver present
98:98 Not applicable
99:99 Unknown

23. Driver's Hours Of Main Sleep Related To: ___/___/___
(Code up to three factors.)
(1) Work schedule
(2) Social schedule
(3) Personal problems
(4) Family problems
(5) Illness
(7) No driver present
(8) Other (specify): ______________________
(9) Unknown

24. Driver's Preceding Seven Day Sleep Pattern:

Longest length of daily sleep
_____ _____ : _____ _____ (hours : minutes)

Shortest length of daily sleep
_____ _____ : _____ _____ (hours : minutes)

Average length of daily sleep
_____ _____ : _____ _____ (hours : minutes)
97:97 No driver present
99:99 Unknown

25. Did The Time At Which The Driver Began To Sleep Rotate/Shift During The Seven Day Interval? _____
(e.g., rotating shift schedule)
(1) Yes (specify): ______________________
(2) No
(7) No driver present
(9) Unknown

26. Driver's Preceding Seven Day Sleep Pattern Related To: ___/___/___
(Code up to three factors.)
(1) Work schedule
(2) Social schedule
(3) Personal problems
(4) Family problems
(5) Illness
(7) No driver present
(8) Other (specify): ______________________
(9) Unknown

27. Driver's Work Schedule
Hours worked on day of crash
_____ _____ : _____ _____ (hours : minutes)

Hours worked on primary job during seven day interval preceding crash
Longest work day
_____ _____ : _____ _____ (hours : minutes)

Shortest work day
_____ _____ : _____ _____ (hours : minutes)

Average work day
_____ _____ : _____ _____ (hours : minutes)
97:97 No driver present
98:98 Not applicable
99:99 Unknown

Total hours worked
_____ _____ _____: _____ _____ (hours : minutes)
997:97 No driver present
998:98 Not applicable
999:99 Unknown

Hours worked on second job during the seven day interval preceding crash
Total hours worked
_____ _____ : _____ _____ (hours : minutes)
97:97 No driver present
98:98 Not applicable
99:99 Unknown

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Figure C.32: Crash Event Form Page 5

Figure C.33

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CRITICAL EVENT ASSOCIATED FACTOR
SUPPORT DATA

28. Was This Driver's Sight Line To The Other Vehicle Clear? ____
    - (1) Yes
    - (2) No, view obstructed by roadway curvature or grade
    - (3) No, view obstructed by roadside appurtenance
    - (4) No, view obstructed by intervening vehicle
    - (7) Not applicable
    - (8) Other (specify): ______________________
    - (9) Unknown

29. Was The Driver's View Of The Other Vehicle Obscured? ____
    - (1) Yes, obscured by sunglare
    - (2) Yes, obscured by headlight glare
    - (3) Yes, obscured by other glare (specify):
    - (4) Yes, obscured by dark (nightime) viewing condition
    - (5) No
    - (7) Not applicable
    - (8) Yes, obscured by other condition (specify): ______________________
    - (9) Unknown

30. Was This Driver Required To Stop Prior To Crash Occurrence? ____
    - (1) Yes, traffic control device (TCD)
    - (2) Yes, yield right-of-way requirement
    - (3) Yes, other reason (specify): ______________________
    - (4) No
    - (7) No driver present
    - (9) Unknown

31. Period of time stopped ____ ____
    - (00) Not required to stop
    - (01) Traveling at constant velocity
    - (02) Decelerated, did not stop
    - (03) Rolling stop prior to proceeding
    - (04) Stopped<1 second prior to proceeding
    - (05) Stopped 1-2 seconds prior to proceeding
    - (06) Stopped 3-5 seconds prior to proceeding
    - (07) Stopped more than 5 seconds prior to proceeding
    - (97) No driver present
    - (99) Unknown

32. After Checking For Traffic, Did This Driver Focus On Intended Turn Destination Or Other Location? ____
    - (1) Yes (specify): ______________________
    - (2) No
    - (7) Not applicable
    - (9) Unknown

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Figure C.33: Crash Event Form Page 6

Figure C.34

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CRITICAL EVENT ASSOCIATED FACTORS

Code all factors that apply. Selection does not imply that the factor contributed to the crash.

DRIVER RELATED PHYSICAL FACTORS

33. Alcohol Use ____ ____
(00) No alcohol use
Code BAC test results.
(decimal implied before first digit – 0..xx)
(92) Field observation of NASS Researcher
(93) AC test performed, results negative
(94) Test refused
(95) None given
(96) AC test performed, results unknown
(97) No driver present
(99) Unknown

Source Of BAC Test Result ____
(0) No BAC test
(1) Police reported
(2) Company reported
(7) Not applicable
(8) Other (specify): ______________________
(9) Unknown

Time Delay (between crash and BAC test)
____ ____ : ____ ____ (hours:minutes)
00:00 No alcohol use
97:97 No driver present
98:98 Not applicable
99:99 Unknown

34. Illegal Drug Use ____ ____/____ ____/____ ____
(00) No illegal drug use /____ ____/____ ____
(Code all that apply.)
(01) Amphetamine
(02) Cocaine
(03) Crack Cocaine
(04) Hashish
(05) Heroin
(06) Lysergic Acid Diethylamide (LSD)
(07) Marijuana
(08) Methadone
(09) Methamphetamine
(10) Morphine
(11) Opium
(12) Phencyclidine (PCP)
(13) Pentobarbital/Secobarbital
(14) Tetrahydrocannabinol (THC)
(97) No driver present
(98) Other (specify): ______________________
(99) Unknown

Drug Test Performed: ____ ____
(00) No drug use
(91) Drug test performed, results positive
(93) Drug test performed, results negative
(94) Test refused
(95) None given
(96) Drug test performed, results unknown
(97) No driver present
(99) Unknown

34. Illegal Drug Use (cont.)
Code Results: ____ ____ ____ ____ ____

(00000) No drug use ____ ____ ____ ____ ____
(00001 - 89999) Test result ____ ____ ____ ____ ____
(99995) None given
(99998) Trace ____ ____ ____ ____ ____
(99999) Unknown
____ ____ ____ ____ ____

35. Over-The-Counter Medication Use ____ ____/____ ____
(00) No over-the-counter medication use /____ ____
(Code all that apply.) /____ ____
(01) Advil /____ ____
(02) Advil cold medicine
(03) Bayer aspirin
(04) Ibuprofin
(05) Laxative
(06) Meijer Aspirin Free
(07) Motrin
(08) Nodoze
(09) Perrigo
(10) Sudafed
(11) Travis D
(12) Tylenol
(13) Tylenol PM
(14) Vicks Nyquil
(15) Vitamins
(97) No driver present
(98) Other (specify): ______________________
(99) Unknown

36. Prescription Medication Use ___ ___ ___/___ ___ ___
(000) No prescription medicine use ___ ___ ___/___ ___ ___
___ ___ ___/___ ___ ___
(Code all that apply.)
(278) Accolate
(137) Accupril
(001) Accupril-BP
(130) Acetaminophen/Codeine
(320) Aciphex
(321) Actos
(322) Acyclovir
(161) Adalat CC
(221) Adderall
(002) Albuterol
(323) Albuterol (liquid)
(316) Albuterol (aerosol)
(317) Albuterol Nee Soln
(233) Alesse
(318) Alesse 28
(271) Allegra
(003) Allegra D
(266) Allopurinol
(259) Alphagan
(135) Alprazolam
(263) Altace
(209) Amaryl
(133) Ambien
(174) Amitripyline
(102) Amoxicillin
(126) Amoxil
(249) Aricept

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Figure C.34: Crash Event Form Page 7

Figure C.35

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CRITICAL EVENT ASSOCIATED FACTORS

Code all factors that apply. Selection does not imply that the factor contributed to the crash.

DRIVER RELATED PHYSICAL FACTORS

36. Prescription Medication Use (cont.)
(255) Arthrotec
(131) Atenolol
(186) Atrovent
(319) Atrovent INH
(103) Augmentin
(237) Avapro
(245) Axid
(225) Azmacort
(004) Azathioprine
(215) Bactroban
(324) Baycol
(381) Benzodiazepines
(325) Benzonatate
(128) Biaxin
(005) Biotin
(176) BuSpar
(326) Butalbital/APAP/Caffiene
(006) Butalbital
(007) Calan Effexor
(008) Captopril
(139) Cardizem CD
(144) Cardura
(222) Carisoprodol
(327) Cartia XT
(185) Ceftin
(168) Cefzil
(104) Celebrex
(187) Celexa
(121) Cephalexin
(279) Cimetidine
(123) Cipro
(105) Claritin
(009) Claritin-D
(275) Claritin-D 12 hr
(276) Claritin-D 24 hr
(260) Climara
(328) Clindamycin
(170) Clonazepam
(226) Clonidine
(231) Combivent
(265) Contuss-XT
(010) Cortef
(011) Coumadin
(156) Cozaar
(201) Cyclobenzaprine
(254) Cycrin
(012) Cylert
(015) Darvocet
(229) Daypro
(280) Deltasone
(149) Depakote
(228) Desogen
(273) Detrol
(013) Diabeta
(211) Diazepan
(324) Diclofenal Sodium
(157) Diflucan
(330) Digoxin
(150) Dilantin
(014) Diovan
(331) Diovan HCT
(332) Doxepin
(333) Doxycycline

36. Prescription Medication Use (cont.)
(281) Dyazide
(282) Effexor
(187) Effexor XR
(283) Elocon
(284) Endocet
(236) Ery-Tab
(239) Estrace
(285) Estraderm
(286) Estradiol
(218) Evista
(017) Fastin
(018) Flexeril
(264) Flomax
(184) Flovent
(377) Flunitrazopam
(378) Flurazepam
(262) Folic Acid
(145) Fosamax
(106) Furosemide
(287) Furosemide Oral
(248) Gemfibrozil
(288) Glipizide
(020) Glucophage
(140) Glucotrol XL
(182) Glyburide
(019) Glynase
(334) Guaifenesin/Phenylpro-panolamine
(289) Guaifenesin/PPA
(290) Humulin 70/30
(291) Humulin N
(292) Humulin R
(155) Hydrochlorothiazide
(107) Hydrocodone W/APAP
(335) Hydroxyzine
(336) Hyoscyamine
(160) Hytrin
(212) Hyzaar
(273) Ibuprofen
(224) Imdur
(181) Imitrex
(244) Isosorbide Mononitrate
(124) K-Dur
(293) K-Dur-20
(242) Klor-Con
(258) Lamisil
(108) Lanoxin
(294) Lasix
(177) Lescol
(165) Levaquin
(253) Levothroid
(109) Levoxyl
(021) Lexxel
(022) Lipitor
(213) Lo/Ovral
(295) Lo/Ovral 28
(296) Loestrin-FE 1.5/30
(297) Loestrin-FE 1/20
(298) Lorabid
(162) Lorazepam
(146) Lotensin
(023) Lotrel
(190) Lotrisone
(232) Macrobid

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Figure C.35: Crash Event Form Page 8

Figure C.36

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CRITICAL EVENT ASSOCIATED FACTORS

Code all factors that apply. Selection does not imply that the factor contributed to the crash.

DRIVER RELATED PHYSICAL FACTORS

36. Prescription Medication Use (cont.)
(337) Meclizine
(206) Medroxyprogesterone
(338) Methocarbamol
(339) Methylphenidate
(251) Methylprednisolone
(188) Metoprolol Tartrate
(340) Metronidazole
(024) Mevacor
(219) Miacalcin
(308) Miacalcin Nasal
(341) Minocycline
(342) Mircette
(164) Monopril
(025) Naprosyn
(362) Naproxen
(343) Naproxen Sodium
(192) Nasonex
(228) Necon
(301) Necon 1/35
(227) Neomycin/Polymx/HC
(154) Neurontin
(234) Nitrostat
(344) Nitroglycerin
(345) Nortriptyline
(026) Norvasc
(129) Ortho Tri-Cyclen
(302) Ortho-Cept
(217) Ortho-Cyclen
(179) Ortho-Novum 7/7/7
(027) Orudis
(250) Oxycodone/Acetaminophen
(346) Oxycodone/APAP
(241) Oxycontin
(028) Parlodel
(110) Paxil
(029) Penicillin
(277) Penicillin VK
(151) Pepcid
(347) Phenazopyridine
(246) Phenergan Supp
(348) Phenobarbital
(208) Plavix
(240) Plendil
(210) Potassium Chloride
(030) Pravachol
(125) Prednisone
(349) Prednisone (oral)
(031) Premarin
(270) Prempro
(111) Prevacid
(112) Prilosec
(138) Prinivil
(147) Procardia XL
(350) Promethazine Codeine
(303) Promethazine Tabs
(304) Propacet 100
(134) Propoxyphene N/APAP
(230) Propranolol
(305) Propranolol LA
(172) Propulsid
(257) Proventil
(351) Proventil HFA
(306) Provera

36. Prescription Medication Use (cont.)
(032) Prozac
(200) Ranitidine
(163) Relafen
(352) Remeron
(307) Retin-A
(204) Rezulin
(308) Rhinocort
(166) Risperdal
(207) Roxicet
(173) Serevent
(214) Serzone
(202) Singulair
(353) Spironolactone
(033) Sular Prylosac
(309) Sumycin
(113) Synthroid
(247) Tamoxifen
(235) Temazepam
(034) Tenormin
(354) Terazosin
(355) Theophylline SR
(252) Tiazac
(310) Timoptic XE
(256) Tobradex
(141) Toprol-XL
(261) Trazodone
(357) Triamcinolone (topical)
(142) Triamterene/HCTZ
(311) Tri-Levlen
(127) Trimethoprim/Sulfa
(268) Trimox
(171) Triphasil
(037) Tylenol/Codeine
(136) Ultram
(358) Valtrex
(220) Vancenase AQ DS
(038) Vasotec
(180) Veetids
(109) Verapamil SR
(148) Viagra
(360) Vicoprofen
(205) Vioxx
(193) Warfarin
(153) Wellbutrin SR
(167) Xalatan
(312) Xanax
(313) Zantac
(216) Zestoretic
(114) Zestril
(040) Ziac
(272) Zithromax
(115) Zithromax (Z-Pack)
(314) Zithromax Susp
(118) Zocor
(119) Zoloft
(315) Zyban
(191) Zyprexa
(182) Zyrtec
(361) Zyrtec Syrup
(997) No driver present
(998) Other (specify): ______
(999) Unknown

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Figure C.36: Crash Event Form Page 9

Figure C.37

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CRITICAL EVENT ASSOCIATED FACTORS

Code all factors that apply. Selection does not imply that the factor contributed to the crash.

DRIVER RELATED PHYSICAL FACTORS

37. Driver Fatigue ____
    (1) Driver fatigued
    (2) Driver not fatigued
    (7) No driver present
    (9) Unknown if driver fatigued

38. Illness ____/____/____
    (Code up to three factors.)
    (0) No illness
    (1) Heart attack
    (2) Seizure (epilepsy related)
    (3) Seizure (other source)
    (4) Blackout (diabetes related)
    (5) Blackout (other source)
    (6) Severe cold/flu symptoms
    (7) No driver present
    (8) Other (specify): ____________
    (9) Unknown

39. Vision ____/____/____
    (Code up to three factors.)
    (0) Normal vision
    (1) Legal blindness
    (2) Myopic (near-sighted) condition
    (3) Hyperopic (far-sighted) condition
    (4) Glaucoma
    (5) Color blind
    (6) Astigmatism
    (7) No driver present
    (8) Other (specify): ____________
    (9) Unknown
    Corrected vision level ____ ____/____ ____
    Code standard vision level descriptor
    (e.g. 20/20, 20/40, etc.) (97/97) Not applicable
    (99/99) Unknown

40. Other Physical Factors ____/____/____/____/____
    (Code all that apply.)
    (0) No other physical factors
    (1) Hearing impairment
    (2) Prosthesis (specify): ____________
    (3) Paraplegia
    (4) Strenuous recreational activities
    (5) Strenuous non-work activities
    (6) Sleep apnea
    (7) No driver present
    (8) Other (specify): ____________
    (9) Unknown

DRIVER RELATED RECOGNITION FACTORS

41. Inattention ____
    (0) Attentive to driving task
    Nature of thought focus (not attentive)
    (1) Personal problem
    (2) Family problem
    (3) Financial problem
    (4) Preceding argument
    (5) Future event (e.g., vacation, wedding, etc.)
    (7) No driver present
    (8) Other (specify): ____________
    (9) Unknown

DRIVER RELATED RECOGNITION FACTORS

42. Conversation ____
    (0) Not conversing
    (1) Conversing with passenger
    (2) Talking on phone
    (3) Talking on CB radio
    (7) No driver present
    (8) Other (specify): ____________
    (9) Unknown
    Nature of relationship between driver and person the driver was conversing with: ____ ____/____ ____
    (Code up to two relationships.)
    (00) Not conversing
    (01) No relationship/stranger
    (02) Business
    (03) Social (friend)
    (04) Boyfriend/girlfriend
    (05) Husband/wife
    (06) Driver/co-driver
    (07) Parent/child
    (97) No driver present
    (98) Other (specify): ____________
    (99) Unknown

    Nature of the discussion: ____
    (0) Not conversing
    (1) Business
    (2) Social
    (3) Family matter
    (4) Argument
    (5) Disciplinary
    (7) No driver present
    (8) Other (specify): ____________
    (9) Unknown

43. Other Non-Driving Activities ____/____
    (Code up to two factors.)
    (0) No non-driving activities
    (1) Looking at movement/actions of other occupants
    (2) Dialing/hanging up phone
    (3) Adjusting radio/CD player
    (4) Adjusting other vehicle controls
    (5) Retrieving object from floor and/or seat
    (6) Retrieving object from other location
    (7) No driver present
    (8) Other (specify): ____________
    (9) Unknown

44. Exterior Factors ____/____
    (Code up to two factors.)
    (0) No exterior factors
    Specific sources include:
    (1) Looking at previous crash
    (2) Looking at approaching traffic
    (3) Looking for street address
    (4) Looking at outside person
    (5) Looking at building
    (6) Unspecified outside focus
    (7) No driver present
    (8) Other (specify): ____________
    (9) Unknown

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DRIVER RELATED RECOGNITION FACTORS

44. Exterior Factors (cont.)
Location of exterior factor with respect to driver ____
(0) No exterior factors
(1) Forward
(2) Forward, left
(3) Forward, right
(4) Left
(5) Right
(6) Rearward
(7) No driver present
(8) Other (specify): ____
(9) Unknown

If exterior factor was located rearward of the driver, how did the driver track this source? ____
(0) No exterior factors
(1) Turned head
(2) Used rearview mirror
(3) Used side mirror
(7) Not applicable
(8) Other (specify): ____
(9) Unknown

45. Inadequate Surveillance ____
(0) No inadequate surveillance factors
Failed to look:
(1) Far enough ahead
(2) Either side ahead
(3) To side
(4) To rear (mirrors)
(5) Other (specify): ____
(6) Looked, but did not see
(7) No driver present
(8) Other (specify): ____
(9) Unknown

46. Other Recognition Factors ____
(0) No other recognition factors
(1) Impending problem masked by traffic flow pattern
(2) Driver focused on extraneous vehicle
(3) Other recognition error (specify): ____
(7) No driver present
(9) Unknown

DRIVER RELATED DECISION FACTORS

47. Traveling Too Fast For Conditions ____
(0) No traveling too fast for conditions factors
Reason given for traveling too fast for conditions
(1) Keeping up with traffic
(2) Did not realize that caution was required
(7) No driver present
(8) Other reason (specify): ____
(9) Unknown

DRIVER RELATED DECISION FACTORS

48. Following Too Closely ____
(0) No following too closely factors
Reason given for following too closely
(1) Rush hour, heavy traffic
(2) Keeping up with traffic
(3) Did not realize that I was too close to forward vehicle
(4) Always drive at this gap distance
(7) No driver present
(8) Other (specify): ____
(9) Unknown

49. Misjudgment Of Gap Distance To Other Vehicle Or Velocity Of Other Vehicle ____
(0) No misjudgment factors
(1) Misjudgment of gap distance
(2) Misjudgment of velocity of other vehicle
(3) Misjudgment of both factors
(7) No driver present
(8) Other (specify): ____
(9) Unknown

Other vehicle approaching from this driver's: ____
(0) No misjudgment factors
(1) Left
(2) Right
(3) Forward direction (i.e., 170-190 degrees opposed)
(4) Left forward direction (i.e. 120-169 degrees opposed)
(5) Right forward direction (i.e. 191-240 degrees opposed)
(6) Rear
(7) No driver present
(9) Unknown

50. False Assumption Of Other Road User's Actions ____
(0) No false assumption factors
(1) Assumed that other driver would merge without stopping
(2) Assumed that other driver would turn without stopping
(3) Assumed that other driver would continue to proceed
(4) Assumed that other driver would yield right-of-way
(7) No driver present
(8) Other false assumption (specify): ____
(9) Unknown

51. Illegal Maneuver ____/____/____
(Code up to three maneuvers.)
(0) No illegal maneuver factors
(1) Crossed full barrier lines while passing
(2) Passed on right (drive off pavement to pass)
(3) Turned from wrong lane
(4) Initiated illegal U-turn
(5) Failed to stop for TCD
(6) Drove wrong way on one-way road
(7) No driver present
(8) Other illegal maneuver (specify): ____
(9) Unknown

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Figure C.38: Crash Event Form Page 11

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DRIVER RELATED DECISION FACTORS

52. Inadequate Evasive Action ____
(0) No inadequate evasive action factors
(1) Insufficient steering inputs
(2) Insufficient braking inputs
(3) Combination of insufficient steering and braking inputs
(7) No driver present
(8) Other inadequate evasive action (specify):
____
(9) Unknown

53. Aggressive Driving Behavior
____ ____ / ____ ____ / ____ ____ / ____ ____
(Code up to four aggressive driving behaviors.)
(00) No aggressive driving behaviors
(01) Speeding
(02) Tailgating
(03) Weaving in and out of traffic
(04) Intentional violation of traffic control devices
(05) Accelerating rapidly/stopping suddenly
(06) Honking horn
(07) Flashing lights
(08) Obscene gestures
(09) Obstructing the paths of others
(97) No driver present
(98) Other (specify): ____________________
____
(99) Unknown

Reasons for aggressive driving behavior ____ / ____
(Code up to two reasons.)
(0) No aggressive driving behaviors
(1) Anger
(2) Frustration
(3) Always drive this way
(7) No driver present
(8) Other (specify): ____________________
(9) Unknown

54. Other Decision Factors ____
(0) No other decision factors
(1) Crossed with obstructed view
(2) Turned with obstructed view
(3) Stopped when not required
(4) Proceeded with insufficient clearance
(5) Turned without signaling
(7) No driver present
(8) Other decision error (specify):
____
____
(9) Unknown

DRIVER RELATED EMOTIONAL FACTORS

55. Was The Driver Upset Prior To Crash? ____
(0) Not upset
(1) Preceding argument with spouse
(2) Preceding argument with other family member
(3) Preceding argument with other individual (specify):
____
(4) Related to financial problems
(5) Related to family problems
(7) No driver present
(8) Other source (specify):
____
(9) Unknown

DRIVER RELATED EMOTIONAL FACTORS

56. Driver Under Work-Related Pressure ____ / ____ / ____
(Code up to three factors.)
(0) No work-related pressure factors
(1) Learning new position
(2) Production/shipping deadlines
(3) Work schedule
(4) Additional production/sales requirements
(5) Forced to accept loads with little or no advance notice
(6) Forced to accept demotion/pay decrease
(7) No driver present
(8) Other pressure (specify): ____________________
(9) Unknown

57. Was The Driver In a Hurry Prior To Crash? ____
(0) Not in a hurry
(1) Due to work-related schedule
(2) Late for business appointment
(3) Late for social appointment
(4) Late for start of work shift/start of school classes
(5) Normal driving pattern
(7) No driver present
(8) Other reason (specify): ____________________
____
(9) Unknown

58. Other Emotional Factors ____
(0) No other emotional factors
(1) Driver clinically depressed
(2) Driver has a diagnosed psychosis (specify):
____
(7) No driver present
(8) Other factors (specify): ____________________
____
(9) Unknown

DRIVER RELATED EXPERIENCE FACTORS

59. Vehicle Familiarity ____
(1) First time driving this vehicle
(2) Had driven this vehicle 2-5 times in the past six months
(3) Had driven this vehicle 6-10 times in the past six months
(4) Had driven this vehicle more than 10 times in the past six months
(7) No driver present
(9) Unknown

60. Roadway Familiarity ____
(1) First time driving on this roadway
(2) Rarely drives on this roadway
(3) Drives on this roadway once per month
(4) Drives on this roadway several times per month
(5) Drives on this roadway weekly
(6) Drives on this roadway daily
(7) No driver present
(8) Other frequency (specify):
____
____
(9) Unknown

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Figure C.39: Crash Event Form Page 12

Figure C.40

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DRIVER RELATED EXPERIENCE FACTORS

61. Other Factor Types ____/____/____
(Code up to three factors.)
(0) No other factor types
(1) Uncomfortable with surrounding traffic densities
(2) Uncomfortable with general traffic speeds
(3) Uncomfortable with general traffic flow (specify): ____________
(4) Uncomfortable with some aspect of vehicle/load (specify): ____________
(7) No driver present
(8) Other (specify): ____________
(9) Unknown

RELATION WITH CARRIER/EMPLOYER FACTORS

62. Under Pressure To Accept Loads ____
(0) Not under pressure to accept load
(1) To accept unscheduled loads while on a scheduled trip
(2) To accept additional loads while on an unscheduled trip
(3) To accept unscheduled loads while on a short notice scheduled trip
(4) To accept additional loads although over allowable driving hours
(7) Not applicable
(8) Other load factors (specify): ____________
(9) Unknown

63. Under Pressure To Operate Even If Fatigued ____/____/____
(Code up to three factors.)
(0) Not under pressure to operate fatigued
(1) Scheduled loads/trips require extended hours to complete
(2) Scheduled trips require rotating shift schedule
(3) Unscheduled loads/trips require extended hours to complete
(7) Not applicable
(8) Other fatigue-related factors (specify): ____________
(9) Unknown

64. Other Relation Factor Types ____/____/____/____/____
(Code all factors that apply.)
(0) No other relation factors
(1) Required to accept short notice trips
(2) Required to fill-in for other drivers
(3) Required to complete uncompensated loading/unloading activities
(4) Variable compensation package
(7) Not applicable
(8) Other factors (specify): ____________
(9) Unknown

TRAFFIC FLOW RELATED FACTORS

65. Traffic Flow Interruption Factors ____/____/____/____
(Code up to four elements.)
(0) No traffic flow factors
(1) Previous crash nearby
(2) Construction work zone
(3) Emergency vehicle approaching
(4) Rush hour congestion
(8) Other (specify): ____________
(9) Unknown

VEHICLE FACTORS

66. Vehicle Condition Related Factors ____/____/____/____
(Code up to four elements.)
(0) No vehicle related factors
(1) View obstruction - related to load
(2) View obstruction - related to vehicle design
(3) View obstruction - other
(4) Tire malfunction
(5) Braking system malfunction
(6) Transmission malfunction
(7) Engine problem
(8) Other (specify): ____________
(9) Unknown

ENVIRONMENTAL RELATED FACTORS

67. Roadway Related Factors ____ ____/____ ____
(Code up to four elements.) ____ ____/____ ____
(00) No roadway related factors
(01) Traffic signs/signals missing
(02) Roadway view obstructions including factors or devices like signal boxes
(03) View obstructed by other vehicle
(04) Roadway geometry (crossover)
(05) Roadway geometry (curve)
(06) Road sight distance insufficient
(07) Lane delineation problem (not present, worn, etc.)
(08) Narrow shoulders
(09) Narrow road
(10) Ramp speed
(11) Roadway condition (potholes, deteriorated road edges, etc.)
(12) Slick surface (low friction value due to icy condition, loose debris, or any other cause)
(13) Road under water
(14) Road washed out
(97) No driver present
(98) Other roadway problem (specify): ____________
(99) Unknown

If element 04 (Roadway geometry) is selected and crash site involves a crossover, record:

Median width = ____ ____ ____ . ____ m
Inside shoulder width = ____ ____ ____ . ____ m

Median:
____ ____ ____ . ____ ft x 0.3048 = ____ ____ ____ . ____ m

Shoulder:
____ ____ ____ . ____ ft x 0.3048 = ____ ____ ____ . ____ m
999.7 Not applicable
999.9 Unknown

If element 05 (Roadway geometry) is selected, and crash site is located in a curve or is associated with a curve, record the radius of curvature:
Radius = ____ ____ ____ . ____ m
____ ____ ____ . ____ x 0.3048 ft = ____ ____ ____ . ____ m
999.7 Not applicable
999.9 Unknown

If element 06 (Road sight distance insufficient) is selected, record the measured sight distance.
Sight Distance = ____ ____ ____ . ____ m
____ ____ ____ ____ . ____ ft x 0.3048 = ____ ____ ____ ____ . ____ m

AASHTO Recommended Sight Distance
____ ____ ____ ____ . ____ m
____ ____ ____ ____ . ____ ft x 0.3048 = ____ ____ ____ ____ . ____ m

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Figure C.40: Crash Event Form Page 13

Figure C.41

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ENVIRONMENTAL RELATED FACTORS

68. Weather Related Factors _____ / _____ / _____ / _____
(Code up to four elements.)
(0) No weather related factors
(1) Rain
(2) Snow
(3) Fog
(4) Wind gust
(5) Hail
(6) Sleet
(7) No driver present
(8) Other (specify): ____________________
(9) Unknown

69. Other Environmental Factors _____ / _____ / _____ / _____
(Code up to four elements.)
(0) No other factors
(1) Glare
(2) Blowing debris
(3) Smoke
(7) No driver present
(8) Other sudden change in ambience (specify): ____________________
(9) Unknown

SOURCE OF CRITICAL EVENT ASSOCIATED FACTOR DATA

(01) Driver interview
(02) Carrier interview
(03) Other interview (specify): ____________________
(04) Police report
(05) Researcher investigation findings
(06) Reviewer assessment
(07) Medical records (including autopsy report)
(98) Other (specify): ____________________
(99) Unknown

	Variable No.	Source Code
70.	_____	_____
71.	_____	_____
72.	_____	_____
73.	_____	_____
74.	_____	_____
75.	_____	_____
76.	_____	_____
77.	_____	_____
78.	_____	_____
79.	_____	_____
80.	_____	_____
81.	_____	_____
82.	_____	_____
83.	_____	_____
84.	_____	_____
85.	_____	_____

SUMMARY: Provide a narrative description summarizing the basis for determining the critical event, critical reason for the critical event, and all associated factors.

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Figure C.41: Crash Event Form Page 14

Appendix D
Literature Review

I. Vehicle Fleet

A. One very important factor with regard to vehicle and roadside hardware interaction are classifications or categories of vehicle classes. Current crash testing under NCHRP Report 350 guidelines features the 820 kg car and the 2000 P pickup, there is a need to have some sense of how the RSH is performing for passenger vehicles intermediate to this range. Several additional vehicle categories have been identified by various studies. A possible finding for this research project may include additional proposed vehicle classifications and an assessment of how representative current classes are. (A.18, C.1.a., C.5)

B. Light truck (i.e. pickups, large vans, mid size and large utility vehicle) sales have continued to climb for the last 20 years. The 3/4 ton and 1/2 ton pickup have the largest market share and are considered representative of this category. The 3/4 ton pickup is considered a practical worst case; however, lighter SUV's are less stable. (C.1.a, C.5) It has been established that Fords have comparatively higher CGs. The implications of varied fleet characteristics and vehicle characteristics will be critical to assess compatibility.

C. The 820 kg car category may not be available in the near future due to phasing out of this lower end category. (C.5) This should be considered in future updates to NCHRP Report 350 and during the definition of performance ranges for future roadside safety systems.

D. Sales trends indicate that the light trucks will continue to be a more significant percentage of the vehicle fleet. Changes in accident data may be reflected as the fleet characteristics are reflected. (C.1., C.5) During this project, accident data should be evaluated to confirm these trends and to establish their implications to RH safety performance.

E. Air bags will be in 100% of the fleet within the next decade. There is some controversy about the meaning of this due to multiple impact consideration with roadside hardware. No evidence has been established to date of establishing the significance of this. This phenomenon is postulated to effect passenger safety during oblique impacts (off angle). Also, the emergence of side bags (ITS, curtain bags, thorax bags, etc) may provide additional occupant protection during side impact scenarios. The additional protection which airbags will provide should be considered as future safety criteria are established. A vehicle based (non-occupant) criteria may not take this additional energy absorbing system into account to estimate occupant protection.

F. Long term projections indicate huge changes in vehicle mass may become reality within the next 25 years. A goal of up to 40% weight reduction, if achieved, could significantly compromise the performance of energy absorbing or force threshold hardware due to higher g's imparted to small cars although safety improvements in vehicle design could offset this. (C.5) During short term planning, this will not be a problem. Without concrete knowledge regarding future vehicle trends, design changes to existing roadside hardware safety systems to accommodate future vehicles may compromise the current performance of these systems.

G. It is estimated that vehicle platforms will undergo major changes every 3 to 4 years with new platforms every 3 - 7 1/2 years. (C.5) The challenge for assuring compatibility could be great if significant changes occur. The focus of this project is to identify critical vehicle characteristics which may be used for the assessment of future interaction of vehicles and roadside systems. A general approach to testing and verification of correct interaction should be proposed.

H. Some increase in vehicle stiffness is forecast over the next decade. (C.5) This is based on frontal crash. Stiffness trends and metrics should be identified for other modes of impact as well. In particular, oblique structural stiffness is important during impact with longitudinal barriers.

I. The cab forward design may see up to 50% penetration by 2003. Disadvantages include a congested engine compartment and large windshield. (C.5) There is some anecdotal evidence that congested engine compartment may be a good thing, particularly for frontal impacts with narrow objects. (Bronstad) Narrow objects, such as guardrail terminal beams, can proceed somewhat unimpeded through the engine compartment of full-size pickups where voids are present (i.e. for frontal impacts). The engine compartment of cars and smaller LTV's are much more congested and provide resistance to invading structures. These voids could be characterized in this project.

J. Little change is forecast for frame design and suspension systems. (C.5) Closer interaction with vehicle manufacturers and related industry may help to confirm this statement. Innovations are not often publicly available therefore the research team cannot easily assume this to be true.

K. It is unlikely that future trends will be obtained from vehicle manufacturers due to "trade secret" status. (C.5) As stated above, there are mechanisms to interact with the automotive design community however, "trade secret" status will probably not change.

II. Vehicle Parameters

A. Problems using the 2000 P pickup in Report 350 evaluations are attributed to higher bumper height, shorter front overhang, stiffer crush properties, and higher CG locations. (C.5) These differences generally contribute to stability problems for 2000 P vehicles. These characteristics support the use of this platform to represent the worst case impacts with large vehicles however, vehicles intermediate to the 820 kg car and the 2000 P vehicle may have structural properties which can drastically influence crash performance depending on impacted device.

B. Geometry ranges for light trucks compared to the 4500 lb car; (C.5) a. top of Bumper exceeded all car values b. front overhang was less than all car values, c. wheel base was more or less (both sides), d. tire diameter - both sides e. curb weight - both sides, f. c.g. height mostly exceeded car, g. c.g. location from front axle - both sides. The combined effect of each of these factors is difficult to analyze. Parametric studies may be performed using finite element models to isolate the effect of design variables on performance behavior during impact. Few full-scale impacts have been performed using other vehicle platforms. As a result performance data is not currently available.

d. The 2000 P (3/4 ton pickup): (C.1.b) e. bumper/suspension varies, f. Ford CG. is typically 2.5 inches higher than Chevrolet, g. CG closer to front axle has tendency to counter rotate instead of smoothly redirected, h. front end stiffer than 4500 lb car. Testing, as currently done with mostly Chevrolet Pickups, is not the practical worst case. A robust approach to testing and roadside safety design should be established where the effects of these slight design changes are not significant.

C. 820 kg (1800 lb) car hood latches and hinges are lower strength; allows detachment. (C.1.b) Generally, this characteristic has not been critical for Report 350 tests.

D. Lower profile cars have been shown to interact unsatisfactorily with certain roadside hardware due to under-ride. (C.3.b., D.5, and D.6) No current testing with these vehicle types is required. Investigation of this effect could be performed during this project on a limited basis using FE Analysis if necessary. Establishing acceptable and unacceptable profile corridors may result.

E. Inertia of smaller cars (e.g. 820 kg) is a potential problem for off-center impacts. (C.5) This will remain a potential problem without drastic changes in energy absorbing capabilities in impacted systems.

F. A controlled hood-collapse mechanism is essential to prevent hood segments from being forced into the passenger compartment for certain hardware.(C.3.a.) During full-frontal impacts conducted under NHTSA's FMVSS 208, this phenomenon would also occur. Since compliance FMVSS 208 is required for all vehicles, this sort of structural behavior is considered during design. It is believed that vehicles are currently being made with this design principle.

G. A study conducted in the 1980's demonstrated that the profile of bumpers and location of the structural part of the bumper can influence override/underride interaction particularly with curved boundary features such as W-beam and thrie beam. Since this older study, there has been no effort to characterize this property. Based on gathered design characteristics of the current vehicle fleet, an evaluation of these characteristics as they relate to guardrail interaction will be given during this study.

H. A current study, which has examined design parameters of 7 vehicles, is considered one of the most comprehensive computer simulation projects which is publicly available to date. (C.5) Some correlation's have shown that much can be learned using some of the older codes, however limitations in accuracy, output information and applicability to new system designs do exist. Often though, use of simplified analysis codes are sometimes more economical to run than finite element codes such LS-DYNA.

I. The most significant factor was determined to be the mass; heavier vehicles impart larger forces/energies whereas lighter vehicles are more critical in terms of occupant risk. (C.5) Since testing is conducted on the extreme ranges of vehicle size - intermediate vehicle size evaluations may be recommended for certain devices. Devices should be classified as size, mass, stiffness or geometrically sensitive in order to establish the nature of applicable tests required for its validation.

J. CGs of light trucks in the vertical direction were typically 20 to 35 inches high whereas passenger car heights are in the 20 to 23 in. range. (C.5) Rollover rates will continue to increase as LTV's continue to increase as a percentage of the vehicle fleet. This data will be verified through investigation of rollover rates on a year-by-year basis.

K. Bumper heights of light trucks average about 17 to 27 in. (bottom to top) while passenger cars average 17 to 21 in. (C.5) This will increase override possibilities. Investigation of accident data is needed to evaluate this phenomenon.

L. The overhang for full-size passenger cars typically averages about 43 in. whereas the average for full-size pickups is about 30 in. (C.5) The combination of shorter pickup front wheel overhang and higher CG leads to a vehicle stability problem. Methods to mitigate the effects of these design characteristics will be studied and reported.

M. Structural differences made the front end of passenger cars ßofter" and more energy absorbing than light trucks. Different vehicle frame/bumper support geometry can provide different performance. (C.5) Some analysis of these factors will be accomplished in this project. Specific emphasis will be placed on understanding frontal and oblique crush stiffnesses.

N. Light truck suspensions are stiffer than passenger cars. (C.5) This fact, while important, will not likely change. Implications of this will be identified as it relates to the compatibility with specific roadside safety systems discussed.

O. Low profile designs are more common to cars and can represent an underride problem for certain RSH. (C.3.b., D.5, D.6) Generally all of the differences between cars and light trucks contribute to stability problems for the light truck category. In addition, vehicles override/vaulting can result due to bumper height considerations. These vehicle characteristics and their relationship to safety performance of each system will be identified and reported during this study.

III. Computer Simulations

A. Large parametric evaluations using the latest finite element analysis codes such as LS-DYNA require a great deal of computational time. In some cases, this type of analysis is impractical. Also, in some cases, a lack of validation for RH objects and vehicles is an issue. The use of HVOSM for rigid barriers simulations and BARRIER VII provides insight for flexible barrier systems although not to the extent that a validated LS-DYNA simulation can provide. (C.5) LS-DYNA simulations are preferred due to the great amount of flexibility and resulting output information, however, they cannot currently be economically employed in large-scale matrices. In many cases, the use of older, more efficient codes can be employed to achieve acceptable results.

B. LS-DYNA. This code has been used to examine performance of RSH with some very good results. It is particularly useful in examining complex behavior/deformation until the point of fracture in the W-beam system during crash tests. (C.5) The older codes lack the detail to examine certain complex behavior. Limitations such as accurate fracture initiation and crack propagation exist in current explicit finite element codes. During instances where fracture results, a technique is used where critical stresses are monitored to understand when fracture would be initiated. At this point, failure is anticipated in some form.

C. Latest versions of HVOSM are useful to perform hundreds of parametric evaluations for comparable performance using different vehicle and impact condition parameters. This 3-D code predicts vehicle stability after striking rigid barriers. (C.5) See the above discussion regarding limitations and applicability of available analysis codes.

D. The BARRIER VII code has been validated and widely used in flexible barrier simulations for over 25 years. It has some capability of predicting wheel snagging, but cannot predict vehicle underride/override or rollover. (C.5) Severe wheel snagging for higher c.g. vehicles can result in rollover. Alternative means for studying this phenomenon may be necessary.

IV. Roadside Safety Hardware (RSH)

In general, light trucks create a greater demand on RSH than did the 4500 lb car. (B.11, C.5) This has been examined more in depth with longitudinal barriers and terminals / crash cushions.

A. Rigid Barriers. Based on crash tests and computer simulations:

1. Light trucks are much more unstable than cars for tracking impacts with NJ barriers. (C.5) Only future accident data can reveal full extent of this problem. Characteristics of the light truck class indicate that high CGs directly yield some degree of instability during a number of impact cases.

2. The SUV category has the greatest level of instability with NJ shape among light truck category. (C.5) This has not been fully evaluated; there is a potential problem here that requires additional investigation. As stated above, evaluation of recent accident statistics will clearly define the seriousness of this interaction.

3. Tracking crash tests with 2000 P pickup with NJ shape under Report 350 TL-3 conditions resulted in satisfactory performance. (C.5) No compatibility issues here. Verification will take place using accident statistics.

4. Accident data indicates that a higher incidence of rollover occurs with light trucks than with passenger cars. (C.5) This will continue to increase as fleet reflects sales trends. Obvious vehicle characteristics such as CG height, frontal over hang distance and high ride height support this conclusion.

5. Of three barriers simulated, the constant slope barrier (CSB) introduced the greatest instability, especially with light trucks. (C.5) As the CSB usage, and light truck sales increase, this could be a problem as reflected in accident history.

6. Within light truck category, the SUV and small pickup (SPU) have greatest propensity for overturning even at relatively low speed of 70 km/h and 15 degree angle. (C.5) Accident experience reflecting this fact should increase serious injury and fatal rates.

7. The vertical wall barrier (VWB) introduces less instability - no overturns were predicted. (C.5) In order to analyze the trade-off in reducing overturn accidents as compared to increasing occupant risk due high acceleration levels and compartment intrusion, a calculation of the level of HARM associated with each is appropriate. This calculation, based on resulting cost due to injury, can help to identify the most desirable countermeasure under consideration..

8. Non-tracking impacts with VWB can result in excessive occupant risk values. (C.5) See above.

B. Flexible Longitudinal Barriers

1. The standard W-beam and thrie beam guardrail and median barrier systems are marginal at best when subjected to the basic TL-3 2000 P test of NCHRP Report 350. (B.11) Modifications to steel post block-out have resulted in successful test results, but performance over the acceptable range of barrier heights has not been explored.

2. For given impact conditions, more pronounced wheel snagging is associated with light trucks due to short overhang. (B.11,C.5) Strong post systems with rigid block-outs have reduced problems associated with this. Relative numbers of this installation type will be identified based on a sampling state inventory findings.

3. For given impact conditions light trucks produce larger barrier deflections than large passenger cars. (C.5) This larger increase is not sufficient to change fixed object distance criteria.

4. Block-out depth is critical for minimizing wheel snagging in strong post barriers. (C.5) Block-out collapse of 6 in block-out cannot be tolerated. Test results for barrier systems using non-steel block-out materials must be evaluated for their suitability.

5. Major wheel snagging occurred in a TL-3 test with 2000 P vehicle and G4-1(S) guardrail resulting in vehicle rollover. Major snagging was predicted by BARRIER VII. Use of an older code can predict wheel snagging if properly interpreted.

6. A G4(1S) test with 2000 P vehicle at 110 km/h and 20 degree angle resulted in vehicle rollover. (C.5) This information is useful to evaluate the current testing criteria as well as guardrail design specifications.

7. A modified G4(1S) with a 6 in. wood block-out was tested under TL-3 conditions with a 1995 Taurus with satisfactory results. A vehicle from the same intermediate class, a 1995 Chevrolet Lumina, was used in a subsequent test that resulted in tearing of the W-beam and vehicle penetration. Cause of the failure has been attributed to differences in frame geometry and stiffness characteristics. (D.1, Interim Report)This is possibly a problem; the project team has located a source of data for frame characteristics. A detailed study will be made and summary findings will be reported.

8. A G9 thrie beam test at TL-3 conditions with 2000 P vehicle resulted in multiple vehicle rollover. Major wheel snagging in the test was predicted by BARRIER VII. (C.5) See above regarding W-beam.

g. Terminals and Crash Cushions

There are a large number of these devices that have met the requirements of NCHRP Report 350 TL-3. (A.7) Many devices meeting Report 230 met Report 350 requirements without any modifications.

1. The MELT terminal under development for Report 350 experienced 2000 P vehicle overturns in TL-3 tests for L-O-N. Devices employing flares at the end are susceptible to problems associated with increased impact angle.

2. In a surprising test, the W-beam fractured in a test of the MELT-2 for the TL-3 critical impact condition with the smaller car. (D.13) This surprising result was evaluated using LS-DYNA. Similar evaluation will be conducted as performance of various roadside safety systems are explored.

D. Signs and Luminaire Supports.

There are a very large number of these devices that have met both NCHRP Report 230 and 350.

1. Since the small car test controls with these devices, and since Report 230 requirements are considered more stringent, devices tested to 230 have been accepted according to criteria of 350. (A.7, A.16, Project Interim Report) A limited study determined problems with sign mounting heights.

Failure Summary- Summaries of known RSH failures are shown in Table 8 Due to vehicle design considerations, it was determined that only 1982 and newer vehicle results would be summarized.

(References D) While much of the RSH meeting Report 230 also met Report 350 requirements, problems associated with the 2000 P pickup required modifications with some designs. Tests with intermediate sedans (Taurus and Lumina) on a W-beam system resulted in a surprising failure attributed to geometric/structural differences.

V. Other findings

The following Selected RSH developed for Report 230 met Report 350 requirements without modification: 1. ET-2000 (A.1) 2. REACT 350 (A.2) 3. 29 Ft luminaire support used with road closure gate. (B.6.c.)

The following Selected RSH developed for Report 230 have been modified to meet 350. 1. BEST (B.6.a) 2. G4-1S (D.1) 3. Buried in-back slope terminals (B.8., B.9.)

A. LS-DYNA applications h. 1990 Taurus and 1982 Honda Civic modeled (A.14) i. LLNL-DYNA 3D modeled G2 Guardrail (B.b.j) j. LS-DYNA 3D steel characteristics (B.6.k) k. LS-DYNA 3D simulations of dual support breakaway sign compared to full-scale crash tests (B.6.l) Used as a Method to compare simulations with Full-Scale test results. (B.6.m)

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