INDIANA UNIVERSITY
TRANSPORTATION RESEARCH CENTER
School of Public and Environmental Affairs
222 West Second Street
Bloomington, Indiana 47403-1501
(812) 855-3908 Fax: (812) 855-3537

ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-03-041
LOCATION - OKLAHOMA
VEHICLE - 2003 CHEVROLET K1500 TAHOE
CRASH DATE - August 2003

Submitted:

September 5, 2007

Contract Number: DTNH22-01-C-07002

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

DISCLAIMERS

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

1. *Report No.* IN-03-041	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* On-Site Certified Advanced 208-Compliant Vehicle Investigation Vehicle - 2003 Chevrolet K1500 Tahoe Location - Oklahoma		5. *Report Date:* September 5, 2007 6. *Performing Organization Code*	
7. *Author(s)* Special Crash Investigations Team #2		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Research Center Indiana University 222 West Second Street Bloomington, Indiana 47403-1501		10. *Work Unit No. (TRAIS)* 11. *Contract or Grant No.* DTNH22-01-C-07002	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation (NPO-122) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. *Type of Report and Period Covered* Technical Report Crash Date: August 2003 14. *Sponsoring Agency Code*	

15. *Supplementary Notes*
On-site air bag deployment investigation involving a 2003 Chevrolet K1500 Tahoe, four-door sport utility vehicle, with manual safety belts and dual front advanced air bags, which ran-off-road and rolled over

16. *Abstract*

This report covers an on-site investigation of a crash that involved a 2003 Chevrolet Tahoe (case vehicle) which ran-off-road and eventually overturned. This crash is of special interest because the case vehicle was equipped with multiple **A**dvance **O**ccupant **P**rotection **S**ystem (**AOPS**) features, including certified advanced 208-compliant air bags, as well as an **E**vent **D**ata **R**ecorder (**EDR**) and the case vehicle's, unrestrained driver (25-year-old, male) sustained only minor injuries as a result of the crash. The trafficway on which the case vehicle was traveling was a four-lane, divided, U.S. highway, traversing generally in a north-south direction. Furthermore, the case vehicle was approaching a right-hand curve. Both the northern and southern roadways had two through lanes, separated by a grass median at the site of the crash. The case vehicle had been traveling north in the outside northbound lane. The case vehicle departed the left side of the northern roadway into the grassy median at the location where the roadway begins to curve. Based on the scene evidence, the vehicle traveled approximately 100 meters on the grass median before veering back to the right and re-entering the roadway. At this point, the case vehicle rotated counterclockwise, traveling approximately 30 meters, before it departed the left side of the northern roadway again, into the grassy median. The case vehicle's right front tire dug into the grassy median enabling the vehicle to "trip over" contacting the ground with its right side. The case vehicle continued to roll over about its longitudinal axis onto its roof and most likely began rolling onto its left side before settling on its roof at final rest. The case vehicle came to rest on its roof, heading in a southwesterly direction. Although the case vehicle was equipped with multi-staged, driver and front right passenger supplemental restraints (air bags), neither air bag deployed. The case vehicle's driver was seated and his seat track appears to be located between its middle and rearmost positions. The tilt steering wheel was located between its middle and down-most positions. He was not using his available, active, three-point, integral lap-and-shoulder, safety belt system and sustained, according to his medical records, minor injuries that included: a laceration and partial avulsion to his right external ear and abrasions to his right knee and right shin area.

17. *Key Words* Advanced Air Bag Non-Deployment; EDR Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
19 *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 17	22. *Price* $8,900

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS IN-03-041

Page No.

SELECTED PHOTOGRAPHS (Continued)

This investigation was brought to NHTSA's attention on or before September 16, 2003, by GES sampling activities. This crash involved a 2003 Chevrolet Tahoe (case vehicle) which ran-off-road and eventually overturned. The crash occurred in August 2003 at 3:10 a.m. in Oklahoma and was investigated by the applicable state police department. This crash is of special interest because the case vehicle was equipped with multiple **A**dvance **O**ccupant **P**rotection **S**ystem (**AOPS**) features, including certified advanced 208-compliant air bags, as well as an **E**vent **D**ata **R**ecorder (**EDR**) and the case vehicle's driver [25-year-old, White (non-Hispanic) male] sustained only minor injuries as a result of the crash. This contractor inspected the scene and vehicles on October 2, 2003 and downloaded the data from the onboard **EDR**. This contractor obtained a very limited partial interview with the driver of the case vehicle on October 28, 2003. This report is based on the Police Crash Report, a partial interview with the case vehicle's driver, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

SUMMARY

Crash Environment: The trafficway on which the case vehicle was traveling was a four-lane, divided, U.S. highway, traversing generally in a north-south direction. Furthermore, the case vehicle was approaching a right-hand curve. Both the northern and southern roadways had two through lanes, separated by a grass median at the site of the crash. At the time of the crash the light condition was dark–not lighted, the atmospheric condition was cloudy, and the roadway pavement was dry. Traffic density was not determined, and the site of the crash was urban undeveloped; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle had been traveling north in the outside northbound lane and intended to negotiate the curve and continue in his northern travel path. The case vehicle departed the left side of the northern roadway into the grassy median at the location where the roadway begins to curve. Based on the scene evidence, the driver most likely steered to the right in an effort to return the vehicle to the roadway. The case vehicle began to rotate clockwise while traveling approximately 100 meters on the grass median before veering back to the right and re-entering the roadway. At this point, according to the Police Crash Report, the case vehicle began to rotate counterclockwise, traversing a distance of approximately 30 meters, before it departed the left side of the northern roadway again, into the grassy median. Based on this contractor's experience, this vehicle behavior most likely occurred because the driver was steering back to the left in an effort to straighten the vehicle out. The crash sequence came to an end in the grassy median when the case vehicle rolled over onto its top before coming to a rest.

Crash: Based on the scene inspection, the case vehicle's right front tire most likely dug into the grassy median enabling the vehicle to "trip over" contacting the ground with its right side.

Post-Crash: The case vehicle continued to roll over about its longitudinal axis onto its roof and most likely began rolling onto its left side before settling on its roof at final rest. According to the Police Crash Report's schematic, the case vehicle came to rest on its roof, heading in a

southwesterly direction. Although the case vehicle was equipped with multi-staged, driver and front right passenger supplemental restraints (air bags), neither air bag deployed.

Case Vehicle: The 2003 Chevrolet Tahoe was a four-wheel drive (4x4), four-door, sport utility vehicle (VIN: 1GNEK13Z83R------) and was **CERTIFIED ADVANCED 208-COMPLIANT**. The case vehicle was equipped with four wheel, anti-lock brakes, dual stage driver and front right passenger air bag inflators, and a driver seat belt sensing system. Furthermore, the case vehicle was equipped with a LATCH system and a new tire pressure monitor. Furthermore, the case vehicle was equipped with occupant detection and automatic air bag suppression system for the front right passenger seating position. The occupant sensing system automatically switches the front right passenger front air bag on or off based on the passenger's weight and the type of pressure on the seat. Front seat back-mounted side impact air bags and power-adjustable pedals were optional for this model, but this vehicle was not so equipped. Finally, the case vehicle was also equipped with an **E**vent **D**ata **R**ecorder (**EDR**).

Vehicle Exterior: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **00-TYDO-3**. No reconstruction program was used on this crash because it involved a non-horizontal impact. The crash severity to the case vehicle was estimated to be low [14-23 km.p.h. (9-14 m.p.h.)]. The case vehicle was towed due to damage.

Exterior Damage: The case vehicle's initial contact with the ground involved its entire right side. As the case vehicle continued to roll over, it contacted the ground with its hood, windshield, windshield header, both "A"-pillars, and the front portion of its roof. Direct damage also occurred to its left fender and the left outside rearview mirror indicating that the case vehicle began, at least, to roll onto its left side. The case vehicle's wheelbase was unaltered from the crash. The case vehicle's entire right side was directly damaged and crushed inward, though at some points crush damage was almost nonexistent. There was also direct damage to the left fender and hood of the case vehicle and along the windshield header and front portion of the roof, especially at the top of the right "A"-Pillar. There was induced damage to both the right and left headlight and turn signal assemblies as well as both the grille and right and left fenders. The windshield's glazing was cracked, the right front and 2nd right rear window glazings were disintegrated, and the glazing in the liftgate rear door system was intact but displaced (i.e., popped out) during the crash sequence. Remote buckling was also found on the right rear door and the right quarter panel. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

The case vehicle manufacturer's recommended tire size was: P265/70R16, and the case vehicle tires were the recommended size. The case vehicle's tire data are shown in the table below. In addition, there is no evidence that any of the case vehicle's tires were damaged, deflated, or physically restricted; however, only the left front tire was present during this contractor's inspection.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	214	31	241	35	9	11	None	No	No
RF	Unk	Unk	241	35	Unk	Unk	Unknown	Unknown	Unknown
LR	Unk	Unk	241	35	Unk	Unk	Unknown	Unknown	Unknown
RR	Unk	Unk	241	35	Unk	Unk	Unknown	Unknown	Unknown

Vehicle Interior: Inspection of the case vehicle's interior revealed contact to the driver's right arm rest (i.e., bent toward the center of the vehicle). Furthermore, there was no obvious evidence of contact to the front of the vehicle or the front sun visors. However there was contact evidence (i.e., scuffs, scrapes, etc.) on the interior surface of the vehicle's roof, both in the front and back of the vehicle. In addition, there was damage (i.e., broken plastic) to the back right interior side surface as well as a fabric tear on the right side of the left second seat's head rest. It cannot be stated with certainty that any of this damage is occupant-related. According to our limited, partial interview with the case vehicle's driver, he indicated that there was a large, wooden speaker box located in the vehicle's back seating area. It is probable that this interior loose object in the back of the vehicle produced some or much of this interior damage; however, no speaker box or other objects were present during our vehicle inspection. On the other hand, the interior damage pattern is obliquely oriented, running from the driver's seat toward the back right interior surfaces. It is also possible that some of the interior damage is occupant extrication related.

There were vertical intrusions to the case vehicle's windshield and windshield header across the entire front seating area. In addition, there was vertical intrusion to the front right seating area by the right "A"-pillar. Finally, there was no evidence of compression of the energy absorbing shear capsules in the base of the steering column and no deformation to the steering wheel rim.

Supplemental Restraints: The case vehicle's driver air bag was located in the steering wheel hub. The front right passenger's air bag was located in the middle of the instrument panel. Neither front air bag deployed during the crash sequence.

Crash Data Recording: The data downloaded from the case vehicle's **EDR** showed the vehicle's SIR warning lamp status, driver's seat belt buckle status, ignition cycles at near deployment, time from algorithm enable to maximum **SDM** (i.e., ***SENSING AND DIAGNOSTIC MODULE***) recorded velocity change (i.e., air bags did not deploy), and the vehicle's speed and brake switch status for the five recorded sample periods preceding the **ALGORITHM ENABLE**. In addition, the vehicle's velocity change (i.e., Delta V) is reported. Downloaded data of interest indicated the following. The case vehicle was traveling at a speed of 27 km.p.h. (17 m.p.h.) one second before algorithm enable, the driver's seat belt status showed it was not buckled, and the Delta V reached a value of 4.49 km.p.h. (2.79 m.p.h.) at the 150 millisecond mark of recorded data. Although it is unknown as to exactly where in the crash sequence the EDR was enabled, the vehicle speed and

braking data indicate that the recorded event may have happened just prior to or during the rollover initiation. If this assumption is correct, then this contractor believes that the recorded Delta V seems reasonable considering the amount of deformation to the case vehicle's front

Case Vehicle's Driver: The exact posture of the case vehicle's driver [25-year-old, White (non-Hispanic) male; 178 centimeters and 66 kilograms (70 inches, 145 pounds)] immediately prior to the crash is unknown. According to the Police Crash Report, the driver was charged with "driving while intoxicated". Based on the scene and vehicle inspections, as the vehicle went off the road the driver was most likely seated in a reclined posture with his back against or near the seat back, his left foot on the floor, his right foot on the accelerator, and at least one hand on the steering wheel. The exact position of his seat track at the time of the crash is unknown because the motorized seat was frozen (i.e., electronically) at the time our inspection and the full movement–forward and rearward, of the seat track could not be determined. The seat track appears to be located between its middle and rearmost positions. The seat back was significantly reclined, and the tilt steering wheel was located between its middle and down-most positions.

Based on this contractor's vehicle inspection and substantiated by the **EDR** data, the case vehicle's driver was not using his available, active, three-point, integral lap-and-shoulder, safety belt system; the belt system was not equipped with a pretensioner. Furthermore, the inspection of the driver's seat belt webbing and latch plate showed no evidence of loading (i.e., stress marks or scuffs); although, there were obvious signs of historical usage on the latch plate.

Based on the scene inspection, the case vehicle's driver most likely steered the vehicle to the right after it had initially ran-off-road, attempting to re-enter the roadway. As a result and independent of the nonuse of his available safety belts, the driver most likely moved slightly to his left just prior to re-entering the roadway. Once on the roadway again the case vehicle was heading in an obliquely oriented fashion and, as a result, the case vehicle's driver over-steered hard to the left and most likely braked, attempting to avoid exiting the right side of the roadway. As a result, the case vehicle departed the left side of the roadway while rotating counterclockwise. The driver most likely moved slightly forward and to his right as a result of these attempted avoidance maneuvers. As the case vehicle rotated counterclockwise out-of-control, the driver released the brake and most likely attempted to steer to the right. It is unclear what, if any, effect these avoidance actions had on his position just prior to rollover initiation. As the case vehicle rolled to the right, the driver moved to his right contacting and deforming his arm rest. As the vehicle rolled onto its roof with the hood down and the back end angled upward, the driver most likely contacted the roof over the front seating area depositing contact evidence. As the case vehicle continued to roll rightward, it is unclear as to where the driver moved and what he contacted; although, contact evidence indicates that he may well have moved backward and toward the right side of the vehicle. According to the partial interview with the driver, he indicates that he was struck in the head by the wooden speaker box which had been located in the back seating area. The injury information confirms the presence of a head contact to the driver's right ear and is not inconsistent with the driver's information. According to the driver, he was in the front seating area when the vehicle came to rest, but his exact posture is unknown. It is entirely possible that if the driver contacted the interior loose object (i.e., wooden speaker box), the object was of

sufficient mass, in conjunction with gravity, to have redirected the driver back forward into the front seating area.

Based on the available evidence, the driver was transported by ambulance to the hospital. He sustained minor injuries and was treated and released. The injuries sustained by the case vehicle's driver included: a laceration and partial avulsion to his right external ear and abrasions to his right knee and right shin area.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle was traveling was a four-lane, divided, U.S. highway, traversing generally in a north-south direction. Furthermore, the case vehicle was approaching a right-hand curve (**Figure 1**). Both the northern and southern roadways had two through lanes, separated by a grass median at the site of the crash. The U.S. highway was curved gently to the right for northbound traffic and was level (i.e., actual slope was 0.0%) prior to and at the area of impact. The pavement was sharp concrete, and the width of both the inside and outside northerly lanes was 3.2 meters (10.5 feet). The shoulders were improved (i.e., concrete). The eastern side of the northern road had a 3.1 meter (10.2 foot) paved shoulder and the western side had a 2.0 meter (6.6 foot) paved shoulder, prior to the unknown width, unprotected grassy median. The roadway was not bordered by curbs. Pavement markings for the northern roadway consisted of a solid yellow edge line on the western (left) side and a solid white edge line on eastern (right) side. In addition, the through lanes were divided by a dashed white line. The estimated coefficient of friction was 0.80. Traffic controls consisted of a regulatory **SPEED LIMIT** sign (Manual on Uniform Traffic Control Devices, R2-1) and a **TRUCK SPEED LIMIT** sign (MUTCD, R2-2 mounted underneath) were located toward the beginning of the right-hand curve (**Figure 2**), prior to the area where the case vehicle re-entered the roadway and south of the area of the crash. The posted speed limit was 113 km.p.h. (70 m.p.h.) for non-trucks and 80 km.p.h. (50 m.p.h.) for trucks. At the time of the crash the light condition was dark–not lighted, the atmospheric condition was cloudy, and the roadway pavement was dry. Traffic density was not determined, and the site of the crash was urban undeveloped; see **CRASH DIAGRAM** at end.

Figure 1: Case vehicle's northerly travel path on inside northern lane of turnpike approaching right-hand curve (case photo #02)

Figure 2: Approximate location of case vehicle's initial road departure from right-hand curve into grassy median (case photo #04)

Pre-Crash: The case vehicle had been traveling north in the outside northbound lane and intended to negotiate the curve and continue in his northern travel path. The case vehicle departed the left side of the northern roadway into the grassy median at the location where the roadway begins to curve (**Figure 2** above). Based on the scene evidence, the driver most likely steered to the right in an effort to return the vehicle to the roadway. The case vehicle began to rotate clockwise while traveling approximately 100 meters on the grass median (**Figure 3**) before veering back to the right and re-entering the roadway (**Figure 4**). At this point, according to the Police Crash Report, the case vehicle began to rotate counterclockwise, traversing a distance of approximately 30 meters, before it departed the left side of the northern roadway again, into the grassy median (**Figure 5**). Based on this contractor's experience, this vehicle behavior most likely occurred because the driver was steering back to the left in an effort to straighten the vehicle out. The crash sequence came to an end in the grassy median when the case vehicle rolled over (**Figure 6**) onto its top before coming to a rest.

Figure 3: Yaw marks deposited by case vehicle during its initial road departure into grassy median (case photo #06)

Figure 4: Case vehicle's re-entrance onto road from grassy median (case photo #09)

Figure 5: Area of case vehicle's second road departure, from right-hand curve, into grassy median; Note: arrow indicates location of suspected rollover initiation (case photo #12)

Figure 6: Area (arrows) in grassy median where case vehicle's rollover is suspected to have initiated (case photo #14)

Crash: Based on the scene inspection, the case vehicle's right front tire most likely dug into the grassy median enabling the vehicle to "trip over" contacting the ground with its right side (**Figure 7** below).

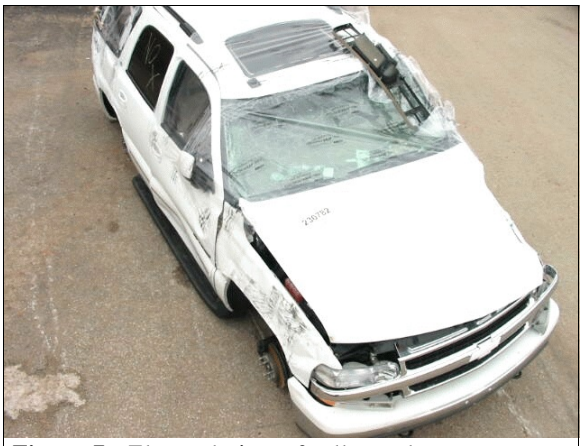


Figure 7: Elevated view of rollover damage to case vehicle's right side (case photo #37)

Figure 8: Rollover crush to case vehicle's left fender and front left hood viewed from left of front; Note: greater crush to right roof and right "A"-pillar and damaged left outside rearview mirror (case photo #23)

Post-Crash: The case vehicle continued to roll over about its longitudinal axis onto its roof and most likely began rolling onto its left side before settling on its roof at final rest (**Figure 8**). According to the Police Crash Report's schematic, the case vehicle came to rest on its roof, heading in a southwesterly direction (**Figure 9**). Although the case vehicle was equipped with multi-staged, driver and front right passenger supplemental restraints (air bags), neither air bag deployed.

Figure 9: Southerly view from beyond case vehicle's approximate final rest position showing northerly travel path after failing to negotiate right-hand curve and suspected area (arrow) of rollover initiation (case photo #16)

CASE VEHICLE

The 2003 Chevrolet Tahoe was a four-wheel drive (4x4), five-passenger, four-door, sport utility vehicle (VIN: 1GNEK13Z83R------) equipped with a 5.3L, V-8 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front and rear disc, four-wheel, anti-lock system. The case vehicle's wheelbase was 295 centimeters (116.0 inches), and the odometer reading at inspection is unknown because the case vehicle was equipped with an electronic odometer. A back (third seating area) bench seat was an option, but this vehicle was not so equipped.

The case vehicle was **CERTIFIED ADVANCED 208-COMPLIANT** and was equipped with dual stage driver and front right passenger air bag inflators, and a driver seat belt sensing system. Furthermore, the case vehicle was equipped with a LATCH system and a new tire pressure monitor. Furthermore, the case vehicle was equipped with occupant detection and automatic air bag suppression system for the front right passenger seating position. The various sensors in the case vehicle's advanced occupant restraint system analyze a combination of factors including the predicted crash severity and driver and front right passenger seat belt usage to determine the front air bag inflation level appropriate for the severity of the crash. For the front right seating position,

an occupant pressure sensor and a seat belt tension sensor provide data to the electronic control module. The electronic control module (a) compares the seat pressure and seat belt tension data to threshold values, (b) determines if the front right air bag should be suppressed or enabled, and (c) communicates the decision to the air bag control module. The air bag will be suppressed when the seat pressure is at or below the established threshold ***or*** there is above normal tension on the safety belt (e.g., a secured child seat). The air bag will be enabled if the pressure is above the threshold ***and*** the seat belt tension is normal (e.g., a restrained adult occupant) or below (e.g., unrestrained occupant).

Front seat back-mounted side impact air bags and power-adjustable pedals were optional for this model, but this vehicle was not so equipped. Finally, the case vehicle was also equipped with an **E**vent **D**ata **R**ecorder (**EDR**).

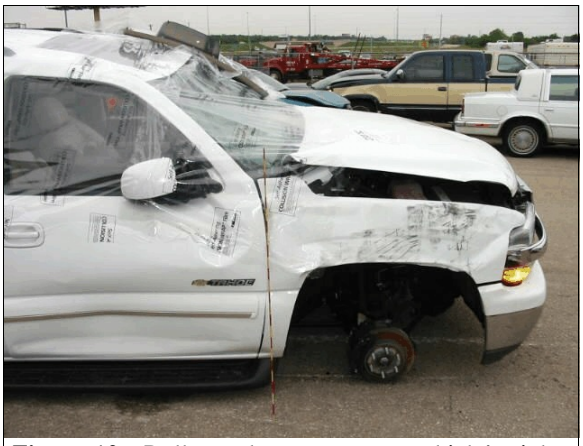


Figure 10: Rollover damage to case vehicle's right fender, lower right front door, right outside rearview mirror, right "A"-pillar, and right hood; Note: right front wheel missing (case photo #36)

Figure 11: Rollover damage to case vehicle's right quarter panel and doors, including disintegrated right front door and 2nd right rear window glazings and remote buckling to doors and quarter panel (case photo #31)

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's initial contact with the ground involved its entire right side (**Figure 7** above and **Figures 10** and **11**). As the case vehicle continued to roll over, it contacted the ground with its hood, windshield, windshield header, both "A"-pillars, and the front portion of its roof (**Figure 12**). Direct damage also occurred to its left fender and the left outside rearview mirror indicating that the case vehicle began, at least, to roll onto its left side (**Figure 8** above and **Figure 13** below). The case vehicle's wheelbase was unaltered from the crash. The case vehicle's entire right side was directly damaged and crushed inward, though at some points crush damage was almost nonexistent. There was also direct

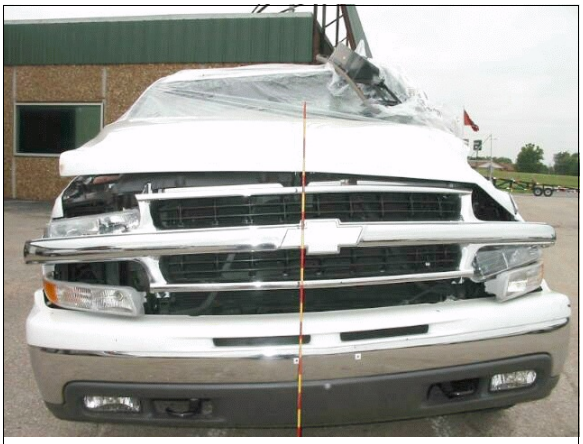


Figure 12: Case vehicle viewed from front bumper level showing greatest roof crush occurred along right roof and right "A"-pillar and induced damage to front and hood (case photo #22)

damage to the left fender and hood of the case vehicle and along the windshield header and front portion of the roof, especially at the top of the right "A"-Pillar. There was induced damage to both the right and left headlight and turn signal assemblies as well as both the grille and right and left fenders (**Figure 12** above). The windshield's glazing was cracked, the right front and 2nd right rear window glazings were disintegrated, and the glazing in the liftgate rear door system was intact but displaced (i.e., popped out) during the crash sequence. Remote buckling was also found on the right rear door and the right quarter panel (**Figure 11** above). No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

Figure 13: Rollover crush to case vehicle's left fender and front left hood viewed from left front; Note: damage to left outside rearview mirror and removed piece of center instrument panel molding across windshield and roof (case photo #25)

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	214	31	241	35	9	11	None	No	No
RF	Unk	Unk	241	35	Unk	Unk	Unknown	Unknown	Unknown
LR	Unk	Unk	241	35	Unk	Unk	Unknown	Unknown	Unknown
RR	Unk	Unk	241	35	Unk	Unk	Unknown	Unknown	Unknown

The case vehicle manufacturer's recommended tire size was: P265/70R16, and the case vehicle tires were the recommended size. The case vehicle's tire data are shown in the table above. In addition, there is no evidence that any of the case vehicle's tires were damaged, deflated, or physically restricted; however, only the left front tire was present during this contractor's inspection.

Figure 14: Case vehicle's front seating area showing no deformation to steering wheel rim, driver's armrest bent toward center console, and angulation of front seat backs (case photo #42)

Interior Damage: Inspection of the case vehicle's interior revealed contact to the driver's right arm rest (i.e., bent toward the center of the vehicle–**Figure 14**). Furthermore, there was no obvious evidence of contact to the front of the

vehicle (**Figures 15** and **16**) or the front sun visors (**Figure 17**). However there was contact evidence (i.e., scuffs, scrapes, etc.) on the interior surface of the vehicle's roof, both in the front (**Figure 18** and **Figure 19** below) and back of the vehicle (**Figures 20** and **21** below). In addition, there was damage (i.e., broken plastic) to the back right interior side surface (**Figures 22** and **23** below) as well as a fabric tear on the right side of the left second seat's head rest (**Figure 24** below). It cannot be stated with certainty that any of this damage is occupant-related. According to our limited, partial interview with the case vehicle's driver, he indicated that there was a large, wooden speaker box located in the vehicle's back seating area. It is probable that this interior loose object in the back of the vehicle produced some or much of this interior damage; however, no speaker box or other objects were present during our vehicle inspection. On the other hand, the interior damage pattern is obliquely oriented, running from the driver's seat toward the back right interior surfaces. It is also possible that some of the interior damage is occupant extrication related.

Figure 15: Case vehicle's driver seating area showing non-deployed driver air bag, cracked windshield's glazing, and removed center instrument panel molding; Note: no obvious evidence of occupant contact (case photo #43)

Figure 16: Case vehicle's front right seating area showing non-deployed front right passenger air bag, cracked windshield, altered center instrument panel, and no obvious occupant contact evidence (case photo #45)

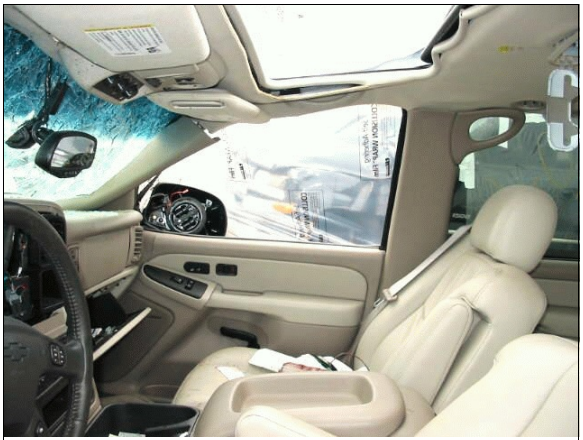


Figure 17: Case vehicle's front seating area showing no evidence of occupant contact to sun visors; Note: reclined nature of front seat backs (case photo #39)

Figure 18: Contact evidence on case vehicle's roof situated between moon roof and damaged dome light (case photo #52)

Figure 19: Close-up of contact evidence (e.g., hair, blood) on case vehicle's roof, situated between moon roof and dome light (case photo #53)

Figure 20: Oblique view of case vehicle's interior indicating driver's suspected front left to back right path of movement during rollover; Note: arrows show possible occupant contact locations (case photo #54)

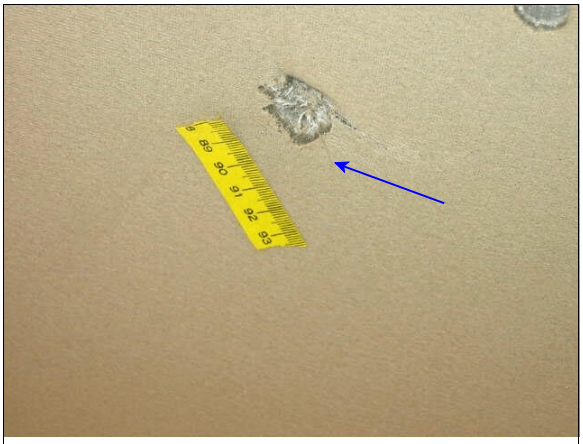


Figure 21: Close-up of contact (i.e., fabric gouge with hair) on roof surface over case vehicle's back seating area (case photo #54b)

Figure 22: Case vehicle's back right seating area showing (i.e., arrows) areas of contact, some occupant-related, some probably related to an interior loose object (case photo #55)

Figure 23: Right interior surface of case vehicle's back right seating area showing disintegrated 2nd right window glazing and contact evidence on interior surface, probably related to an interior loose object (case photo #57)

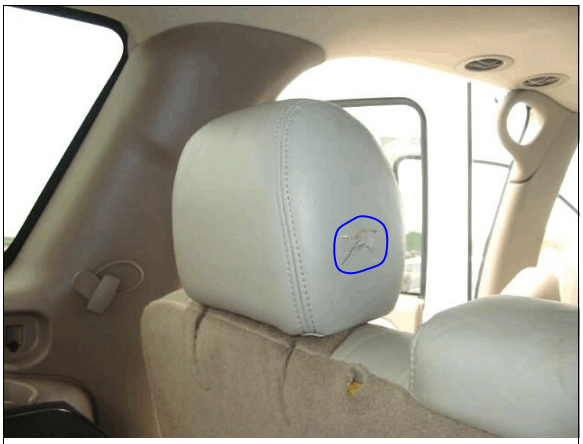


Figure 24: Close-up of contact-related tear on right side of case vehicle's second seat left headrest, probably caused by contact with an interior loose object (case photo #61)

There were vertical intrusions to the case vehicle's windshield and windshield header across the entire front seating area. In addition, there was vertical intrusion to the front right seating area by the right "A"-pillar. Finally, there was no evidence of compression of the energy absorbing shear capsules in the base of the steering column and no deformation to the steering wheel rim.

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **00-TYDO-3**. No reconstruction program was used on this crash because it involved a non-horizontal impact. The crash severity to the case vehicle was estimated to be low [14-23 km.p.h. (9-14 m.p.h.)]. The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained dual stage frontal air bags at the driver and front right passenger positions. The case vehicle's driver air bag was located in the steering wheel hub (**Figure 15** above). The front right passenger's air bag was located in the middle of the instrument panel (**Figure 16** above). Neither front air bag deployed during the crash sequence.

CRASH DATA RECORDING

The data downloaded from the case vehicle's **EDR** showed the vehicle's SIR warning lamp status, driver's seat belt buckle status, ignition cycles at near deployment, time from algorithm enable to maximum **SDM** (i.e., ***SENSING AND DIAGNOSTIC MODULE***) recorded velocity change (i.e., air bags did not deploy), and the vehicle's speed and brake switch status for the five recorded sample periods preceding the **ALGORITHM ENABLE**. In addition, the vehicle's velocity change (i.e., Delta V) is reported. Downloaded data of interest indicated the following. The case vehicle was traveling at a speed of 27 km.p.h. (17 m.p.h.) one second before algorithm enable, the driver's seat belt status showed it was not buckled, and the Delta V reached a value of 4.49 km.p.h. (2.79 m.p.h.) at the 150 millisecond mark of recorded data; see **EVENT DATA RECORDER DATA** (**Figures 25** through **27**) below. Although it is unknown as to exactly where in the crash sequence the EDR was enabled, the vehicle speed and braking data indicate that the recorded event may have happened just prior to or during the rollover initiation. If this assumption is correct, then this contractor believes that the recorded Delta V seems reasonable considering the amount of deformation to the case vehicle's front

CASE VEHICLE DRIVER KINEMATICS

The exact posture of the case vehicle's driver [25-year-old, White (non-Hispanic) male; 178 centimeters and 66 kilograms (70 inches, 145 pounds)] immediately prior to the crash is unknown. According to the Police Crash Report, the driver was charged with "driving while intoxicated". Based on the scene and vehicle inspections, as the vehicle went off the road the driver was most likely seated in a reclined posture with his back against or near the seat back, his left foot on the floor, his right foot on the accelerator, and at least one hand on the steering wheel. The exact position of his seat track at the time of the crash is unknown because the motorized seat was frozen (i.e., electronically) at the time our inspection and the full movement–forward and rearward, of

the seat track could not be determined. The seat track appears to be located between its middle and rearmost positions. The seat back was significantly reclined, and the tilt steering wheel was located between its middle and down-most positions.

Based on this contractor's vehicle inspection and substantiated by the **EDR** data, the case vehicle's driver was not using his available, active, three-point, integral lap-and-shoulder, safety belt system; the belt system was not equipped with a pretensioner. Furthermore, the inspection of the driver's seat belt webbing and latch plate showed no evidence of loading (i.e., stress marks or scuffs); although, there were obvious signs of historical usage on the latch plate.

Based on the scene inspection, the case vehicle's driver most likely steered the vehicle to the right after it had initially ran-off-road, attempting to re-enter the roadway. As a result and independent of the nonuse of his available safety belts, the driver most likely moved slightly to his left just prior to re-entering the roadway. Once on the roadway again the case vehicle was heading in an obliquely oriented fashion and, as a result, the case vehicle's driver over-steered hard to the left and most likely braked, attempting to avoid exiting the right side of the roadway. As a result, the case vehicle departed the left side of the roadway while rotating counterclockwise. The driver most likely moved slightly forward and to his right as a result of these attempted avoidance maneuvers. As the case vehicle rotated counterclockwise out-of-control, the driver released the brake and most likely attempted to steer to the right. It is unclear what, if any, effect these avoidance actions had on his position just prior to rollover initiation. As the case vehicle rolled to the right, the driver moved to his right contacting and deforming his arm rest. As the vehicle rolled onto its roof with the hood down and the back end angled upward, the driver most likely contacted the roof over the front seating area depositing contact evidence. As the case vehicle continued to roll rightward, it is unclear as to where the driver moved and what he contacted; although, contact evidence indicates that he may well have moved backward and toward the right side of the vehicle. According to the partial interview with the driver, he indicates that he was struck in the head by the wooden speaker box which had been located in the back seating area. The injury information confirms the presence of a head contact to the driver's right ear and is not inconsistent with the driver's information. According to the driver, he was in the front seating area when the vehicle came to rest, but his exact posture is unknown. It is entirely possible that if the driver contacted the interior loose object (i.e., wooden speaker box), the object was of sufficient mass, in conjunction with gravity, to have redirected the driver back forward into the front seating area.

CASE VEHICLE DRIVER INJURIES

Based on the available evidence, the driver was transported by ambulance to the hospital. He sustained minor injuries and was treated and released. The injuries sustained by the case vehicle's driver included: a laceration and partial avulsion to his right external ear and abrasions to his right knee and right shin area.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Laceration, complex, stellate, right ear, 3-4 cm (1.2-1.6 in) around anthelix[1]	minor 290602.1,1	Interior loose object (i.e., wooden speaker box	Probable	Emergency room records
2	Avulsion, partial, 5 cm (2.0 in) right ear, not further specified	minor 290802.1,1	Interior loose object (i.e., wooden speaker box	Probable	Emergency room records
3	Abrasion, 1 cm (0.4 in) right knee, not further specified	minor 890202.1,1	Center instrument panel and below	Possible	Emergency room records
4	Abrasion, 2 cm (0.8 in) right leg over tibia/fibula, not further specified	minor 890202.1,1	Floor, center console	Possible	Emergency room records

[1] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
anthelix (ant/he-liks): antihelix.
antihelix (an"te-he/liks): the prominent semicircular ridge seen on the lateral aspect of the auricle of the external ear, anteroinferior to the helix; called also anthelix.

1GNEK13Z83R	System Status At Non-Deployment
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Non-Deployment	1388
Ignition Cycles At Investigation	1402
Maximum SDM Recorded Velocity Change (MPH)	-2.87
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	125
Event Recording Complete	Yes
Multiple Events Associated With This Record	Yes
One Or More Associated Events Not Recorded	Yes

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	0.00	0.00	-0.31	-0.62	-0.93	-1.24	-1.55	-1.86	-2.17	-2.48	-2.48	-2.79	-2.79	-2.79	-2.79

PRE-CRASH DATA				
Seconds Before AE	**Vehicle Speed (MPH)**	**Engine Speed (RPM)**	**Percent Throttle**	**Brake Switch Circuit Status**
-5	43	1216	0	ON
-4	32	832	0	ON
-3	30	832	0	OFF
-2	25	704	0	OFF
-1	17	640	0	OFF

Figure 25: Case vehicle's non-deployment data including: pre-crash speed, brake switch status, restraint system status, and the case vehicle's change in velocity (Delta V) over the first 150 milliseconds post algorithm enablement

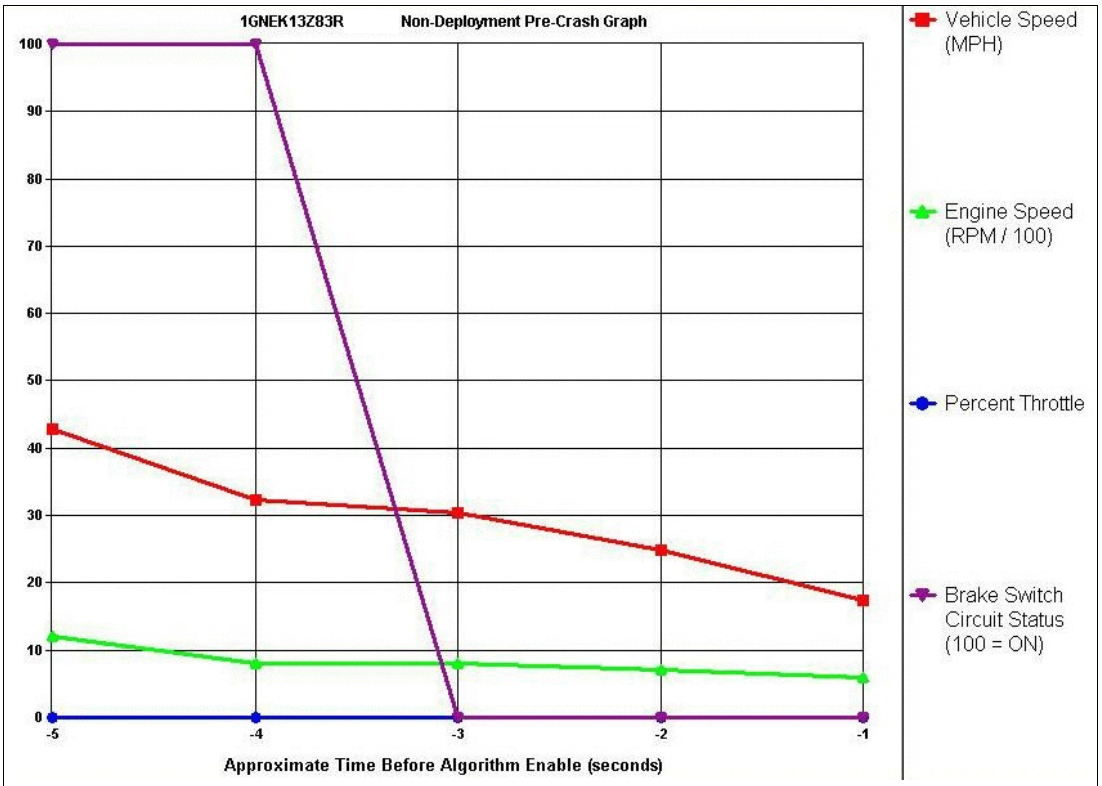


Figure 26: Case vehicle's pre-crash speed and brake switch circuit status showing that the vehicle had decelerated to approximately 51 km.p.h. (32 m.p.h.) when the brake was activated approximately 4 seconds prior to algorithm enable.

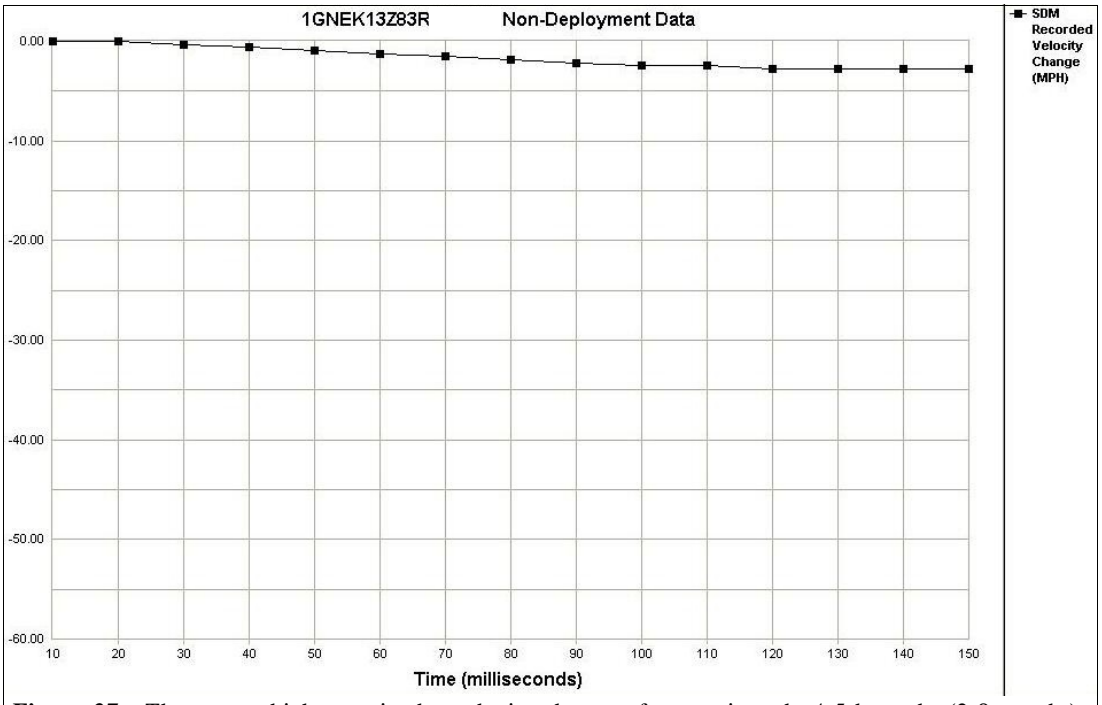
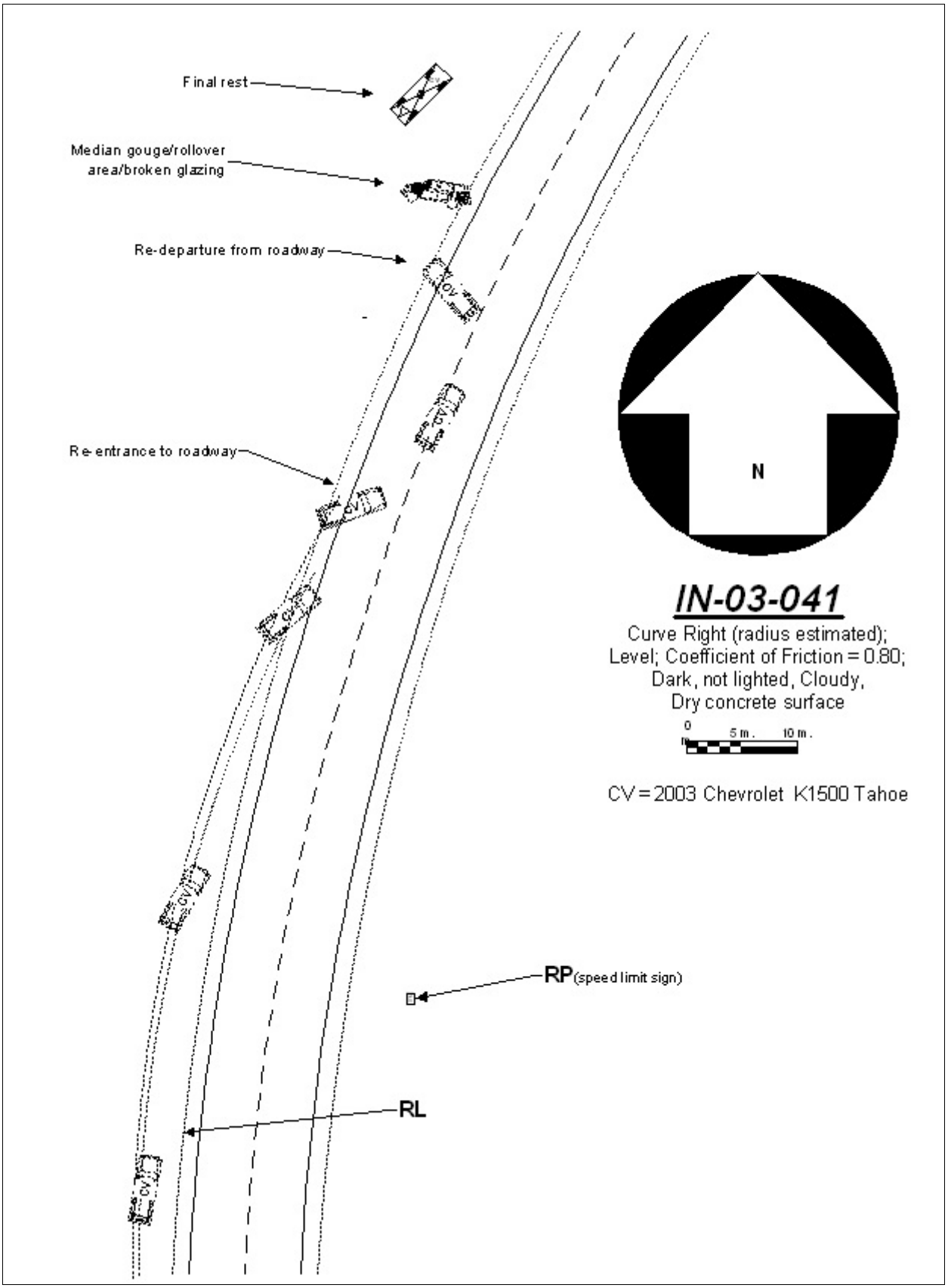


Figure 27: The case vehicle sustained a velocity change of approximately 4.5 km.p.h. (2.8 m.p.h.) during the first 150 milliseconds after the algorithm was enabled


Final rest
Median gouge/rollover area/broken glazing
Re-departure from roadway
Re-entrance to roadway
CV
RP (speed limit sign)
RL
N
IN-03-041
Curve Right (radius estimated);
Level; Coefficient of Friction = 0.80;
Dark, not lighted, Cloudy,
Dry concrete surface
0
5 m.
10 m.
CV = 2003 Chevrolet K1500 Tahoe