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ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-03-042
LOCATION - KENTUCKY
VEHICLE - 2003 CHEVROLET K1500 SILVERADO
CRASH DATE - August 2003

Submitted:

September 7, 2007

Contract Number: DTNH22-01-C-07002

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
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Washington, D.C. 20590-0003

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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

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15. *Supplementary Notes*
On-site air bag deployment investigation involving a 2003 Chevrolet K1500 Silverado, four-door, extended cab pickup, with manual safety belts and dual front advanced air bags, a 1989 Peterbilt 362 truck-tractor, and a 1976 Ford F100

16. *Abstract*
This report covers an on-site investigation of an air bag deployment crash that involved a 2003 Chevrolet K1500 Silverado (case vehicle), a 1989 Peterbilt 362 truck-tractor with logging semitrailer (1st other vehicle), and a 1976 Ford F100 (2nd other vehicle). This crash is of special interest because the case vehicle was equipped with multiple **A**dvanced **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 case vehicle's restrained driver (60-year-old, male) sustained minor injuries from his deploying driver air bag. The trafficway on which all three vehicles were traveling was a three-lane, undivided, U.S. highway, traversing in a generally winding, east-west direction. The east-west roadway had two easterly travel lanes and one westerly travel lane. The case vehicle was negotiating a downhill, left-hand curve, traveling in a west-northwesterly direction in the western lane. The Peterbilt was negotiating an uphill, right-hand curve, traveling in the inside through lane. The Ford was also negotiating a downhill, left-hand curve, traveling an undetermined distance ahead of the case vehicle in a west-northwesterly direction. The crash sequence began in the western lane of the roadway when the Peterbilt traveled left over the centerline of the roadway and began tipping over toward its left side. As the Peterbilt was tipping over, an unknown portion of the Peterbilt collided with the left frontal portion of the Ford, shearing off the top portion of the Ford pickup's cab. After impacting the Ford, the Peterbilt's semitrailer began to rotate clockwise (i.e., in a jackknifing fashion) while it continued forward in its easterly travel path, veering off the roadway onto the northern roadside. The front left of the case vehicle was impacted the left rear portion of the Peterbilt's, rotating, semitrailer on the right (northern) shoulder. The case vehicle's impact with the semitrailer caused the case vehicle's driver (only) supplemental restraint (air bag) to deploy. The case vehicle's driver was seated with his seat track located in its rearmost position, and the tilt steering wheel was located in its center position. He was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system and sustained, according to his interview and his medical records, minor injuries that included: a minor, superficial laceration to his right eyelid, a contusion above his right eye, and an abrasion on his left wrist.

17. *Key Words* Advanced Air Bag Deployment; EDR	Motor Vehicle Traffic Crash Injury Severity	18. *Distribution Statement* General Public	
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This investigation was brought to NHTSA's attention on or before September 25, 2003 by NASS GES sampling activities. This crash involved a 2003 Chevrolet K1500 Silverado (case vehicle), a 1989 Peterbilt 362 truck-tractor with logging semitrailer (1st other vehicle), and a 1976 Ford F100 (2nd other vehicle). The crash occurred in August 2003, at 12:29 p.m., in Kentucky and was investigated by the applicable state police department. This crash is of special interest because the case vehicle was equipped with multiple **A**dvanced **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 case vehicle's driver [60-year-old, White (non-Hispanic) male] sustained minor injuries from his deploying driver air bag. This contractor inspected the scene and vehicles on October 8, 2003 and downloaded the data from the onboard EDR. This contractor interviewed the driver for the case vehicle on October 13, 2003 and downloaded the data from the onboard EDR. This report is based on the Police Crash Report, an interview with 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 all three vehicles were traveling was a three-lane, undivided, U.S. highway, traversing in a generally winding, east-west direction. The east-west roadway had two easterly travel lanes and one westerly travel lane. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry; see **CRASH DIAGRAM** at end.

Pre-Crash:

The case vehicle was negotiating a downhill, left-hand curve, traveling in a west-northwesterly direction in the western lane. The Peterbilt was negotiating an uphill, right-hand curve, traveling in the inside through lane of the same U.S. highway. The Ford was also negotiating a downhill, left-hand curve, traveling an undetermined distance ahead of the case vehicle in a west-northwesterly direction in the same western lane of the roadway. The crash sequence began when the Peterbilt traveled to its left over the centerline of the roadway and began tipping over toward its left side. The case vehicle's driver steered to the right and braked, attempting to avoid becoming involved in the crash. The crash sequence began in the western lane of the roadway.

Crash:

As the Peterbilt was tipping over onto its left side, an unknown portion of the Peterbilt collided with the left frontal portion of the Ford, shearing off the top portion of the Ford pickup's cab. The Peterbilt's semitrailer began to rotate clockwise (i.e., in a jackknifing fashion) after impacting the Ford. The Peterbilt continued forward in its easterly travel path, but it veered off the roadway onto the northern roadside.

The front left of the case vehicle impacted the left rear portion of the Peterbilt's, rotating, semitrailer on the right (northern) shoulder–where the case vehicle's driver had taken evasive action. The case vehicle's impact with the semitrailer caused the case vehicle's driver (only) supplemental restraint (air bag) to deploy. Based on the downloaded EDR data only one stage of the driver's dual stage air bag was activated. The case vehicle was equipped with a switchable (i.e., a cutoff switch) front right passenger supplemental restraint (air bag) that was set to the "auto" position. This air bag did not deploy during the crash sequence.

Post-Crash:

The Ford was redirected off the right edge of the road and traveled along the right (northern) roadside and across a private driveway before impacting a guardrail–that protected the western side of the driveway, and a tree.

The Peterbilt continued forward in its easterly travel path on the northern roadside finally rolling over onto its left side before striking and uprooting a significant section of a "W"-beam longitudinal barrier before coming to rest on its left side on the highway's northern roadside.

The collision with the semitrailer redirected the case vehicle further to the right where it impacted a couple of small trees and large tree with its front. The case vehicle came to rest on the northern roadside, near the large tree, heading in a west-northwesterly direction.

Case Vehicle:

The 2003 Chevrolet Silverado K1500 was a four wheel drive (4x4), four-door, extended cab pickup truck (VIN: 1GCEK19VX3Z------) 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. In addition, there was an occupant detection and automatic air bag suppression system for the front right passenger seating position, as evident by the aforementioned air bag **ON/OFF** switch. The occupant sensing system automatically switches the right front-passenger front air bag on or off based on the passenger's weight and the type of pressure on the seat. Finally, the case vehicle was also equipped with an **E**vent **D**ata **R**ecorder (**EDR**). The case vehicle's driver supplemental restraint system (air bag) deployed as a result of the front left impact.

Vehicle Exterior:

Based on the vehicle inspection, the CDCs for the case vehicle are estimated because of the multiple overlapping impacts to the front of the vehicle. For the case vehicle's deployment impact (i.e., 2nd event) with the Peterbilt's logging semitrailer, the CDC is estimated as: **11-FLEE-8** (**340** degrees). For the three tree impacts (i.e., 7th, 8th, and 9th events), the CDCs are estimated as: **12-FCEN-1** (**0** degrees) for each of the two saplings, and **12-FCEW-2** (**0** degrees) for the large tree (i.e., 9th event). No reconstruction program was used on the case vehicle's initial impact with the logging semitrailer because the impact was out-of-scope of NASS, CDS, WinSMASH protocol. The impact began as a narrow end engagement with sideswiping type crush that resulted in pocketing (i.e., shearing of the left front wheel assembly). This contractor's visually estimated Delta V was low [14-23 km.p.h. (9-14 m.p.h.)]. The WinSMASH reconstruction program, barrier algorithm, was used on the measurements taken on the damage across the front of the case vehicle caused by the trees. Because overlapping damage invalidates the WinSMASH program, the following values can be used as an approximation only for the large tree impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 27.0 km.p.h. (16.8 m.p.h.), -27.0 km.p.h. (-16.8 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was towed due to damage.

Crash Data Recording:

The data downloaded from the case vehicle's **EDR** showed that the driver's seat belt status was buckled, the second stage of the driver's multi-stage air bag was not activated, and for the deployment event (i.e., 2nd event), the Delta V was 5.99 km.p.h. (3.72 m.p.h.) at the 110 millisecond mark of recorded data. This contractor believes that the recorded Delta V captured only the initial portion of the case vehicle's interaction with the Peterbilt's semitrailer and that the **EDR** had exhausted its available memory (i.e., stopped recording data) before the contact to the left front wheel assembly occurred.

1st Other Vehicle:

The 1989 Peterbilt 362 was a four wheel drive (6 x 4), cab over engine, two-door truck-tractor (VIN: 1XP6DB97X7KD------) hauling an unknown logging semitrailer (VIN: unknown).

2nd Other Vehicle:

The 1976 Ford F-100 was a rear wheel drive, two door, conventional cab pickup truck (VIN: F10BCA-----). The Ford was not equipped with any supplemental restraints.

Case Vehicle's Driver:

The driver of the case vehicle (60-year-old, male) was seated with his seat track located in its rearmost position, and the tilt steering wheel was located in its center position. He was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system and sustained, according to his interview and his available medical records, a superficial laceration to his right eyelid, a contusion above his right eye, and an abrasion on his left wrist. The laceration and contusion were caused by his deploying air bag in conjunction with his eye glasses.

CRASH CIRCUMSTANCES

Figure 1: Ford and case vehicle's west-northwesterly approach to impact area (i.e., arrow) with Peterbilt tractor-semitrailer (case photo #10)

Figure 2: Ford's and case vehicle's westerly travel path into initial impact areas (i.e., arrows) with Peterbilt tractor-semitrailer; Note: damaged longitudinal barrier marks Peterbilt's final rest position (case photo #12)

Crash Environment: The trafficway on which all three vehicles were traveling was a three-lane, undivided, U.S. highway (**Figures 1** and **2** above), traversing in a generally winding, east-west direction. The east-west roadway had two easterly travel lanes and one westerly travel lane. The U.S. highway was curved to the left for western traffic and had a 5.7% grade negative to the west (i.e., a downgrade in the case vehicle's and Ford's direction of travel), near the area of impact. For the Peterbilt tractor and semitrailer, the highway was curved to the right and had a 3.3% grade positive to the east near the impact area (**Figure 3**). The pavement was bituminous, but traffic polished, and the width of the westerly travel lane was 3.4 meters (11.2 feet). The shoulders were improved (i.e., bituminous), with a 1.3 meter (4.3 foot) wide paved shoulder adjacent to the northern side of the roadway. At the point of initial impact (**Figure 4**) the paved shoulder was followed by an unmeasured area of loose crushed gravel and then grass prior to the tree-line. Further east of the primary impact area the northern roadside was protected by a longitudinal barrier (i.e., "W"-beam guardrail–**Figure 1** above). Pavement markings consisted of a double solid yellow centerline for both the eastern and western traffic, and the easterly lanes were divided by a dashed white line. In addition, solid white edge lines were present. The estimated coefficient of friction was 0.65. Traffic controls consisted of an unidentified warning sign for easterly traffic and three unidentified regulatory signs for westerly traffic. All of these signs were within the curved portion of the trafficway. The statutory speed limit was 89 km.p.h. (55 m.p.h.). No regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry. Traffic density was at least moderate, and the site of the crash was primarily rural undeveloped with scattered residences; see **CRASH DIAGRAM** at end.

Figure 3: Peterbilt's easterly travel path across centerlines into western lane and approach to areas of impact with Ford and case vehicle (case photo #01)

Pre-Crash: The case vehicle was negotiating a downhill, left-hand curve, traveling in a west-northwesterly direction in the western lane and intended to continue in its western path of travel (**Figure 2** above). The Peterbilt was negotiating an uphill, right-hand curve, traveling in the inside through lane of the three-lane, undivided, U.S. highway and intended to continue in its eastern path of travel. The Ford was also negotiating a downhill, left-hand curve, traveling an undetermined distance ahead of the case vehicle in a west-northwesterly direction in the same western lane of the roadway and intended to continue in its western path of travel (**Figure 4**). According to

Figure 4: **Ford's** and **case vehicle's** westerly travel path into areas (i.e., arrows) of initial impact with Peterbilt tractor-semitrailer (case photo #13)

the Police Crash Report, our scene inspection, and the interview with the case vehicle's driver, the crash sequence began when the Peterbilt traveled to its left over the centerline of the roadway (**Figure 3** above) and began tipping over toward its left side. The case vehicle's driver steered to the right and braked, attempting to avoid becoming involved in the crash. The crash sequence began in the western lane of the roadway.

Figure 5: Peterbilt's estimated area of impact with Ford in western travel lane (i.e., foreground), estimated area of impact with case vehicle on northern shoulder (i.e., arrow), and subsequent easterly travel path toward impact with guardrail (case photo #03)

Figure 6: Case vehicle's left front and frontal damage viewed from left of front; left front damage from impact with Peterbilt's logging trailer, frontal damage from large tree (case photo #31)

Crash: According to the case vehicle's driver, as the Peterbilt was tipping over onto its left side (**Figure 5**), an unknown portion of the Peterbilt collided with the left frontal portion of the Ford, shearing off the top portion of the Ford pickup's cab. The Peterbilt's semitrailer began to rotate clockwise (i.e., in a jackknifing fashion) after impacting the Ford. The Peterbilt continued forward in its easterly travel path, but it veered off the roadway onto the northern roadside.

The front left of the case vehicle (**Figures 6** and **7**), which was following the Ford, impacted the left rear portion of the Peterbilt's, rotating, semitrailer on the right (northern) shoulder–where the case vehicle's driver had taken evasive action.

Figure 7: Case vehicle's left front damage from impact with Peterbilt's logging trailer; Note: left front wheel assembly sheared off by trailer (case photo #33)

Figure 8: Case vehicle's front right passenger air bag cutoff switch set to "Auto" (case photo #48)

The case vehicle's impact with the semitrailer caused the case vehicle's driver (only) supplemental restraint (air bag) to deploy. Based on the downloaded EDR data only one stage of the driver's dual stage air bag was activated. The case vehicle was equipped with a switchable (i.e., a cutoff switch) front right passenger supplemental restraint (air bag) that was set to the "auto" position (**Figure 8** above). This air bag did not deploy during the crash sequence.

Figure 9: Ford's westerly travel path on northern roadside after initial impact with Peterbilt truck-tractor; Note: arrow indicates Ford's final rest position against guardrail and tree (case photo #20c)

Post-Crash: The Ford was redirected off the right edge of the road (**Figure 9**) and traveled along the right (northern) roadside (**Figure 10**) and across a private driveway (**Figure 11**) before impacting a guardrail–that protected the western side of the driveway, and a tree (**Figure 12** below).

Figure 10: Ford's westerly travel path on northern roadside continues after initial impact with Peterbilt; Note: arrows indicate impact and final rest position against guardrail & tree (case photo #22)

Figure 11: Ford continues its westerly travel path toward impact and final rest position (arrows) against guardrail and tree (case photo #23)

The Peterbilt continued forward in its easterly travel path on the northern roadside (**Figure 13** below) finally rolling over onto its left side before striking and uprooting a significant section of a "W"-beam longitudinal barrier (**Figure 14** below) before coming to rest on its left side on the highway's northern roadside (**Figure 15** below).

The collision with the semitrailer redirected the case vehicle further to the right (**Figure 16** below) where it impacted a couple of small trees and large tree with its front (**Figure 17** below). The case vehicle came to rest on the northern roadside, near the large tree, heading in a west-northwesterly direction.

Figure 12: Ford's westerly travel path into guardrail and then tree; Ford came to rest against or near tree (case photo #25)

Figure 13: Peterbilt's eastward travel path as it rolled over, landing primarily on the northern shoulder, while continuing to travel forward, impacting and damaging the northern guardrail; Note: arrow shows western-most guardrail support post (case photo #04)

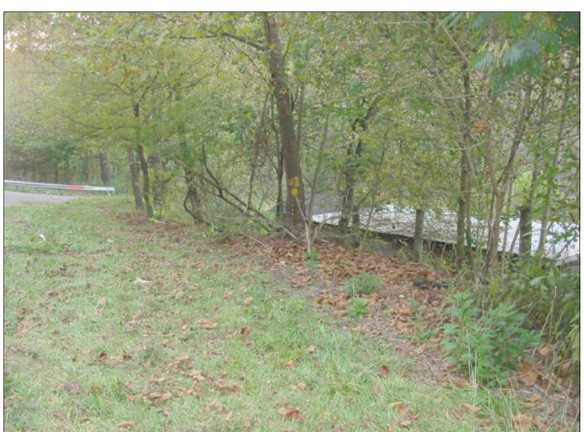


Figure 16: Case vehicle's west-northwest travel path toward tree on northern roadside after impacting and being redirected by Peterbilt (case photo #16)

Figure 14: Damage to roadway's northern longitudinal barrier caused by overturned Peterbilt tractor-semitrailer; Note: contact damage to trees on northern roadside (case photo #06)

Figure 15: Westerly view from beyond Peterbilt's final rest position showing travel path after failing to negotiate right-hand curve (case photo #07)

Figure 17: Case vehicle's impact and approximate final rest position against large tree on roadway's northern roadside; Note: case vehicle struck and knocked over at least two small trees prior to large tree (case photo #17)

The 2003 Chevrolet Silverado K1500 was a four wheel drive (4x4), four-door, extended cab pickup truck (VIN: 1GCEK19VX3Z------) equipped with a 4.8L, 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 with dynamic rear proportioning. The case vehicle's wheelbase was 364 centimeters (143.5 inches), and the odometer reading at inspection is unknown because the case vehicle was equipped with an electronic odometer.

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 an air bag **ON/OFF** switch, and there was an occupant detection and automatic air bag suppression system for the front right passenger seating position, as evident by the aforementioned air bag **ON/OFF** switch (**Figure 8** above). 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). The case vehicle was equipped with LATCH system features. Finally, the case vehicle was also equipped with an **E**vent **D**ata **R**ecorder (**EDR**).

Inspection of the vehicle's interior revealed a 40/20/40 adjustable front bench seat; a non-adjustable, folding back bench seat; adjustable head restraints for both the front and back outboard seating positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the front and back outboard positions; and a two-point, lap belt system at the front and back center positions. The front seat belt systems were integral and thus were not equipped with "D"-rings or manually operated, upper anchorage adjusters. The vehicle was equipped with knee bolsters for both the driver and front right seating positions. The driver's knee bolster was scuffed but undeformed from occupant contact. The front right knee bolster did not show evidence of occupant contact or deformation.

Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of an advanced frontal air bag for the driver and front right passenger seating positions. Only the driver's frontal air bag deployed as a result of the case vehicle's front left corner impact with the semitrailer being hauled by the Peterbilt tractor-trailer.

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's initial contact with the Peterbilt involved its front left corner (**Figures 6** and **7** above). It is not possible to determine exactly where direct damage began for this impact, but it extended from the left front bumper corner back to the left front door (**Figure 18**). No crush measurements could be obtained. The case vehicle's contact with the trees involved the front central portion. Direct damage began 40 centimeters (15.7 inches) leftward from the front right bumper corner (**Figure 19**) and extended 63 centimeters (24.8 inches) inward along the front bumper. Residual maximum crush was measured as 40 centimeters (15.7 inches) near C_4 (**Figure 20**). The table below shows the case vehicle's composite crush profile for the three tree impacts.

Figure 18: Continuation of case vehicle's left front damage from impact with Peterbilt's logging trailer onto left front door (case photo #34)

Figure 19: Case vehicle's frontal damage from impact with large tree; Note: contour gauge set at bumper level (case photo #29)

Figure 20: Overhead view of case vehicle's frontal damage from tree impact with contour gauge set at bumper level (case photo #41)

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	7th - 9th	63	40	144	9	10	33	39	2	0	1	0
in		24.8	15.7	56.7	3.5	3.9	13.0	15.4	0.8	0.0	0.4	0.0

The wheelbase on the case vehicle's left side was shortened approximately 19 centimeters (7.5 inches) while the right side was extended at most 1 centimeter (0.4 inches). As a result of the initial impact, the case vehicle's front left bumper, left fender, and left headlight and turn signal assemblies were directly damaged and crushed rearward. The left front wheel assembly was sheared off, and the left front door was crushed inward. As a result of the tree impact, the case vehicle's front bumper, bumper fascia, grille, hood, and radiator were directly damaged and crushed rearward. The right, and possibly some portion of the left, headlight and turn signal assemblies were detached from the vehicle as a result of either direct or induced damage or physical removal by salvage personnel. There was induced damage to the hood, both the right and left fenders, and the left front and rear doors. The windshield's glazing was significantly cracked. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	0	0	241	35	10	13	Sheared off from impact	No	Yes
RF	228	33	241	35	10	13	None	No	No
LR	207	30	241	35	10	13	None	No	No
RR	228	33	241	35	10	13	None	No	No

The case vehicle manufacturer's recommended tire size was: P245/75R16, but tire size P265/75R16 was optional; the case vehicle was equipped with tire size: LT245/75R16. The case vehicle's tire data are shown in the table above. In addition, none of the case vehicle's other tires were damaged, deflated, or physically restricted.

Figure 21: Case vehicle's driver seating area showing deployed driver air bag, cracked windshield's glazing, and no apparent contact evidence to steering wheel rim, center instrument panel, or greenhouse areas (case photo #46)

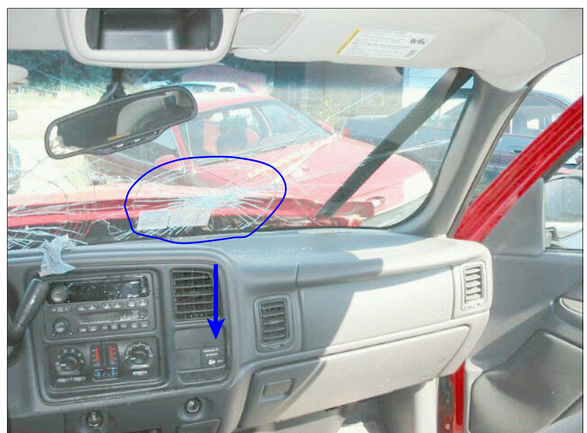


Figure 22: Case vehicle's front right seating area showing non-deployed front right passenger air bag, air bag cutoff switch (arrow), cracks to windshield's glazing–including a possible contact (circle) by an interior loose object, and no obvious contact evidence on center or right instrument panel or greenhouse areas (case photo #49)

Interior Damage: Inspection of the case vehicle's interior (**Figures 21** and **22**) revealed moderate scuffing on the driver's knee bolster, left of the steering column (**Figure 23** below) and a possible contact to the right windshield's glazing (**Figure 22**). The knee bolster contact most likely resulted from the driver's left knee; although, no knee injury was reported. The contact to the right windshield's glazing most likely resulted from contact by an interior loose object. There was longitudinal intrusion to the driver's toe pan [19 centimeters (7.5 inches)] and the emergency parking brake pedal [18 centimeters (7.1 inches)]. In addition, there was lateral intrusion to the

Figure 23: Contact evidence (i.e., scuff) on left portion of case vehicle's driver knee bolster (case photo #46a)

brake pedal [6 centimeters (2.4 inches)] and the interior surface panel of the driver's door [7 centimeters (2.8 inches)]. It could not be determined if there was compression of the energy absorbing shear capsules, but there was no deformation to the steering wheel rim.

Damage Classification: Based on the vehicle inspection, the CDCs for the case vehicle are estimated because of the multiple overlapping impacts to the front of the vehicle. For the case vehicle's deployment impact (i.e., 2nd event) with the Peterbilt's logging semitrailer, the CDC is estimated as: **11-FLEE-8** (**340** degrees). For the three tree impacts (i.e., 7th, 8th, and 9th events), the CDCs are estimated as: **12-FCEN-1** (**0** degrees) for each of the two saplings, and **12-FCEW-2** (**0** degrees) for the large tree (i.e., 9th event). No reconstruction program was used on the case vehicle's initial impact with the logging semitrailer because the impact was out-of-scope of NASS, CDS, WinSMASH protocol. The impact began as a narrow end engagement with sideswiping type crush that resulted in pocketing (i.e., shearing of the left front wheel assembly). This contractor's visually estimated Delta V was low [14-23 km.p.h. (9-14 m.p.h.)]. The WinSMASH reconstruction program, barrier algorithm, was used on the measurements taken on the damage across the front of the case vehicle caused by the trees. Because overlapping damage invalidates the WinSMASH program, the following values can be used as an approximation only for the large tree impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 27.0 km.p.h. (16.8 m.p.h.), -27.0 km.p.h. (-16.8 m.p.h.), and 0.0 km.p.h. (0.0 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. Only the driver's frontal air bag deployed as a result of front left corner impact with the semitrailer being hauled by the Peterbilt tractor-trailer. Only one stage of the driver's dual-stage air bags was activated. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical, essentially, "I"-configuration cover flaps made of thick vinyl. Both the left and right flaps were trapezoidal in shape with overall dimensions of 14 centimeters (5.5 inches) at the top horizontal seam, 10 centimeters (3.9 inches) at the bottom horizontal seam, and 12 centimeters (4.7 inches) vertically along the seam that separated the two flaps. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each approximately 10 centimeters (3.9 inches) in width. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 10:30 and 1:30 clock positions. The deployed driver's air bag was round with a diameter of 65 centimeters (25.6 inches). The distance between the mid-center of the driver's seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 40 centimeters (15.7 inches). The distance between the mid-center of the driver's seat back and the hub of the steering wheel was 63 centimeters (24.8 inches). An inspection of the driver's air bag fabric revealed a significant amount of blood smeared across the upper half and lower central portion (i.e., toward the 6 o'clock position) of the air bag's fabric (**Figure 24**). In addition, there was blood evidence on back surface of the air bag's fabric, in the upper left quadrant (**Figure 25**) of the bag (i.e., as viewed from the driver's seating position).

Figure 24: Case vehicle's deployed driver air bag showing copious blood evidence over three quadrants of the bag's front surface (case photo #50)

Figure 25: Case vehicle's deployed driver air bag showing blood stains on left upper quadrant of bag's back surface (case photo #51)

The front right passenger's air bag was located in the middle of the instrument panel. This air bag did not deploy during the crash.

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 deployment, time from algorithm enable to deployment (i.e., air bag deployments) for the system's first stage, 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 82 km.p.h. (51 m.p.h.) prior to the crash, the driver's seat belt status showed it was buckled, the second stage of the driver's multi-stage air bag was not activated, and the Delta V was 5.99 km.p.h. (3.72 m.p.h.) at the 110 millisecond mark of recorded data; see **EVENT DATA RECORDER DATA** (**Figures 28** through **30**) below. The initial narrow end engagement and subsequent wheel interaction (i.e., similar to a sideswiping impact that starts on the side but results in pocketing) resulted in the air bag deploying late during the sequence of the impact. This delayed deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V–i.e., ramp versus spike). This contractor believes that the recorded Delta V captured only the initial portion of the case vehicle's interaction with the Peterbilt's semitrailer and that the **EDR** had exhausted its available memory (i.e., stopped recording data) before the contact to the left front wheel assembly occurred.

Immediately prior to the crash the case vehicle's driver [60-year-old, White (non-Hispanic) male; 183 centimeters and 88 kilograms (72 inches, 195 pounds)] was seated most likely in a slightly reclined posture with his back against the seat back, his left foot on the floor, his right foot on the brake, and both hands on the steering wheel. His seat track was located in its rearmost position, the seat back was slightly reclined, the tilt steering wheel was located in its center position.

Based on this contractor's vehicle inspection and substantiated by the EDR data, the case vehicle's driver was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system; the belt system was not equipped with a pretensioner. There was no mention by the driver of belt pattern bruising and/or abrasions to the his body, but the inspection of the driver's seat belt webbing and latch plate showed there were blood stains on the outer portion of the belt webbing (**Figure 26**) and moderate scuffing and friction burns on the inside portion (**Figure 27**).

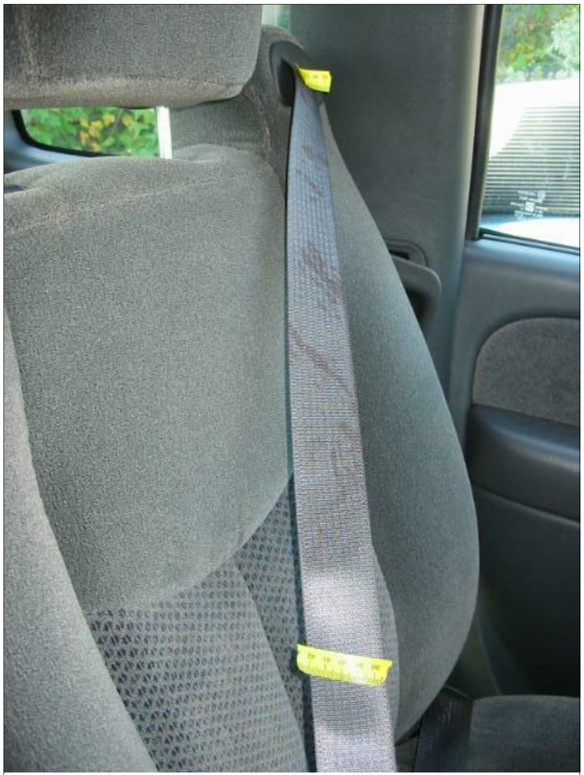


Figure 26: Blood stains on outward surface of shoulder portion of case vehicle's driver safety belt (case photo #55)

Figure 27: Scuffs/friction burns on inward surface (i.e., next to body) of shoulder portion of case vehicle's driver safety belt (case photo #56)

The case vehicle's driver steered to the right and braked, attempting to avoid becoming involved in the crash. As a result of these attempted avoidance maneuvers and the use of his available safety belts, he most likely moved slightly forward and to his left just prior to impact. The case vehicle's impact with the Peterbilt's semitrailer enabled the case vehicle's driver to continue forward and further leftward along a path opposite the case vehicle's **340** degree Direction of Principal Force as the case vehicle decelerated. As a result of this impact, the driver loaded his safety belt system and contacted the deploying driver air bag. Based on the driver's interview and the available medical records, the driver, who wears glasses, was contacted by the deploying air bag causing his glasses to break and lacerating his right eyelid. This laceration is believed to be the source of the copious blood evidence on the air bag's front surface. After this initial impact, the driver most likely rebounded backward to a more normal upright seating position as the vehicle continued west-northwestward on the northern roadside. The vehicle collided with three trees. The impact with the first two (i.e., small) trees had a negligible effect on the driver's posture; however, the impact with the last (i.e., large) large tree enabled the driver to continue forward along a path opposite the case vehicle's **0** degree Direction of Principal Force as the case vehicle decelerated. As a result, the driver reloaded his safety belt system which prevented the driver from contacting the steering wheel. The blood spots on the left upper quadrant (i.e., as viewed from the driver's seating position) of the air bag's back surface most likely occurred as the driver moved back forward, depositing the blood evidence on the back of the air bag as it was deflating. As the vehicle came to final rest, the driver rebounded backward toward his pre-crash seating position. The driver's exact posture at final rest is unknown, but he was able to exit his vehicle without assistance.

CASE VEHICLE DRIVER INJURIES

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 minor, superficial laceration to his right eyelid, a contusion above his right eye, and an abrasion on his left wrist. The laceration and contusion were caused by his deploying air bag in conjunction with his eye glasses.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Laceration, superficial, 1 cm (0.4 in), right eyelid	minor 297602.1,1	Air bag, driver's and eyewear	Probable	Emergency room records
2	Contusion {bruise} above eye, not further specified	minor 297402.1,1	Air bag, driver's and eyewear	Probable	Interviewee (same person)
3	Abrasions left wrist, not further specified	minor 790202.1,2	Air bag, driver's	Probable	Emergency room records

1ST OTHER VEHICLE

The 1989 Peterbilt 362 was a four wheel drive (6 x 4), cab over engine, two-door truck-tractor (VIN: 1XP6DB97X7KD------) hauling an unknown logging semitrailer (VIN: unknown).

Damage Classification: With no available vehicle photographs, the TDCs for the Peterbilt are not estimable. The Peterbilt was towed due to damage.

Peterbilt's Occupants: According to the Police Crash Report, the Peterbilt's driver [30-year-old, (unknown race and/or ethnic origin) male] was restrained by his available, active, two-point, lap safety belt system. It is unknown if the driver was transported by ambulance to the hospital, but he sustained police-reported "A" (Incapacitating) injuries as a result of this crash.

The 1976 Ford F-100 was a rear wheel drive, two door, conventional cab pickup truck (VIN: F10BCA-----). The Ford was not equipped with any supplemental restraints.

Damage Classification: With no available photographs, the CDCs for the Ford are not estimable. The Ford was towed due to damage.

Ford's Occupants: According to the Police Crash Report, the Ford's driver [46-year-old, (unknown race and/or ethnic origin) male] was restrained by his available, active, two-point, lap safety belt system. Based on the Police Crash Report, the driver was dead at the scene and was transported by ambulance to the coroner's office. The Ford's driver sustained fatal injuries and had to be extricated by mechanical means as a result of this crash.

1GCEK19VX3Z	System Status At Deployment
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	1128
Ignition Cycles At Investigation	1134
Maximum SDM Recorded Velocity Change (MPH)	-4.81
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	42.5
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	17.5
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Time Between Non-Deployment And Deployment Events (sec)	N/A
Frontal Deployment Level Event Counter	1
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	0.00	-1.24	-1.55	-4.34	-3.72	-3.72	-3.72	-4.03	-4.03	-4.34	-3.72	N/A	N/A	N/A	N/A

PRE-CRASH DATA

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	51	1472	0	OFF
-4	51	1472	0	ON
-3	51	1472	0	ON
-2	47	1344	0	ON
-1	43	1216	5	ON

Figure 28: Case vehicle's at deployment data including: pre-crash speed, brake switch status, restraint system status, and activation data for vehicle's dual inflation air bags, and the case vehicle's change in velocity (Delta V) over the first 110 milliseconds post deployment

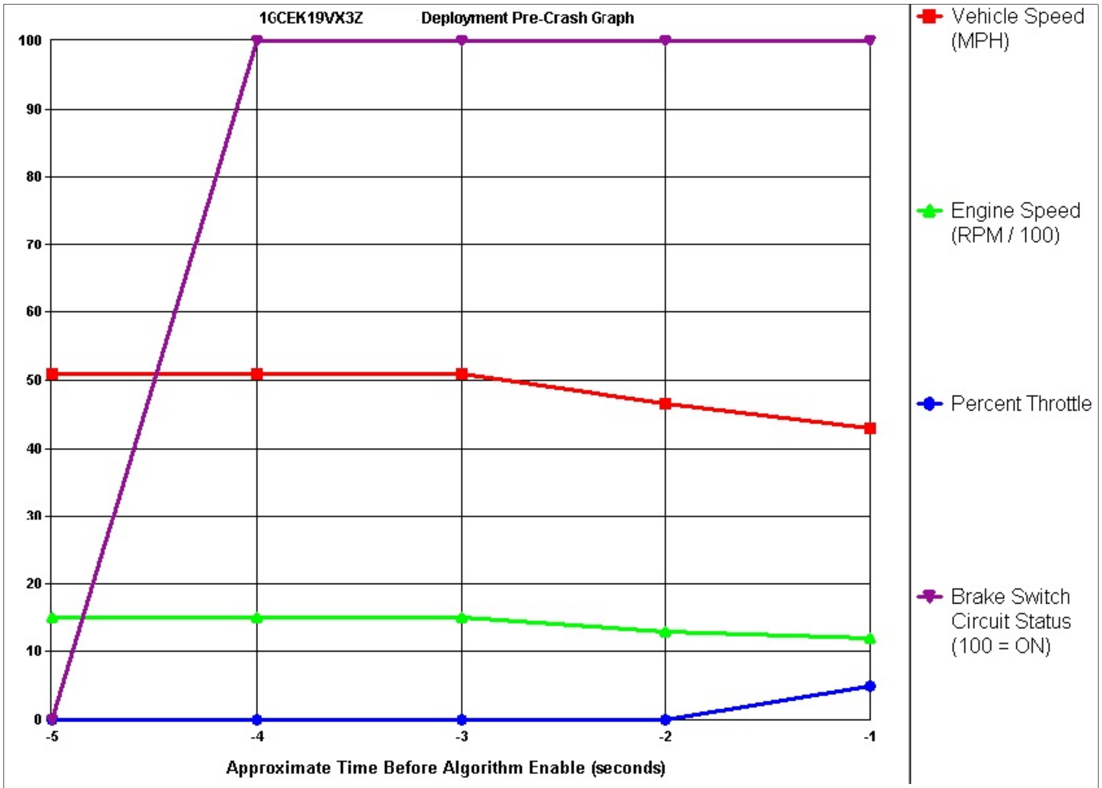


Figure 29: Case vehicle's pre-crash speed and brake switch circuit status showing that the vehicle had been traveling at approximately 82 km.p.h. (51 m.p.h.) when the brake was activated approximately 5 seconds prior to algorithm enable.

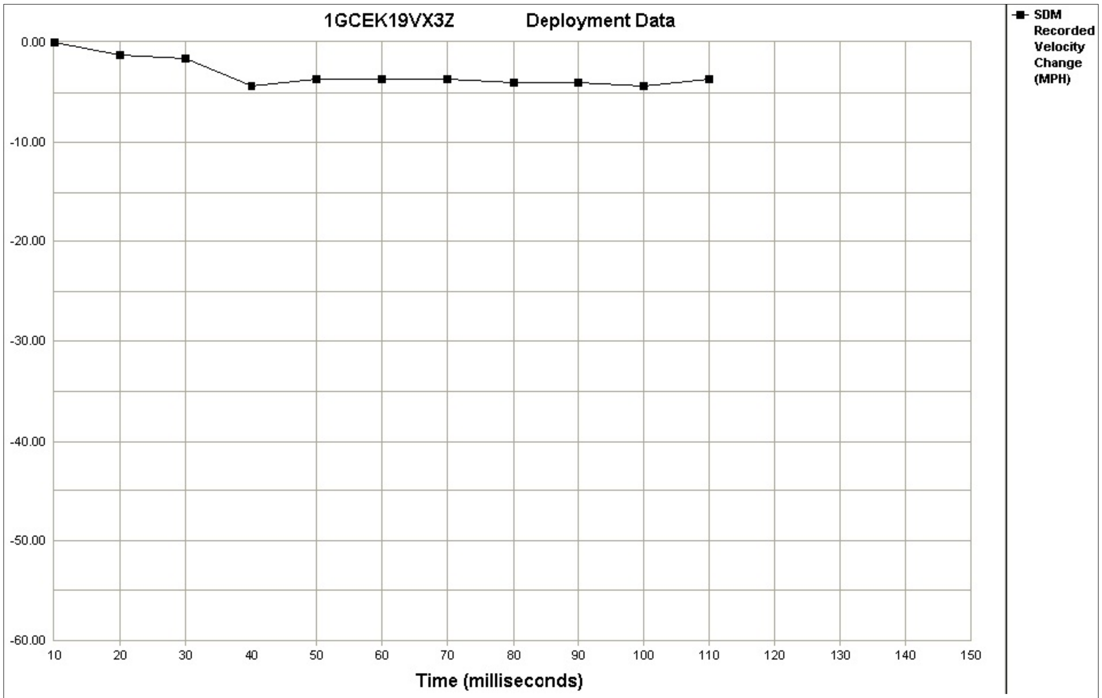
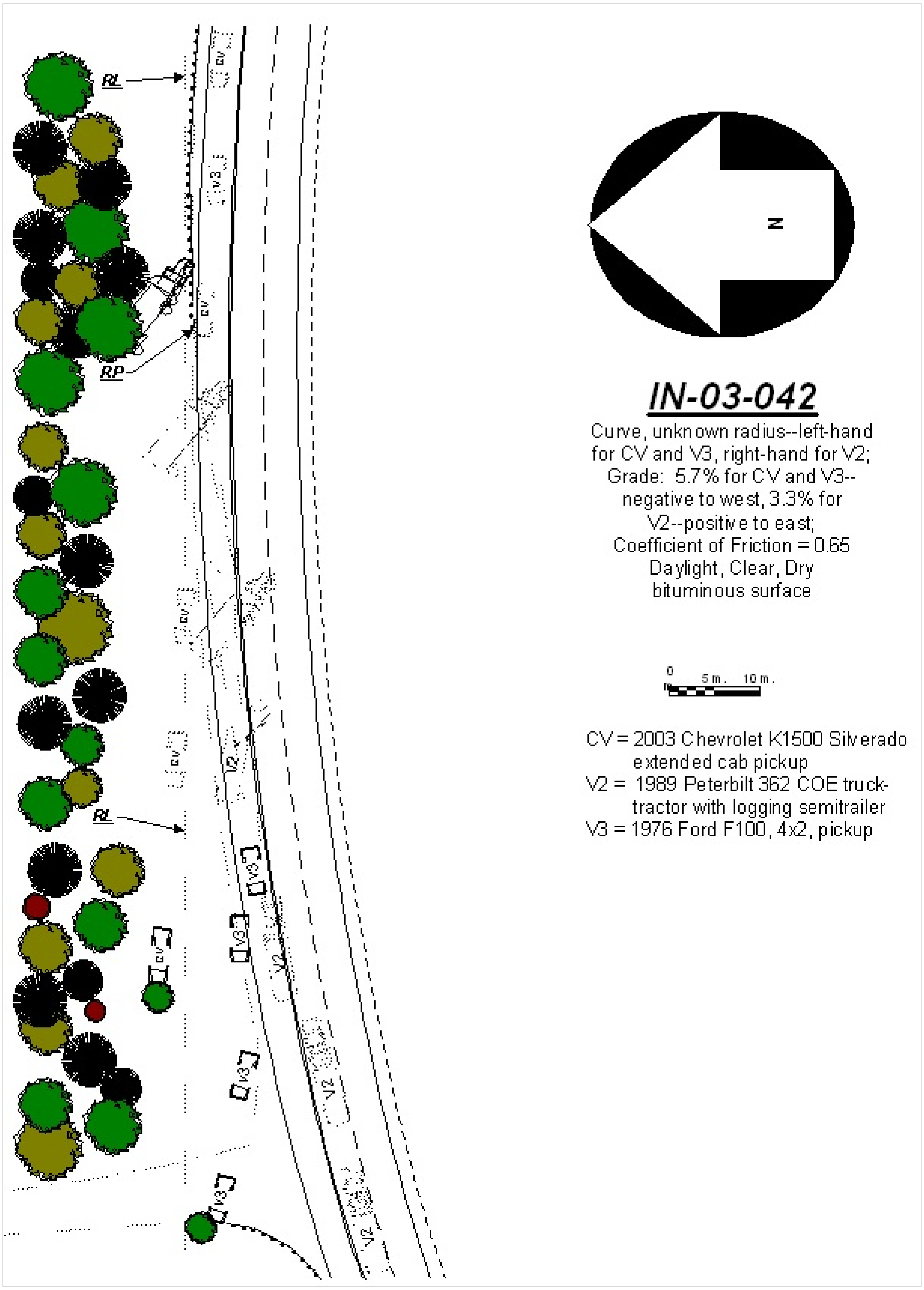


Figure 30: The case vehicle sustained a maximum velocity change of approximately 7.7 km.p.h. (4.8 m.p.h.) during the first 110 milliseconds after the crash was detected


RL
RP
RL
CV
V3
V2
N
IN-03-042
Curve, unknown radius--left-hand for CV and V3, right-hand for V2;
Grade: 5.7% for CV and V3--negative to west, 3.3% for V2--positive to east;
Coefficient of Friction = 0.65
Daylight, Clear, Dry
bituminous surface
0 5 m. 10 m.
CV = 2003 Chevrolet K1500 Silverado extended cab pickup
V2 = 1989 Peterbilt 362 COE truck-tractor with logging semitrailer
V3 = 1976 Ford F100, 4x2, pickup