



# 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

## SCI/NASS COMBINATION CASE REPORT

CASE NUMBER - NASS-2003-49-115B

LOCATION - Texas

VEHICLE - 1999 CHEVROLET SILVERADO 1500 PICKUP TRUCK

CRASH DATE - May 2003

Submitted:

January 20, 2004

Revised:

September 20, 2005



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. <i>Report No.</i> NASS-2003-49-115B		2. <i>Government Accession No.</i>		3. <i>Recipient's Catalog No.</i>	
4. <i>Title and Subtitle</i> SCI/NASS Combination Adult Air Bag Fatality Investigation Vehicle - 1999 Chevrolet Silverado 1500 Pickup Truck Location - Texas				5. <i>Report Date:</i> January 20, 2004	
				6. <i>Performing Organization Code</i>	
7. <i>Author(s)</i> Special Crash Investigations Team #2				8. <i>Performing Organization Report No.</i>	
9. <i>Performing Organization Name and Address</i> Transportation Research Center Indiana University 222 West Second Street Bloomington, Indiana 47403-1501				10. <i>Work Unit No. (TRAIS)</i>	
				11. <i>Contract or Grant No.</i> DTNH22-01-C-07002	
12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation (NRD-32) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003				13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: May 2003	
				14. <i>Sponsoring Agency Code</i>	
15. <i>Supplementary Notes</i> Combination SCI/NASS investigation involving a 1999 Chevrolet Silverado 1500 pickup truck equipped with redesigned air bags and integrated safety belts that impacted a large tree					
16. <i>Abstract</i> This combination SCI/NASS investigation concerns an air bag deployment crash involving a 1999 Chevrolet Silverado 1500 pickup truck (case vehicle) that impacted a large tree. This crash is of special interest because the redesigned air bag deployed and the case vehicle's driver (44-year-old female), who was restrained by the integrated, manual, lap-and-shoulder safety belt, suffered critical injuries in her neck and chest, resulting in her death. In addition, the case vehicle was equipped with an Event Data Recorder (EDR) that was successfully downloaded. There was no other occupant in the case vehicle. The case vehicle was traveling east in the outside eastbound lane of a two-lane roadway that was part of a divided trafficway (i.e., two lanes in each direction separated by grass median), apparently intending to continue straight ahead. It was dark but lighted and it was raining, with the concrete road surface wet but otherwise free of defects. For some unknown reason, the case vehicle traveled off the left (north) side of the roadway and entered the median. The case vehicle crossed the median, the westbound travel lanes, a gore area and a westbound exit lane, and departed the north side of the trafficway heading approximately north. It continued north on the roadside beyond the exit lane, crossed an east-west frontage road, vaulted a ditch, passed through a barbed wire fence and struck a large tree head-on, causing the case vehicle's driver air bag to deploy (the passenger air bag suppression switch was in the "off" position). The driver was not in a normal upright seated posture and the deploying air bag struck her face and chest. Her injuries included: atlanto-axial (C1/C2) dislocation; laceration of the brain stem; bilateral cerebral edema; bilateral rib fractures; bilateral lung contusions; and other minor injuries. She was transported to a local hospital, where she was declared dead approximately 7 hours after the crash. The case vehicle came to rest against the tree, heading north, and was subsequently towed due to disabling damage.					
17. <i>Key Words</i> Redesigned Air Bag Deployment Motor Vehicle Traffic Crash Injury Severity				18. <i>Distribution Statement</i> General Public	
19. <i>Security Classif. (of this report)</i> Unclassified		20. <i>Security Classif. (of this page)</i> Unclassified		21. <i>No. of Pages</i> 9	22. <i>Price</i> \$2,000

TABLE OF CONTENTS

NASS-2003-49-115B

	<u>Page No.</u>
BACKGROUND . . . . .	1
CRASH CIRCUMSTANCES . . . . .	1
CASE VEHICLE: 1999 CHEVROLET SILVERADO 1500 PICKUP TRUCK . . . . .	2
AUTOMATIC RESTRAINT SYSTEM . . . . .	3
EVENT DATA RECORDER . . . . .	4
CASE VEHICLE DRIVER . . . . .	4
DRIVER'S INJURIES . . . . .	5
SCENE DIAGRAM . . . . .	7
SENSING AND DIAGNOSTIC MODULE	
Figure 10: System Status at Non-Deployment . . . . .	8
Figure 11: Non-Deployment Velocity Change Graph . . . . .	8
Figure 12: System Status at Deployment . . . . .	9
Figure 13: Deployment Velocity Change Graph . . . . .	9
SELECTED PHOTOGRAPHS	
Figure 1: Looking east along case vehicle' s eastbound approach . . . . .	1
Figure 2: Case vehicle' s northward path across median . . . . .	1
Figure 3: Case vehicle' s northward path across frontage road . . . . .	2
Figure 4: Case vehicle' s final rest area with its front against the tree . . . . .	2
Figure 5: Case vehicle' s front and left side . . . . .	2
Figure 6: Case vehicle' s front, showing broken steel bumper . . . . .	3
Figure 7: Driver' s seat, showing integrated manual safety belt . . . . .	3
Figure 8: Front of driver' s air bag . . . . .	3
Figure 9: Driver' s seating area, view from right . . . . .	5

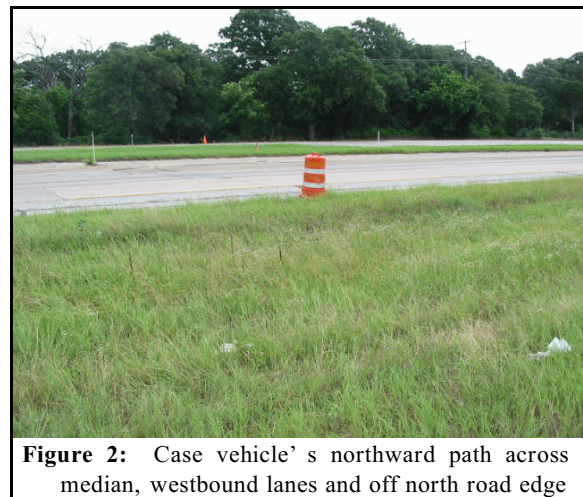
This SCI/NASS combination investigation was brought to the NHTSA's attention in June 2003 by NASS/CDS sampling activities. This crash involved a 1999 Chevrolet Silverado pickup truck (case vehicle) that ran off the road and struck a tree. The crash occurred in May 2003, at 12:30 a.m., in Texas and was investigated by the applicable municipal police. This crash is of special interest because the redesigned air bag deployed and the case vehicle's driver (44-year-old female, black, non-Hispanic), who was restrained by the manual, integrated, lap-and-shoulder safety belt system, suffered critical injuries in her neck and chest, resulting in her death. In addition, the case vehicle was equipped with an Event Data Recorder (EDR) that was successfully downloaded. There was no other occupant in the case vehicle. The case was designated as a SCI/NASS combination investigation on September 5, 2003. This contractor received a copy of the finished NASS case in December 2003. This report is based on the police crash report, NASS scene and vehicle photographs, the coded NASS case, the downloaded EDR data, occupant kinematic principles and this contractor's evaluation of the evidence.

### CRASH CIRCUMSTANCES

The case vehicle was traveling east in the outside eastbound lane of a two-lane roadway that was part of a divided trafficway (i.e., two lanes in each direction separated by grass median), apparently intending to continue straight ahead (**Figure 1**). It was dark but lighted and it was raining, with the concrete road surface wet but otherwise free of defects. The speed limit was 97 km.p.h. [60 m.p.h.]. For some unknown reason, the case vehicle traveled off the left (north) side of the roadway and entered the median. The crash events began within an interchange area, but there is no evidence that the driver's actions were related to negotiating the exit/entrance area. The case vehicle crossed the median, the westbound travel lanes, a gore area and a westbound exit lane, and departed the north side of the trafficway heading approximately north (**Figure 2**). It continued north on the roadside beyond the exit lane, crossed an east-west frontage road, vaulted a ditch (**Figure 3**), passed through a barbed wire fence and struck a large tree head-on, causing the case vehicle's driver air bag to deploy (**Figure 4**). The case vehicle came to rest against the tree, heading north.



**Figure 1:** Looking east along the case vehicle's eastbound approach; final rest was beyond the frontage road, in the trees at the upper left corner of this view (arrow)



**Figure 2:** Case vehicle's northward path across median, westbound lanes and off north road edge



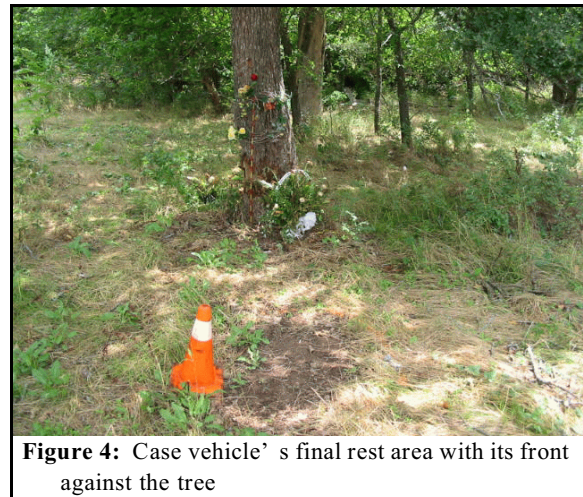
The case vehicle was a 1999 Chevrolet Silverado 1500, four-door, five passenger, extended cab, 4 x 2 pickup truck (VIN: 2GCEC19W2X1-----), equipped with a 4.3 liter V-6 gasoline engine and an automatic transmission with a column-mounted selector lever. Four-wheel anti-lock brakes were standard for this model. The odometer reading is not known due to the non-functional electronic instrument panel. The wheelbase was 365 centimeters [143.5 inches]. The case vehicle was towed due to disabling damage.

The front of the case vehicle impacted and passed through a barbed wire fence (event #1), breaking the fence and causing very minor damage to the vehicle. The CDC for the fence impact was determined to be **12-FDEW-1 (0)**. The fence impact was out of scope for the WinSMASH reconstruction program.

The case vehicle impacted the tree head-on, slightly left of center, causing a deep narrow impact with maximum crush measured as 57 centimeters [22.4 inches] (**Figure 5**). The plastic bumper cover was displaced upward and the steel bumper was fractured near the center and displaced downward, with the broken ends crushed rearward (**Figure 6**). The radiator and its upper support brackets were crushed rearward. The leading edge of the engine hood was folded downward. There was minor induced damage on the fenders. The windshield was cracked and there was no other glazing damage. The wheelbase was shortened 10 centimeters [3.9 inches] on the left and 3 centimeters [1.2 inches] on the right. None of the tires were deflated and the front left tire was restricted. The CDC for the tree impact was determined to be **12-FYEW-3 (0)**. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's most severe impact (event #2). The total, longitudinal and lateral delta Vs are, respectively: 37 km.p.h. [23.0 m.p.h.], -37 km.p.h. [-23.0 m.p.h.] and 0 km.p.h. [0 m.p.h.].



**Figure 3:** Case vehicle's northward path off frontage road toward fence and tree



**Figure 4:** Case vehicle's final rest area with its front against the tree



**Figure 5:** Case vehicle's front and left side

The case vehicle was fitted with two bucket seats in the front row and a bench seat in the back row. The two front seats had integrated safety belts (**Figure 7**). The interior had been thoroughly cleaned by the salvage operator prior to the NASS inspection and there was little evidence remaining. The inspection of the case vehicle's interior did reveal 5 centimeters [2 inches] of longitudinal intrusion by the center portion of the instrument panel, and no other intrusions. There was evidence of occupant contact on the front of the driver's air bag, on the safety belt webbing and on the knee bolster. In addition, the right side of the steering wheel rim was cracked (but not measurably bent) and the column-mounted automatic transmission selector lever was bent, probably due to occupant contact.

#### AUTOMATIC RESTRAINT SYSTEM

The driver's air bag was located in the steering wheel hub and the front right passenger air bag was located in the mid-instrument panel position. The case vehicle had an original equipment air bag suppression switch for the front right passenger air bag and the switch was in the "OFF" position. The driver's air bag deployed but the front right passenger's did not.

The driver's air bag was installed in the steering wheel hub with the module cover flaps in the I-configuration. The flaps opened at the tear points and there was no evidence of damage to the flaps or the adjacent structures. Each flap measured 11 centimeters [4.3 inches] vertically and 8 centimeters [3.1 inches] horizontally. The deployed air bag was round with a diameter of 60 centimeters [23.6 inches], and with two vent ports on the back at the 11 and 1 o'clock positions. There was no evidence of damage to the air bag (**Figure 8**). The NASS investigator indicated that there was contact evidence on the front of the air bag, but this is not visible in the photographs.



**Figure 6:** Front of case vehicle, showing broken steel bumper



**Figure 7:** Driver's seat, showing integrated manual safety belt system



**Figure 8:** Front of driver's air bag



The case vehicle was equipped with an Event Data Recorder (EDR) that was successfully downloaded. The Sensing and Diagnostic Module (SDM) reports are included at the end of this document (**Figures 10 - 13**). The SDM recorded a non-deployment event and a deployment event. Both the non-deployment and the deployment reports indicate that the driver's safety belt was not buckled, but other evidence indicates that the driver's safety belt system was in use. There is a known issue with the model SDM where it continued to report buckle status after the electrical system was compromised. It appears that this unit recorded an erroneous belt status.

The SDM System Status at Non-Deployment report (**Figure 10**) and the System Status at Deployment report (**Figure 12**) both indicate that the SIR Warning Lamp showed no faults in the air bag circuits, the events occurred during ignition cycle 10,660 and the EDR download was obtained during ignition cycle 10,664. Both reports indicate that the driver's safety belt was unbuckled, but this is believed to be false reporting due to disruption of the EDR electrical circuit. Both reports also indicate that the passenger's air bag was suppressed, and the manually operated suppression switch was found in the "OFF" position.

The Non-Deployment report indicates that the maximum recorded longitudinal velocity change for the non-deployment event was -0.4 km.p.h. [-0.22 m.p.h.] and this maximum was reached at 7.5 milliseconds [0.0075 seconds] after algorithm enable (**Figures 10 and 11**). The Non-Deployment report also indicates that a deployment was not commanded prior to the recording of the non-deployment event. This non-deployment event is associated with the case vehicle's impact with the barbed wire fence (NASS event #1). The non-deployment velocity change graph (**Figure 11**) is essentially flat, with the first plotted point (at 10 milliseconds) the only non-zero point, reflecting the very short duration and very low magnitude of the impact pulse as the vehicle broke through the strands of the barbed wire fence.

The Deployment report indicates that the maximum recorded longitudinal velocity change for the deployment event was -50.5 km.p.h. [-31.37 m.p.h.] and this maximum was reached at 140 milliseconds [0.140 seconds] after algorithm enable (**Figures 12 and 13**). The Deployment report also indicates that the command to deploy was issued 6.25 milliseconds [0.00625 seconds] after algorithm enable. The deployment event is associated with the tree impact (NASS event #2). The Deployment report indicates that algorithm enable for the deployment event was 0.14 seconds after algorithm enable for the non-deployment event, which is reasonable for the physical configuration at the scene. The deployment velocity change graph (**Figure 13**) shows a steep pulse for the first 100 milliseconds, followed by a plateau that persists, with slight modulation, for the 300 millisecond interval recorded for this impact.

#### CASE VEHICLE DRIVER

The case vehicle driver (44-year-old female, black, non-Hispanic, 160 centimeters, 86 kilograms [63 inches, 190 pounds]) was restrained by the available integrated, active, three-point lap-and-shoulder safety belt system. Because she was the sole occupant in the case vehicle, there is no knowledge of her pre-crash posture. The case vehicle interior had been cleaned very thoroughly prior to the NASS inspection, with the seats moved during the cleaning such that the



seat track and seat back incline adjustments are not known. The tilt steering wheel was found in the full down position (**Figure 9**). The autopsy report indicates that her blood alcohol concentration was 0.09 milligrams per decaliter.

The case vehicle was traveling east in the eastbound lane of an interstate highway, at or near the 97 km.p.h. [60 m.p.h.] speed limit, when the vehicle veered sharply to the left, entered the median heading approximately north, traveled approximately 50 meters [164 feet] across a variety of terrain features and eventually impacted a tree at high speed. There was no evidence of braking or evasive steering. It is not known why the vehicle departed the original travel lane, but it appears that the driver was somehow incapacitated and not able to control the vehicle, and she was probably not in an upright seated posture. She was jostled erratically as the vehicle bounced



**Figure 9:** Driver' s seating area

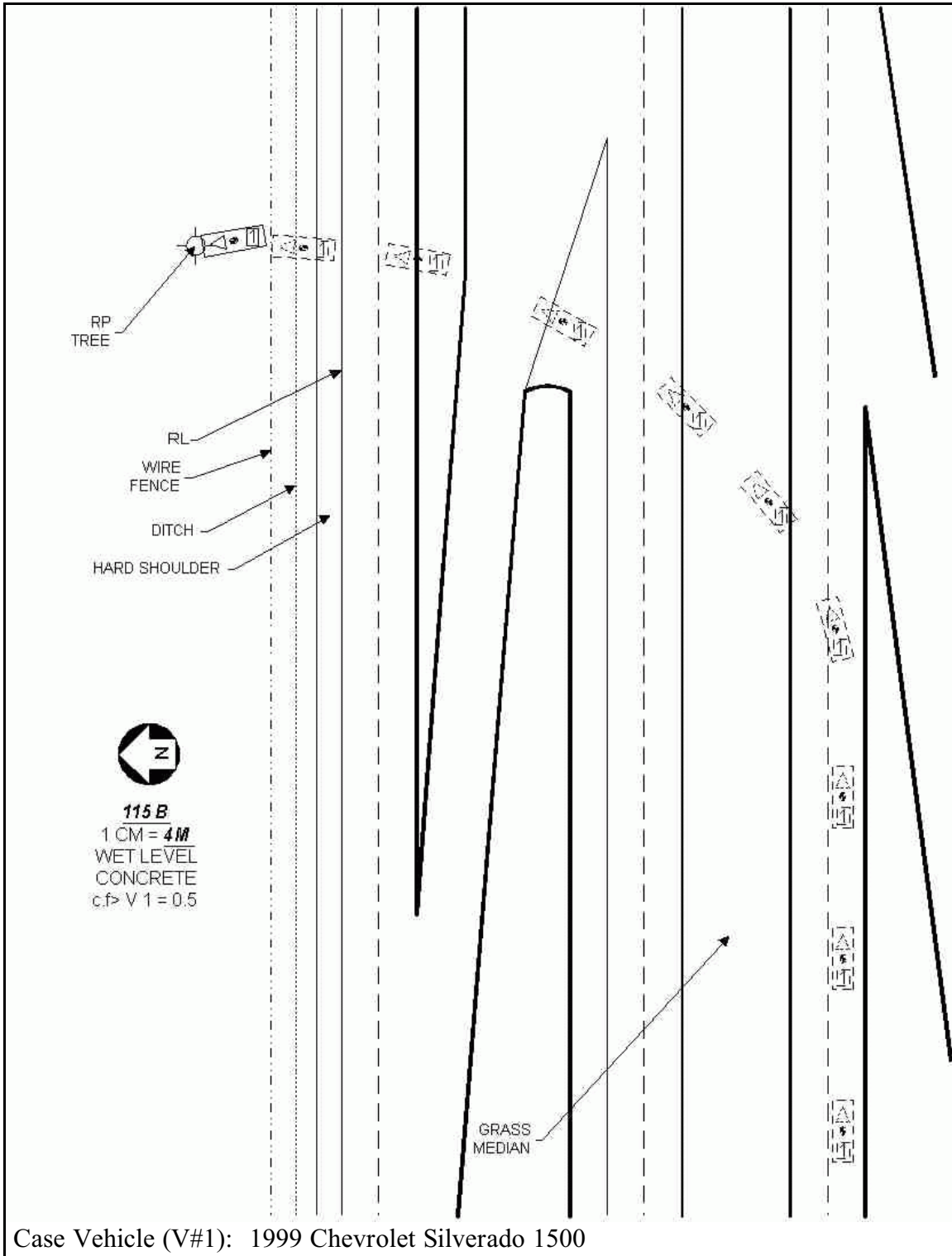
across the terrain and, because there was no significant deceleration during this relatively long episode of off-road travel, the safety belt retractor probably did not lock until the impact events. The first impact, with a barbed wire fence, probably did not affect her posture. The front-center of the case vehicle impacted a large tree, with the vehicle' s rear end pitching upward, causing the driver to move forward and upward, toward the 12:00 o' clock direction of force, and causing the driver air bag to deploy. The air bag struck her face and chest, causing atlanto-axial (C1/C2) dislocation, brain stem lacerations and tearing of the alar and cruciate ligaments. In addition, she sustained bilateral rib fractures and bilateral contusions of the lungs. She also sustained contusions and abrasions from the air bag on her forehead and face, and suffered bilateral cerebral edema. The safety belt retractor locked and she loaded against the safety belt webbing, sustaining an abrasion on her left shoulder, and contusions on her left hip and across the middle of her abdomen. At final rest, she was probably slumped back into the driver' s seat.

#### CASE VEHICLE DRIVER' S INJURIES

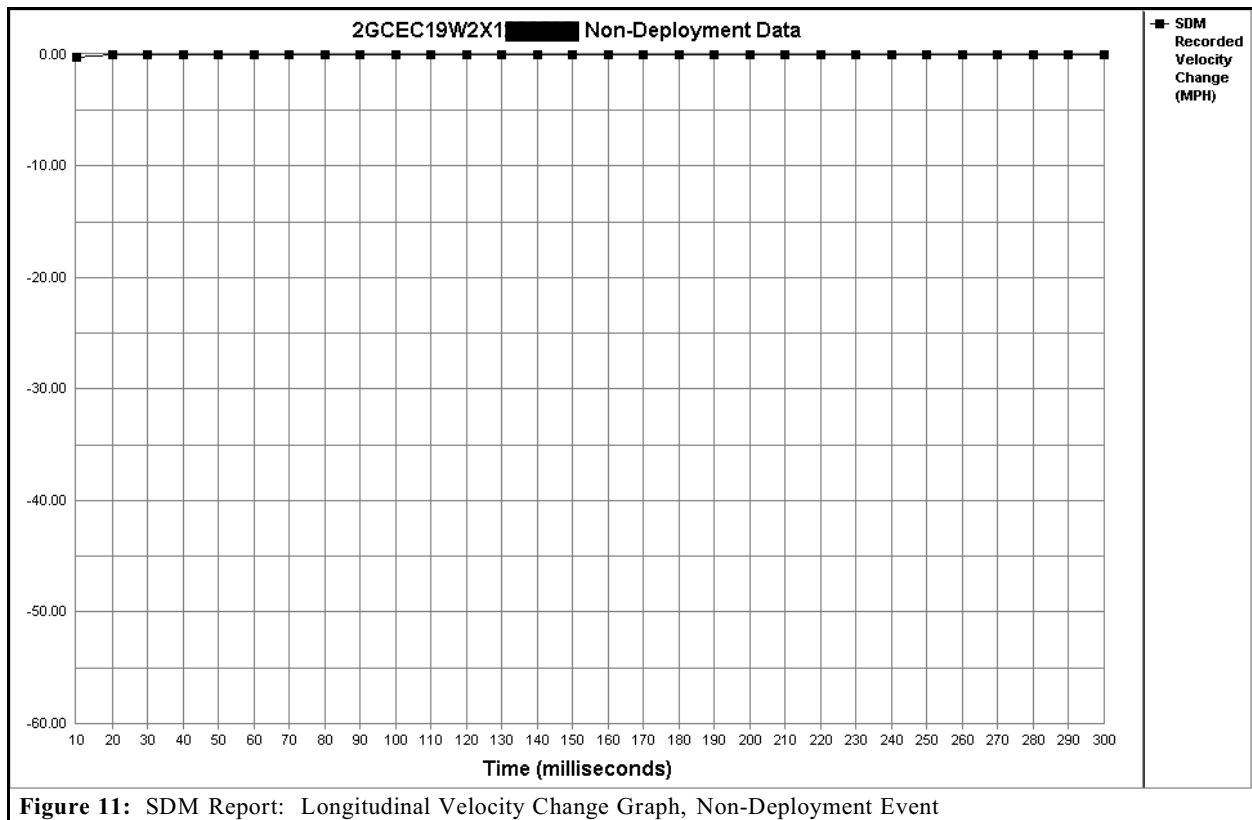
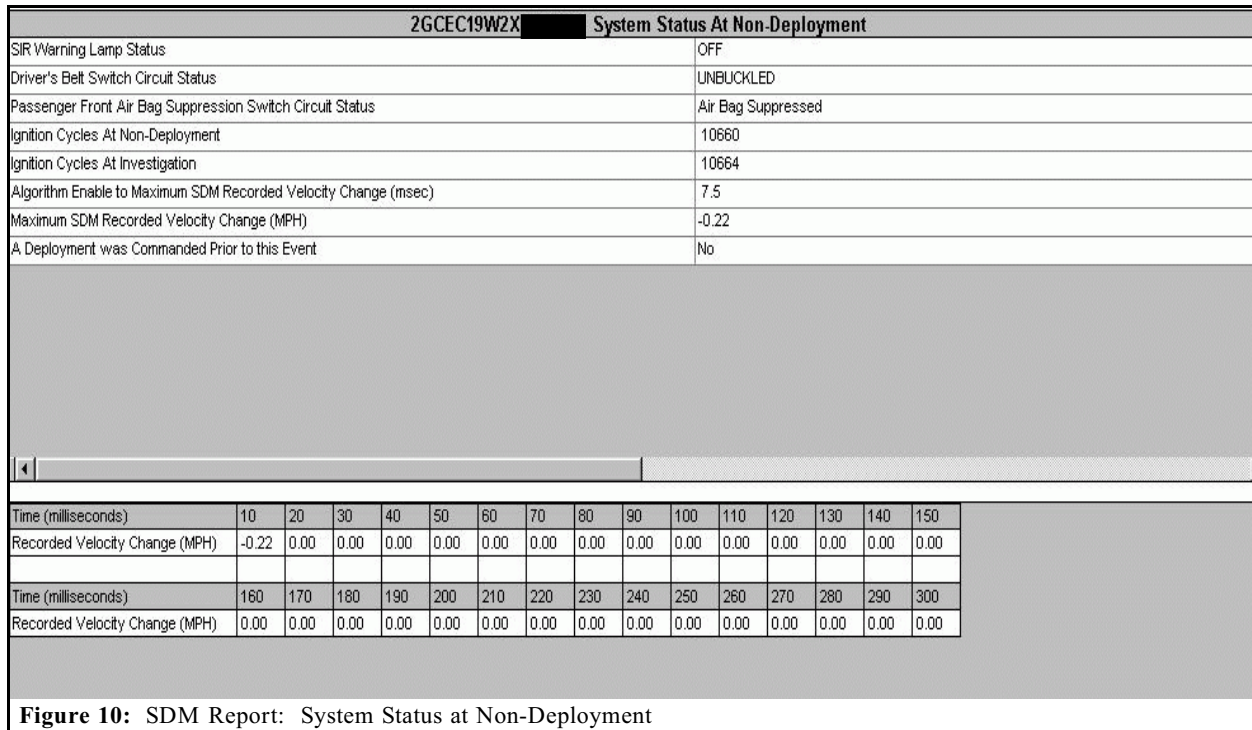
The driver was transported via ambulance to a hospital, where she was pronounced dead approximately seven hours after the crash.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Brain stem (pontomedullary) tear/laceration, with associated subarachnoid hemorrhage	140212.6 maximum	Driver' s air bag (indirect)	Certain	Autopsy
2	Bilateral rib cage fractures, left 1st - 5th, right 1st - 6th	450240.4 severe	Driver' s air bag	Certain	Autopsy

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
3	Bilateral lung contusions	441410.4 severe	Driver' s air bag	Certain	Autopsy
4	Cervical spine dislocation, C1/C2 atlanto-axial (odontoid)	650206.3 serious	Driver' s air bag (indirect)	Certain	Autopsy
5	Interspinous posterior ligament laceration (torn from alar and cruciate)	630284.1 minor	Driver' s air bag (indirect)	Certain	Autopsy
6	Cerebral edema, right	140660.3 serious	Driver' s air bag	Certain	Autopsy
7	Cerebral edema, left	140660.3 serious	Driver' s air bag	Certain	Autopsy
8	Right forehead abrasion	290202.1 minor	Driver' s air bag and eyewear	Certain	Autopsy
9	Right forehead contusion	290402.1 minor	Driver' s air bag and eyewear	Certain	Autopsy
10	Right eyelid contusion	297402.1 minor	Driver' s air bag and eyewear	Certain	Autopsy
11	Chin abrasion	290202.1 minor	Driver' s air bag	Certain	Autopsy
12	Left neck abrasion	390202.1 minor	Safety belt webbing	Certain	Autopsy
13	Left chest abrasion	490402.1 minor	Driver' s air bag	Certain	Autopsy
14	Mid-abdominal contusion	590402.1 minor	Safety belt webbing	Certain	Autopsy
15	Left upper thigh and hip contusion	890402.1 minor	Safety belt webbing	Certain	Autopsy



Case Vehicle (V#1): 1999 Chevrolet Silverado 1500





2GCEC19W2X1 System Status At Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Suppressed
Ignition Cycles At Deployment	10660
Ignition Cycles At Investigation	10664
Time From Algorithm Enable To Deployment Command (msec)	6.25
Time Between Non-Deployment And Deployment Events (sec)	.14

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.88	-2.41	-3.73	-5.27	-7.90	-11.41	-16.02	-19.75	-23.26	-26.99	-29.84	-30.50	-31.15	-31.37	-31.37
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Recorded Velocity Change (MPH)	-31.37	-31.37	-31.15	-30.94	-30.94	-30.94	-30.72	-30.72	-30.50	-30.28	-30.06	-29.84	-29.62	-29.62	-29.62

Figure 12: SDM Report: System Status at Deployment

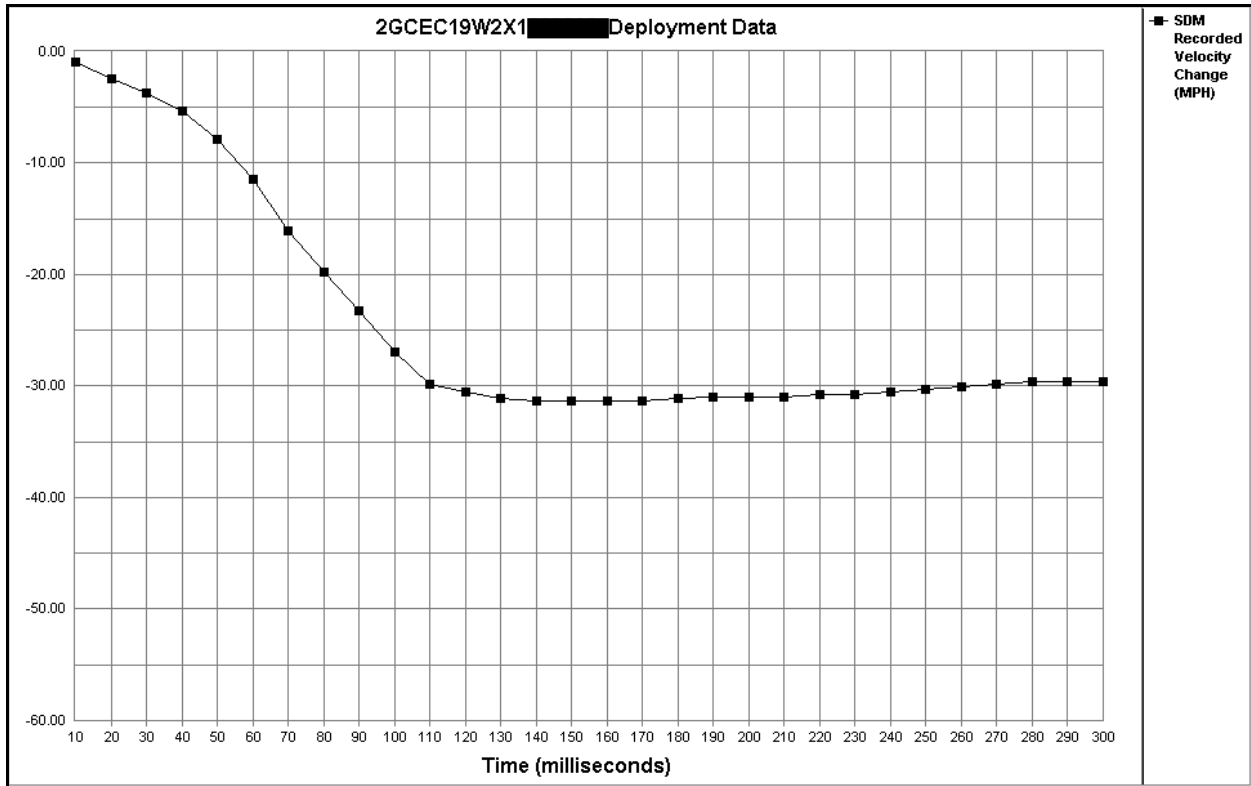


Figure 13: SDM Report: Longitudinal Velocity Change Graph, Deployment Event