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ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-04-002
LOCATION - TEXAS
VEHICLE - 2003 CHEVROLET C1500 SILVERADO
CRASH DATE - January 2004

Submitted:

September 14, 2007

Contract Number: DTNH22-01-C-07002

Prepared for:

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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 C1500 Silverado, two-door pickup, with manual safety belts and dual front advanced air bags, and a 1986 BMW 325es, two-door coupe

16. *Abstract*
This report covers an on-site investigation of an air bag deployment crash that involved a 2003 Chevrolet C1500 Silverado (case vehicle) and a 1986 BMW 325i (other vehicle). This crash is of special interest because the case vehicle was equipped with multiple Advance Occupant Protection System (**AOPS**) features, including certified advanced 208-compliant air bags, as well as an Event Data Recorder (**EDR**) and the case vehicle's restrained driver (44-year-old, male) sustained only minor soft tissue injuries as a result of the crash. The trafficway on which both vehicles were traveling was an eight-lane, divided, state highway, traversing in an east-west direction, and both vehicles were approaching a four-leg intersection. On the eastern leg of the intersection, the westbound roadway had three through lanes and one left-hand turn lane. On the western leg of the intersection, the eastbound roadway had four through lanes and a right-hand turn lane. The case vehicle had been traveling west in the westbound, left-hand, turn lane and was turning left at the intersection. The BMW was traveling east in the outside through lane of the eastbound roadway. The crash occurred in the outside through lane of the eastbound roadway, within the four-leg intersection of the two trafficways. The front of the case vehicle impacted the left front half of the BMW, causing the case vehicle's driver supplemental restraint (air bag) to deploy. 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. The case vehicle's driver was seated with his seat track located in its middle 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, minor soft tissue contusions to his left upper chest/shoulder area as well as a "V" shaped bruise over his lower sternum.

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TABLE OF CONTENTS

Page No.

Page No.

SELECTED PHOTOGRAPHS (Continued)

BACKGROUND

This investigation was brought to NHTSA's attention on or before January 21, 2004 by NASS GES sampling activities. This crash involved a 2003 Chevrolet C1500 Silverado (case vehicle) and a 1986 BMW 325es (other vehicle). The crash occurred in January 2004 at 11:19 p.m., in Texas and was investigated by the applicable city 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 [44-year-old, White (non-Hispanic) male] sustained only minor soft tissue injuries as a result of the crash. This contractor inspected the scene and vehicles on 28-29 January 2004 and downloaded the data from the onboard EDR. This contractor interviewed the driver of the case vehicle on 13 February 2004. This report is based on the Police Crash Report, an interview with the case vehicle's driver, scene and vehicle inspections, occupant kinematic principles, self-reported injury information, and this contractor's evaluation of the evidence.

SUMMARY

The trafficway on which both vehicles were traveling was an eight-lane, divided, state highway, traversing in an east-west direction, and both vehicles were approaching a four-leg intersection. On the eastern leg of the intersection, the westbound roadway had three through lanes and one left-hand turn lane. On the western leg of the intersection, the eastbound roadway had four through lanes and a right-hand turn lane. The trafficway onto which the case vehicle was turning was a one-way, undivided, service road of an intersecting, state highway, which traversed in a north-south direction. On the southern leg of the intersection, the north-south roadway had two through lanes. At the time of the crash the light condition was dark, but illuminated by overhead street lamps at the area of impact, there were no adverse atmospheric conditions (i.e., clear or cloudy), and the road pavement was dry.

The case vehicle had been traveling west in the westbound, left-hand, turn lane and was turning left at the intersection, intending to travel south on the one-way, service road. The BMW was traveling east in the outside through lane of the eastbound roadway and intended to proceed straight ahead. According to the case vehicle's driver and supported by the downloaded **EDR** data, the driver did not make any avoidance maneuvers prior to the crash. The crash occurred in the outside through lane of the eastbound roadway, within the four-leg intersection of the two trafficways.

The front of the case vehicle impacted the left front half of the BMW, causing the case vehicle's driver supplemental restraint (air bag) to deploy. Based on the downloaded **EDR** data, only one stage of the driver's multi-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.

As a result of the impact, the case vehicle rotated approximately 70 degrees counter-clockwise and was redirected to its left. The case vehicle came to rest partially off the roadway, straddling the curb on the southeast corner of the intersection, heading in an east-southeasterly direction. The BMW was redirected to its right (southeast) and rotated approximately 45 degrees clockwise. The BMW is estimated to have come to final rest partially off the southern leg of the intersection, straddling the east curb, heading southeast.

The 2003 Chevrolet C1500 Silverado was a rear wheel drive (4x2), two-door, regular cab pickup truck (VIN: 1GECE14X93Z------). The case vehicle was equipped with four wheel, anti-lock brakes, dual stage driver and front right passenger air bag inflators, and driver and front right passenger seat belt buckle switch sensors. In addition, there was an unknown type of seat weight sensor for the front right passenger seating position, as evident by the aforementioned air bag **AUTO/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**).

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **01-FDEW-2** (**30** degrees). The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 28.4 km.p.h. (17.6 m.p.h.), -24.6 km.p.h. (-15.3 m.p.h.), and -14.2 km.p.h. (-8.8 m.p.h.). The case vehicle was towed due to damage.

The data downloaded from the case vehicle's **EDR** showed that the driver's seat belt status was buckled, the second stage of the multi-stage air bags was not activated, and the Delta V reached a value of 26.44 km.p.h. (16.43 m.p.h.) at the 140 millisecond mark of recorded data.

The 1986 BMW 325i was a rear wheel drive, two-door coupe (VIN: WBAAB5403G9------). The BMW was not equipped with anti-lock brakes or air bags.

The case vehicle's driver [44-year-old, White (non-Hispanic) male; 173 centimeters and 64 kilograms (68 inches, 140 pounds)] was seated with his seat track located in its middle 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, minor soft tissue contusions to his left upper chest/shoulder area as well as a "V" shaped bruise over his lower sternum.

According to the Police Crash Report, the BMW's driver [22-year-old, White (unknown if Hispanic) male] was restrained by his available, active, three-point, lap-and-shoulder, safety belt systems. The driver was transported by ambulance to the hospital; however, his treatment status is unknown. He sustained police-reported "B" (non-incapacitating-evident) injuries, but the exact nature of these injuries are unknown.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was an eight-lane, divided, state highway, traversing in an east-west direction, and both vehicles were approaching a four-leg intersection. On the eastern leg of the intersection, the westbound roadway had three through lanes and one left-hand turn lane (**Figure 1** below). On the western leg of the intersection, the eastbound roadway had four through lanes and a right-hand turn lane (**Figure 2**). The trafficway onto which the case vehicle was turning was a one-way, undivided, service road of an intersecting, state highway, which traversed in a north-south direction. On the southern leg of the intersection, the north-south roadway had two through lanes.

Figure 1: Case vehicle's westbound travel path in left-hand turn lane prior to making left turn; Note: arrow indicates approximate location of impact (case photo #01)

Figure 2: BMW's eastward travel path in outside through lane; Note: arrow indicates approximate location of impact (case photo #07a)

The state highway was straight and generally level; however, the east leg of the intersection had a 3.1% grade negative to the west (i.e., a downgrade in the case vehicle's direction of travel in the left-hand turn lane) because this road segment was part of an overpass. The south leg of the intersection had a 2.4% grade negative to the south (i.e., a downgrade in the case vehicle's intended direction of travel). The actual grade in transition near the area of impact was most likely somewhere between these two measured values. For the state highway, the eastern roadway's pavement was concrete, and for the western roadway, the pavement was bituminous, but traveled. The width of the left-hand turn lane on the eastern leg's westbound roadway was 3.8 meters (12.5 feet), and the width of the outside through lane on the western leg's eastbound roadway was 3.2 meters (10.5 feet). The trafficway was bordered by barrier curbs on both the eastern and western legs. In addition, on both the east and west legs, the east and westbound roadways were protected by a raised concrete median (**Figure 1**). On the east leg, the median was 1.1 meters (3.6 feet) while the median on the west leg was 4.2 meters (13.8 feet) in width. On the eastern leg pavement markings for the westbound roadway consisted of a solid yellow edge line on the left-hand (southern) side and a solid white edge line on right-hand (northern) side. In addition, the through lanes were divided by a dashed white lines and the left-hand turn lane was separated from the through lanes by solid white lane line. On the western leg pavement markings for the eastbound roadway consisted of a solid yellow edge line on the left-hand (northern) side and a solid white edge line on right-hand (southern) side. In addition, the four (4) through lanes were divided by a dashed white lines and the right-hand turn lane was separated from the through lanes by a solid white lane line and raised pavement markers. The coefficient of friction was not estimated. Traffic controls for the westbound roadway on the eastern leg consisted of a regulatory **KEEP RIGHT** sign (Manual on Uniform Traffic Control Devices, R4-7) which was mounted in the median on the western leg of the intersection (**Figure 1**). For the eastbound roadway on the western leg, there was a regulatory **MANDATORY MOVEMENT LANE CONTROL** sign (MUTCD, R3-5) with **SUPPLEMENTAL PLAQUE**

(R3-5b) mounted on the right-hand (southern) roadside (**Figure 2** above). In addition, four on-colors, pre-timed, horizontal mounted traffic control signals were mounted to control each of the traffic lanes and were located on the northwest and southeast quadrants of the intersection, respectively. The statutory speed limit was 48 km.p.h. (30 m.p.h.). No regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was dark, but illuminated by overhead street lamps at the area of impact, there were no adverse atmospheric conditions (i.e., clear or cloudy), and the road pavement was dry. According to the case vehicle's driver, the traffic density was light, and the site of the crash was urban commercial; see **CRASH DIAGRAM** at end.

Figure 3: Case vehicle's travel path, west-to-south, during left-hand turn; Note: arrow indicates approximate area of impact (case photo #02)

Pre-Crash: The case vehicle had been traveling west in the westbound, left-hand, turn lane (**Figure 1** above) and was turning left at the intersection, intending to travel south on the one-way, service road (**Figure 3**). The BMW was traveling east in the outside through lane of the eastbound roadway and intended to proceed straight ahead (**Figure 2** above). According to the case vehicle's driver and supported by the downloaded **EDR** data, the driver did not make any avoidance maneuvers prior to the crash. The crash occurred in the outside through lane of the eastbound roadway, within the four-leg intersection of the two trafficways (**Figure 2** above and **Figure 3**).

Figure 4: Case vehicle's frontal damage with contour gauge set at bumper level (case photo #11)

Crash: The front (**Figures 4** and **5**) of the case vehicle impacted the left front half of the BMW (**Figures 6** and **7** below), causing the case vehicle's driver supplemental restraint (air bag) to deploy. Based on the downloaded **EDR** data, only one stage of the driver's multi-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** below). This air bag did not deploy during the crash sequence.

Figure 5: Case vehicle's frontal damage viewed from right of front showing direct damage extending across entire front (case photo #22)

Figure 6 BMW's damaged left front half with contour gauge set above sill level; Note: damaged left front wheel assembly and direct contact to left "A"-pillar (case photo #45)

Figure 7: BMW's damaged left front door with crush extending onto left quarter panel; Note: door's window frame secured to left "B"-pillar for crush measurement purposes (case photo #46)

Post-Crash: As a result of the impact (**Figure 9**), the case vehicle rotated approximately 70 degrees counter-clockwise and was redirected to its left. The case vehicle came to rest partially off the roadway, straddling the curb on the southeast corner of the intersection, heading in an east-southeasterly direction (**Figure 10** below). The BMW was redirected to its right (southeast) and rotated approximately 45 degrees clockwise. The BMW is estimated to have come to final rest partially off the southern leg of the intersection, straddling the east curb, heading southeast (**Figure 9** and **Figure 10** below).

CASE VEHICLE

The 2003 Chevrolet C1500 Silverado was a rear wheel drive (4x2), three-passenger, two-door, regular cab pickup truck (VIN: 1GECE14X93Z------) equipped with a 4.3L, V-6 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 302 centimeters (119.0 inches), and the odometer reading at inspection was unknown because the case vehicle was equipped with an electronic odometer.

Figure 8: Case vehicle's front right passenger air bag cutoff switch showing switch located in "automatic" position; Note: with no front right passenger the seat's sensor correctly indicated that no deployment was required (case photo #33)

Figure 9: Arrows indicate areas of impact (green), and final rest for case vehicle (blue) and BMW (red); post-impact, case vehicle rotated counter-clockwise and BMW clockwise (case photo #09)

Figure 10: Westward view from beyond case vehicle's final rest position on southeast corner of four-leg intersection; Note: maroon pickup shows BMW's travel path and arrow indicates approximate location of impact (case photo #10)

The case vehicle was **CERTIFIED ADVANCED 208-COMPLIANT** and was equipped with dual stage driver and front right passenger air bag inflators, driver and front right passenger seat belt buckle switch sensors, 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). In addition, front seat back-mounted side impact air bags were optional for this model, but this vehicle was not so equipped. 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 height adjustable head restraints for the front outboard positions and 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 split bench seat with separate seat backs; adjustable head restraints for the front outboard seating positions; continuous loop, three-point, integral lap-and-shoulder, safety belt systems at the front outboard positions; and a two-point, lap belt system at the front center position. Because the front outboard seat belt systems were integral, the case vehicle was not equipped with manually operated, upper anchorage adjusters. The top surface for both of the two front adjustable head restraints was determined to be 22.5 centimeters (8.9 inches) above the top of their respective seat backs. The vehicle was equipped with knee bolsters for both the driver and front right seating positions. The driver's knee bolster showed evidence of occupant contact (i.e., faint scuffs). 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 frontal impact with the BMW.

Exterior Damage: The case vehicle's contact with BMW involved the entire frontal plane (**Figure 4** above and **Figure 11**). Direct damage began at the front left bumper corner and extended 162 centimeters (63.8 inches), along the front bumper. The Field L was determined to be 176 centimeters (69.3 inches). Residual maximum crush was measured as 50 centimeters (19.7 inches) at C_1 (**Figure 12**). The table below shows the case vehicle's crush profile.

Figure 11: Overhead view of case vehicle's frontal damage with contour gauge positioned at bumper level (case photo #23a)

Figure 12: Case vehicle's frontal damage viewed along reference line from left; Note: greater crush at C_1, indicating oblique nature of case vehicle's interaction with BMW's left side (case photo #14)

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								$\pm D$	$\pm D$
cm	1	162	50	176	50	33	31	20	12	3	0	0
in		63.8	19.7	69.3	19.7	13.0	12.2	7.9	4.7	1.2	0.0	0.0

The wheelbase on the case vehicle's left side was shortened 13 centimeters (5.1 inches) while the right side was extended 7 centimeters (2.8 inches). The case vehicle's front bumper, bumper fascia, grille, radiator, hood, left fender, and both the right and left headlight and turn signal assemblies were directly damaged and crushed rearward. There was induced damage to the hood as well as both the right and left fenders. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior. The recommended tire size was: P235/75R16 , and the case vehicle tires were the recommended size. The case vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	234	34	241	35	8	10	None	Yes	No
RF	248	36	241	35	8	10	None	No	No

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LR	234	34	241	35	8	10	None	No	No
RR	248	36	241	35	8	10	None	No	No

Interior Damage: Inspection of the case vehicle's interior revealed only minor evidence (i.e., faint scuffs) of occupant contact. Scuffs were noted on the driver's knee bolster, on both the left and right sides of the steering column (**Figures 13** and **14**). Finally, there was no evidence of intrusion to the case vehicle's interior, no evidence of compression to the energy absorbing shear capsules in the steering column, and no deformation to the steering wheel rim.

Figure 13: Vertical view of case vehicle's driver seating area showing deployed driver air bag and only possible contact evidence on left side of driver's knee bolster (case photo #26)

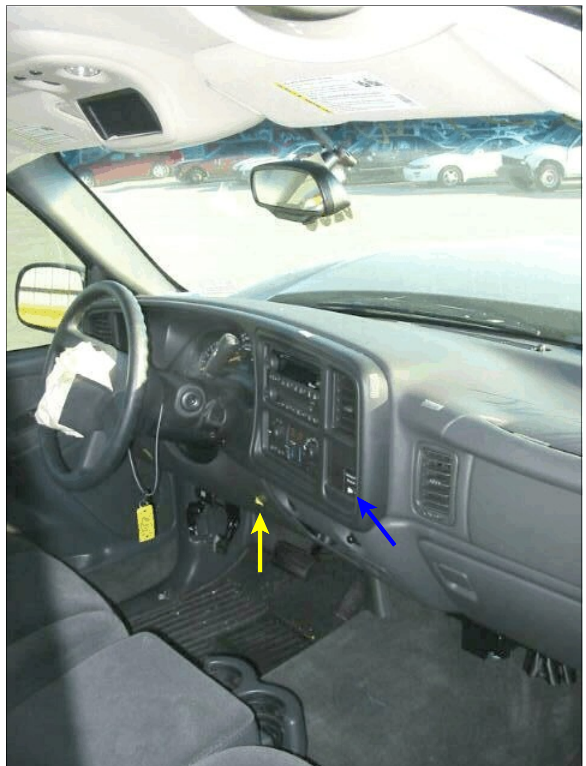


Figure 14: Vertical view of case vehicle's front seating area showing deployed driver air bag, non-deployed front right passenger air bag, possible contact evidence on right side of driver's knee bolster, and air bag cutoff switch (case photo #29)

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **01-FDEW-2** (**30** degrees). The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 28.4 km.p.h. (17.6 m.p.h.), -24.6 km.p.h. (-15.3 m.p.h.), and -14.2 km.p.h. (-8.8 m.p.h.). The case vehicle was towed due to damage.

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 the frontal impact with the BMW. Only one stage of the multi-stage air bag 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) along the top horizontal seam, 11 centimeters (4.3 inches) along the bottom horizontal seam, and 11.5 centimeters (4.5 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 11 centimeters (4.3 inches) in width. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 1 and 11 o'clock positions. The deployed driver's air bag was round with a diameter of 66 centimeters (26.0 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 not determined. An inspection of the driver's air bag fabric revealed no contact evidence readily apparent on the air bag's fabric (**Figure 15**).

Figure 15: Case vehicle's deployed driver air bag showing no obvious evidence of occupant contact (case photo #38)

The front right passenger's advanced air bag was located in the middle of the instrument panel. This air bag did not deploy in this crash (**Figures 13** and **14** above).

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, vehicle's speed and brake switch status for the five recorded sample periods preceding the **ALGORITHM ENABLE**, ignition cycles at deployment, time from algorithm enable to deployment (i.e., air bag deployments) for the system's first stage, time from algorithm enable to maximum **SDM** (i.e., ***SENSING AND DIAGNOSTIC MODULE***) recorded velocity change, and velocity change (i.e., Delta V). Downloaded data of interest indicated the following. At the 5th sample period prior to algorithm enable the case vehicle was traveling at a speed of 50 km.p.h. (31 m.p.h.) and the brake was activated. In this contractor's opinion, this reflects the driver's approach in the left hand turn lane for the signalized intersection. The driver was braking into the intersection and possibly during the initial phase of his left-hand turn. As a result the vehicle was decelerating. Between the 3rd and 2nd sample periods prior to algorithm enable, the driver deactivated the brake and the vehicle began to pick up speed. In our opinion, this most likely occurred during the end phase of the left-hand turn when the driver began to straighten out the vehicle. The driver's seat belt status showed it was buckled, the second stage of the multi-stage air bags was not activated, and the Delta V reached a value of 26.44 km.p.h. (16.43 m.p.h.) at the 140 millisecond mark of recorded data; see **EVENT DATA RECORDER DATA** (**Figures 19** through **21**) below. This contractor believes that the recorded Delta V seems reasonable considering the amount of deformation to the case vehicle's front. It should also be noted that the case vehicle's **EDR** recorded a non-deployment event; however, this event occurred approximately 200 ignition cycles prior to this crash. This near deployment obviously was not part of this crash, but the recorded data are included; see **EVENT DATA RECORDER DATA** (**Figures 22** through **24**) below.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [44-year-old, White (non-Hispanic) male; 173 centimeters and 64 kilograms (68 inches, 140 pounds)] was seated in a slightly reclined posture with his back against the seat back, his left foot on the floor, his right foot on the accelerator, and both hands on the steering wheel; although, the exact position of his hands is unknown. According to the case vehicle's driver, his seat track was located in its middle position, the seat back was slightly reclined, and 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. Furthermore, according to the driver, there was evidence of belt pattern bruising and/or abrasions to the driver's torso, and the inspection of the driver's seat belt webbing and latch plate showed trace evidence (i.e., minor stretch marks) of loading on the belt's webbing (**Figure 16**).

Figure 16: Loading evidence (i.e., wear mark) on webbing of case vehicle's drivers seat belt (case photo #34)

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the use of his available safety belts, his pre-impact body position did not change significantly just prior to impact. Since the driver was completing a left-hand turn, his torso position may have moved very slightly to his left because he was leaning into the turn just prior to impact. The case vehicle's impact with the BMW enabled the case vehicle's driver to continue forward, slightly upward, and rightward along a path opposite the case vehicle's **30** degree Direction of Principal Force as the case vehicle decelerated. As a result of the crash, the driver loaded his safety belts and contacted his deploying driver air bag. These restraints limited the driver's motion toward the one o'clock direction. When the case vehicle reached maximum engagement, the case vehicle began to rotate counterclockwise. As a result the driver moved rightward but, once again, his safety belts restricted and limited this movement. As the vehicle moved in a south-southeasterly direction, the driver most likely rebounded backwards toward his original seating position. As the vehicle came to rest, the driver moved forward once again, but his safety belts limited this motion. The exact posture of the case vehicle's driver at final rest is unknown, but he was most likely seated near his original pre-crash position. According to his interview, the driver exited the vehicle without assistance.

CASE VEHICLE DRIVER INJURIES

The driver was not transported by ambulance to a hospital and, according to his interview, he did not seek any follow-up medical treatment beyond the treatment that was administered at the crash scene by paramedics. According to his interview, the driver sustained minor soft tissue contusions to his left upper chest/shoulder area as well as a "V" shaped bruise over his lower sternum.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion {bruise}"V-shaped", 7.6 cm (3 in) over lower sternum	minor 490402.1,4	Torso portion of safety belt system	Probable	Interviewee (same person)
2	Contusion {bruise}, 7.6 to 10.2 cm (3-4 in), left upper chest/shoulder area	minor 790402.1,2	Torso portion of safety belt system	Certain	Interviewee (same person)

OTHER VEHICLE

Based on the VIN and manufacturer's specifications, the 1986 BMW 325es was a rear wheel drive, five-passenger, two-door coupe (VIN: WBAAB5403G9------) equipped with a 2.7L, I-6 engine and a five-speed manual transmission. The BMW's wheelbase was 257 centimeters (101.2 inches), and the odometer reading is unknown because the BMW's interior was not inspected. The BMW was not equipped with anti-lock brakes or supplemental restraint systems (air bags). Based on the available information, the vehicle was equipped with manual, three-point, lap-and-shoulder, safety belt systems for the front and back outboard seating positions. The back center seat had a manual, two-point, lap belt. Standard interior equipment included bucket seats for the driver and front right passenger, and a non-adjustable back bench seat.

Exterior Damage: The BMW's contact with the case vehicle involved its left side (**Figures 6** and **7** above). Direct damage began 28 centimeters (11.0 inches) forward of the left rear axle and extended 283 centimeters (111.4 inches) forward, along the left side. The Field "L" began 23 centimeters (9.1 inches) forward of the left rear axle and extend 288 centimeters (113.4 inches) towards the vehicle's front. Residual maximum crush was measured as 40 centimeters (15.7 inches) at C_4 (**Figures 17** and **18** below). The table below shows the BMW's crush profile.

Figure 17: Overhead view of frontal portion of BMW's left side damage with contour gauge positioned above the sill (case photo #47)

Figure 18: Overhead view of middle portion of BMW's left side impact with contour gauge positioned above the sill (case photo #48)

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								$\pm D$	$\pm D$
cm	1	283	40	288	1	24	30	40	18	9	49	47
in		111.4	15.7	113.4	0.4	9.4	11.8	15.7	7.1	3.5	19.3	18.5

The wheelbase on the BMW's left side was shortened 17 centimeters (6.7 inches) while the right side was extended approximately 1 centimeter (0.4 inches). The BMW's left fender, left front door, left "A"-pillar, and left quarter panel were directly damaged and crushed inward.

The recommended tire size was: P195/65HR14, and the BMW's tires were the recommended size. The BMW's tire data are shown in the table below. In addition, the BMW's left front tire was rotated inward from the crash.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	0	0	214	31	4	5	Sidewall puncture	No	Yes
RF	221	32	214	31	5	6	None	No	No
LR	248	36	214	31	6	8	None	No	No
RR	248	36	214	31	7	9	None	No	No

Damage Classification: Based on the vehicle inspection, the CDC for the BMW was determined to be: **10-LYAW-3** (**300** degrees). The WinSMASH reconstruction program, damage only algorithm, was used on the BMW's highest severity impact. The Total, Longitudinal, and Lateral

Delta Vs are, respectively: 42.4 km.p.h. (26.3 m.p.h.), -21.2 km.p.h. (-13.2 m.p.h.), and +36.7 km.p.h. (+22.8 m.p.h.). The BMW was towed due to damage.

BMW's Occupants: According to the Police Crash Report, the BMW's driver [22-year-old, White (unknown if Hispanic) male] was restrained by his available, active, three-point, lap-and-shoulder, safety belt systems. The driver was transported by ambulance to the hospital; however, his treatment status is unknown. He sustained police-reported "B" (non-incapacitating-evident) injuries, but the exact nature of these injuries are unknown.

1GCEC14X93Z	System Status At Deployment
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	1205
Ignition Cycles At Investigation	1208
Maximum SDM Recorded Velocity Change (MPH)	-16.84
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	185
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	40
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)	-0.62	-1.55	-2.48	-4.03	-5.58	-7.75	-9.30	-10.54	-12.09	-13.02	-13.64	-14.88	-15.50	-16.43	N/A

PRE-CRASH DATA

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	31	896	0	ON
-4	29	832	0	ON
-3	22	768	0	ON
-2	21	896	0	OFF
-1	22	1472	20	OFF

Figure 19: 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 140 milliseconds post deployment

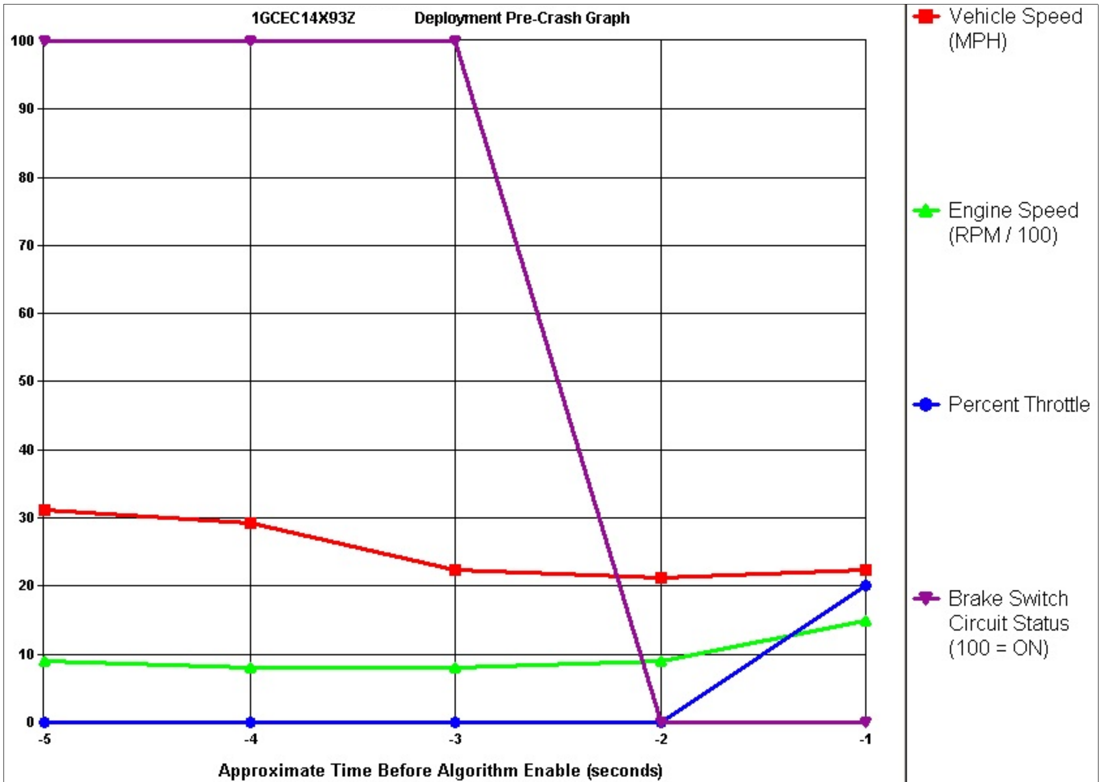


Figure 20: Case vehicle's pre-crash speed and brake switch circuit status showing that the vehicle's speed was recorded at 50 km.p.h. (31 m.p.h.) with the brake activated at approximately 5 seconds prior to algorithm enable and that the brake switch had been deactivated between the third and second recorded sample periods prior to algorithm enable.

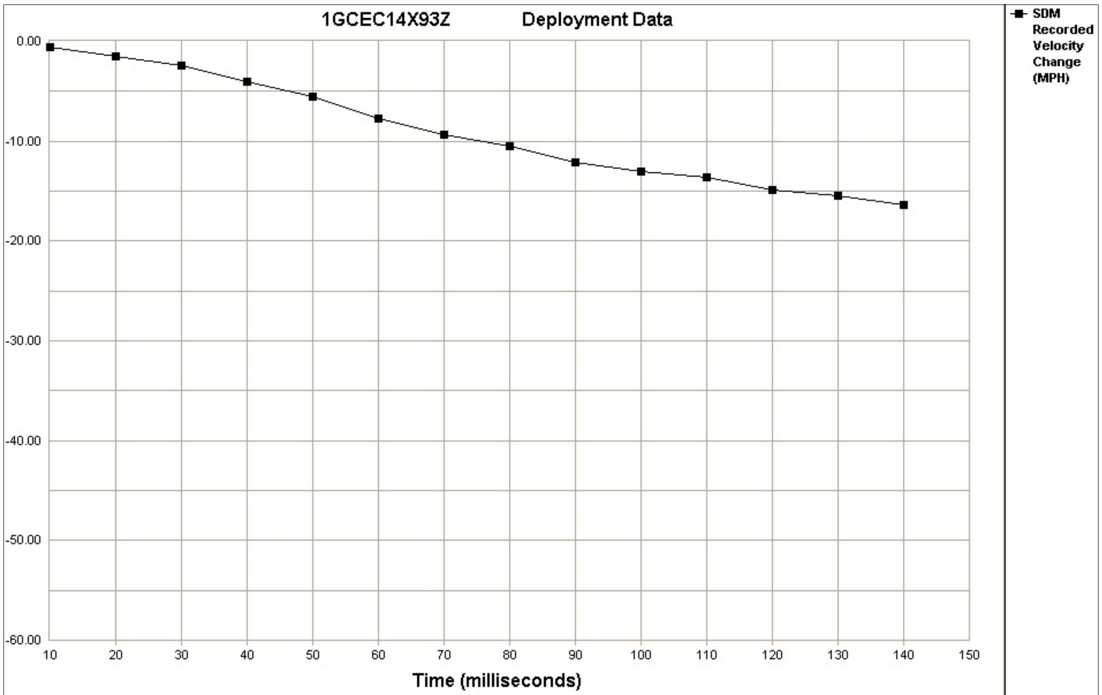


Figure 21: The case vehicle sustained a velocity change of approximately 26.4 km.p.h. (16.4 m.p.h.) during the first 140 milliseconds after the algorithm was enabled; maximum velocity change was recorded as 27.1 km.p.h. (16.8 m.p.h.) at 185 milliseconds

1GCEC14X93Z	System Status At Non-Deployment
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Non-Deployment	1001
Ignition Cycles At Investigation	1208
Maximum SDM Recorded Velocity Change (MPH)	0.00
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	0
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	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	0	0	0	OFF
-4	0	0	0	OFF
-3	0	0	0	OFF
-2	0	0	0	OFF
-1	0	0	0	OFF

Figure 22: Case vehicle's non-deployment data including: pre-crash speed, brake switch status, restraint system status, time (in milliseconds) from algorithm enable to maximum SDM recorded velocity, and the case vehicle's change in velocity (Delta V) over the first 100 milliseconds post algorithm enablement

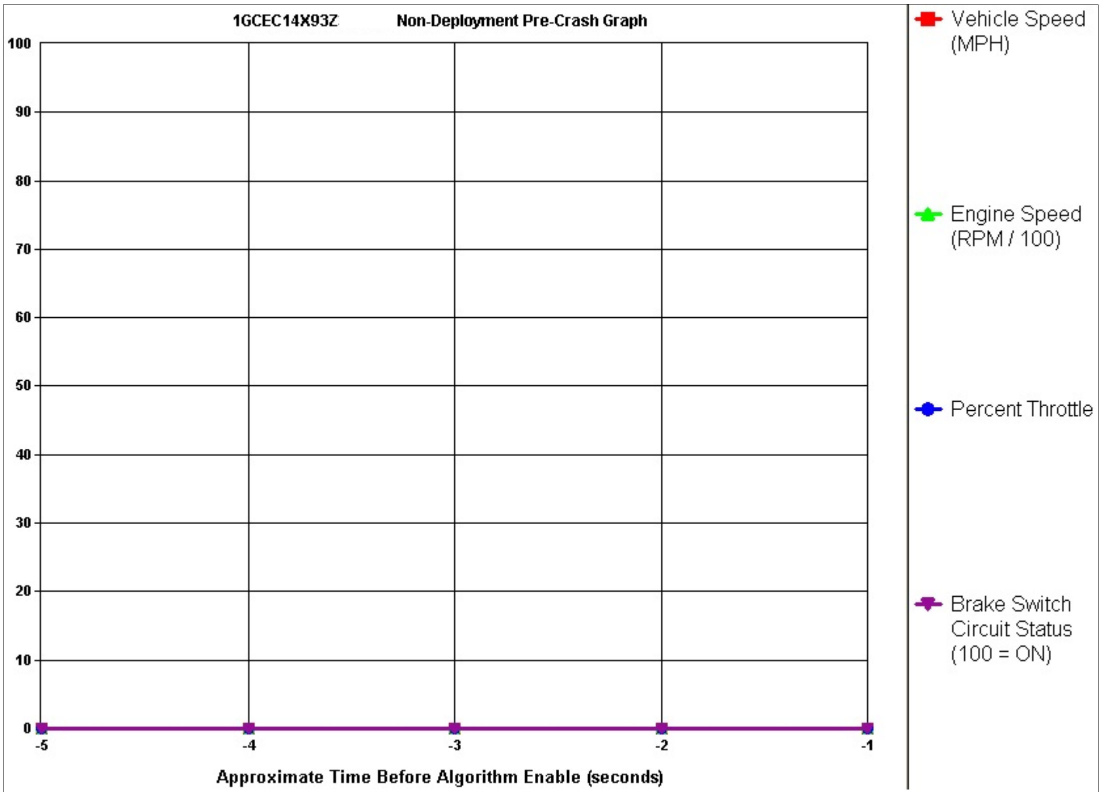


Figure 23: Case vehicle's pre-crash speed and brake switch circuit status showing that the vehicle's speed was recorded at 0 km.p.h. (0 m.p.h.) and that the brake switch had not been activated during the five recorded sample periods.

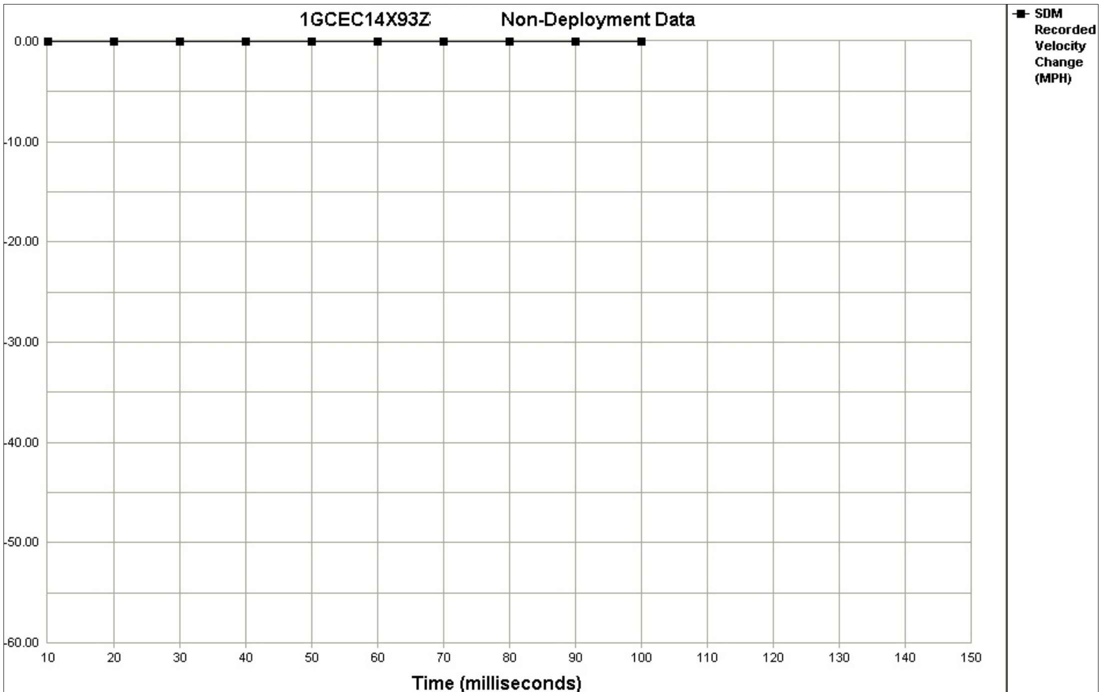
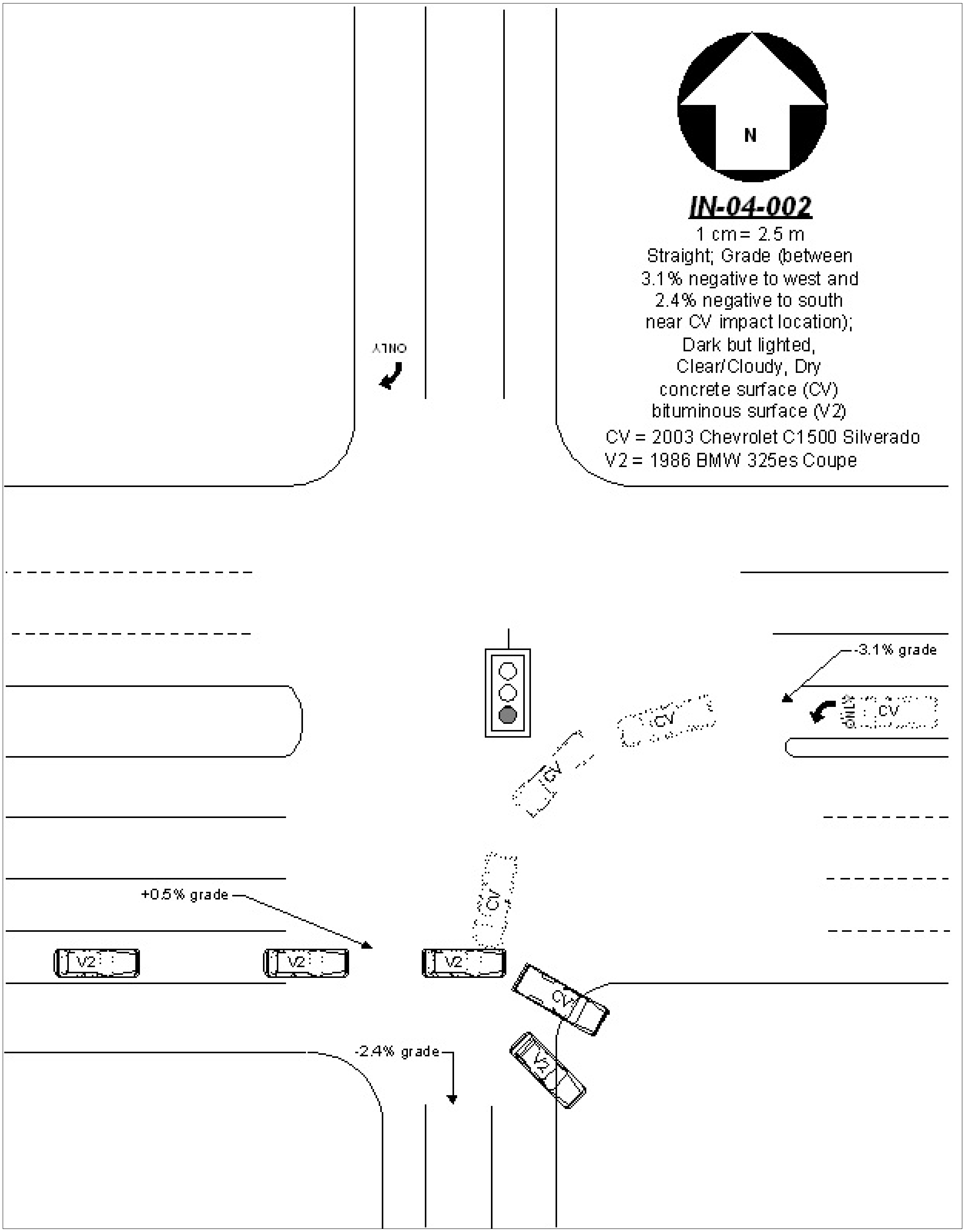


Figure 24: The case vehicle sustained a velocity change of approximately 0.0 km.p.h. (0.0 m.p.h.) during the first 100 milliseconds after the algorithm was enabled; maximum velocity change was recorded as 0.0 km.p.h. (0.0 m.p.h.) at algorithm enable (i.e., 0 milliseconds)


N
IN-04-002
1 cm = 2.5 m
Straight; Grade (between
3.1% negative to west and
2.4% negative to south
near CV impact location);
Dark but lighted,
Clear/Cloudy, Dry
concrete surface (CV)
bituminous surface (V2)
CV = 2003 Chevrolet C1500 Silverado
V2 = 1986 BMW 325es Coupe
ONLY
-3.1% grade
ONLY
CV
CV
CV
CV
CV
+0.5% grade
V2
V2
V2
V2
-2.4% grade