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ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-05-028
LOCATION - MICHIGAN
VEHICLE - 2003 CHEVROLET SUBURBAN
CRASH DATE - July 2005

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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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16. *Abstract* This report covers an on-site investigation of an air bag deployment crash that involved a 2003 Chevrolet Suburban (case vehicle) and a 2001 Chevrolet Silverado K2500 pickup truck (other vehicle), which collided head-on on a two-lane state highway. This crash is of special interest because the case vehicle was equipped with multiple Advanced 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 unrestrained driver [52-year-old, White (non-Hispanic) male] sustained a police reported “B” (non-incapacitating) injury as a result of the crash. The case vehicle was traveling west in the westbound lane at an EDR indicated speed of 97 km.p.h. (60 m.p.h.). The Silverado was traveling east in the eastbound lane and turned left across the path of the case vehicle intending to enter a private driveway. The front of the case vehicle impacted the front of the Silverado causing both stages of the case vehicle’s driver air bag to deploy. The case vehicle’s front right air bag did not deploy because there was no passenger seated in the front right seat. The impact caused the case vehicle to rotate clockwise and the Silverado rotated counterclockwise. The Silverado's front right bumper corner then impacted the case vehicle’s left front door. The case vehicle most likely came to final rest facing northwest either totally or partially on the north shoulder. The Silverado rotated counterclockwise and most likely came to final rest facing northwest across both travel lanes. The case vehicle’s driver was unrestrained. He sustained a nonanatomic brain injury from impacting the windshield, as well as multiple lacerations, contusions and abrasions. The case vehicle’s driver was transported by ambulance to a local hospital and was treated and released.			
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TABLE OF CONTENTS

Page No.

BACKGROUND 1

SUMMARY 1

CRASH CIRCUMSTANCES 2

CASE VEHICLE: 2003 CHEVROLET SUBURBAN 4
- CASE VEHICLE DAMAGE 4
- AUTOMATIC RESTRAINT SYSTEM 6
- CRASH DATA RECORDING 7
- CASE VEHICLE DRIVER KINEMATICS 8
- CASE VEHICLE DRIVER INJURIES 9

OTHER VEHICLE: 2001 CHEVROLET SILVERADO K2500 10

EVENT DATA RECORDER DATA 11

CRASH DIAGRAM 16

This investigation was brought to NHTSA's attention on or before August 19, 2005 by the Nationwide Insurance Company. This crash involved a 2003 Chevrolet Suburban (case vehicle) and a 2001 Chevrolet Silverado K2500 pickup truck (other vehicle). The crash occurred in July 2005, at 4:21 p.m., in Michigan and was investigated by the county sheriff department. This crash is of special interest because the supplemental restraint (air bag) system in the Chevrolet Suburban is certified by the manufacturer to be compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Standard (FMVSS) No. 208. The case vehicle was also equipped with an Event Data Recorder (EDR), and the unrestrained driver [52-year-old, White (non-Hispanic) male] sustained a police reported "B" (non-incapacitating) injury as a result of the crash. This contractor inspected the case vehicle and harvested the air bag Sensing and Diagnostic Module (SDM), which contains the EDR, on September 13, 2005. The scene inspection was completed on September 14, 2005, and this contractor interviewed the driver on September 27, 2005. The Silverado was not inspected. This report is based on the police crash report, scene and vehicle inspections, the EDR data, driver medical records, an interview with the case vehicle's driver, occupant kinematic principles and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling west in the westbound lane of a two-lane state highway at an EDR indicated speed of 97 km.p.h. (60 m.p.h.). The Silverado was traveling east in the eastbound lane and turned left across the path of the case vehicle intending to enter a private driveway. The front of the case vehicle impacted the front of the Silverado causing both stages of the case vehicle's driver air bag to deploy. The case vehicle's front right air bag did not deploy because there was no passenger seated in the front right seat. The impact caused the case vehicle to rotate clockwise and the Silverado rotated counterclockwise. The Silverado's front right bumper corner then impacted the case vehicle's left front door. The case vehicle most likely came to final rest facing northwest either totally or partially on the north shoulder. The Silverado rotated counterclockwise and most likely came to final rest facing northwest across both travel lanes.

The CDCs for the case vehicle were determined to be: **12-FYEW-3** (**350** degrees) for the initial impact with the Silverado and **09-LPMW-2** (**280** degrees) for the secondary impact to the left front door. The maximum residual front crush was measured as 68 centimeters (26.8 inches) The WinSMASH reconstruction program, missing vehicle algorithm, calculated the case vehicle's Total, Longitudinal, and Lateral Delta Vs respectively as: 47 km.p.h. (29.2 m.p.h.), -46.3 km.p.h. (28.8 m.p.h.), and 8.2 km.p.h. (5.1 m.p.h.). In addition, the EDR data indicated that the case vehicle sustained a maximum longitudinal Delta V of -50.70 km.p.h. (-31.50 m.p.h.) occurring 150 milliseconds after algorithm enable. The case vehicle was towed due to damage.

A CDC could not be determined for the Silverado because it was not inspected, and there were no available photographs of the damaged vehicle. The WinSMASH reconstruction program, missing vehicle algorithm, calculated the Silverado's Total, Longitudinal, and Lateral Delta Vs for the front impact respectively as: 42.0 km.p.h. (26.1 m.p.h.), -41.4 km.p.h. (25.7 m.p.h.), and -7.3 km.p.h. (4.5 m.p.h.). The Silverado was towed due to damage.

Immediately prior to the crash the case vehicle's driver was seated upright, but leaning to the right. His back was against the seat back, his feet were on the floor, his right hand was on the steering wheel and his left arm was on the driver's door arm rest. His seat track was located between its middle and rearmost positions, the seat back was slightly reclined and the tilt steering column was located in its center position. The driver was not restrained by his integrated, three-point, lap-and-shoulder safety belt. In addition, the driver was not wearing glasses or contact lenses at the time of the crash.

The case vehicle's driver made no known pre-crash avoidance maneuvers. His pre-impact body position most likely did not significantly change just prior to impact. The case vehicle's impact with the Silverado caused the driver to continue forward and slightly leftward along a path opposite the case vehicle's 350 degree direction of principal force as the case vehicle decelerated. Both of the driver's knees and lower legs impacted his knee bolster causing multiple abrasions, contusions and lacerations. His face and chest impacted his deployed air bag causing a contusion and abrasion to his nose and a contusion to his chin. He rode down the air bag, loaded the steering assembly and traveled over and to the left of the air bag and impacted his head on the windshield causing a nonanatomic brain injury, as well as a large laceration to the left side of his head and a "spider-web" fracture pattern to the windshield. It appeared his left shoulder also impacted the left "A"-pillar displacing the "A"-pillar cover to the left and bruising his shoulder. The driver's left forearm impacted the instrument panel lacerating the forearm, his right arm impacted the instrument panel bruising both the forearm and upper arm. The driver then moved to the left opposite the case vehicle's 280 degree direction of principal force as the Silverado's front right bumper corner impacted the driver's door. As a result, the driver's left arm and left thigh most likely impacted the left front door. The driver then moved back into his seat and remained in his seat at the case vehicle came to final rest. The driver was removed from the case vehicle by rescue personnel and transported to a local hospital where he was treated and released. The deployment of the driver's air bag mitigated his interaction with the steering assembly and reduced his injury potential.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was a two-lane, undivided, state highway, traversing in an east-west direction. Each travel lane was 3.7 meters (12 feet) in width. Each side of the roadway was bordered by gravel shoulders approximately 2.5 meters (8.2 feet) in width. Roadway pavement marking consisted of solid white edge lines and broken white center lines. At the time of the crash the light condition was daylight, the atmospheric condition was rain, and the roadway pavement was wet bituminous with an estimated coefficient of friction of 0.60. In addition, the roadway had a 1.3% positive grade in the case vehicle's direction of travel. Traffic density was light, the speed limit was 89 km.p.h. (55 m.p.h.), and the site of the crash was rural residential. See the Crash Diagram at end of this report.

Pre-Crash: The case vehicle was traveling west in the westbound lane (**Figure 1** below), and the driver was intending to continue straight ahead. The EDR data indicated that the case vehicle's travel speed just prior to the crash was 97 km.p.h. (60 m.p.h.). The Silverado was traveling east

in the eastbound lane (**Figure 2**) and was in the process of turning left into a private driveway. The crash occurred in the westbound lane of the roadway.

Figure 1: Approach of case vehicle westbound to impact, red arrow shows impact area, green arrow shows driveway Silverado was turning into

Figure 2: Approach of V2 eastbound turning left into driveway, arrow shows impact gouge

Figure 3: Damage to front of case vehicle from impact with front of Silverado, each increment on rods is 5 cm (2 in)

Figure 4: Overview of damage to left front door from impact with front right bumper corner of Silverado

Crash: The front of the case vehicle (**Figure 3**) impacted the front of the Silverado causing both stages of the case vehicle's driver air bag to deploy. The case vehicle's front right air bag did not deploy because there was no passenger seated in the front right seat. The case vehicle's front right occupant detection system properly determined the absence of an occupant and suppressed deployment of the front right air bag. The impact caused the case vehicle to rotate clockwise and the Silverado rotated counterclockwise. The damage to the case vehicle's left front door indicated that the Silverado's front right bumper corner then impacted the case vehicle's left front door (**Figure 4**).

Post-Crash: The final rest positions of the case vehicle and the Silverado are not known. There was no scene evidence of the final rest positions. In addition, the police crash schematic showed no rest position for either vehicle. Based on the damage to the case vehicle and the gouge found in the roadway, the case vehicle rotated slightly clockwise and traveled northwest to final rest.

It is likely that the case vehicle came to final rest facing northwest either totally or partially on the north shoulder. The Silverado rotated counterclockwise and most likely came to final rest facing northwest across both travel lanes.

CASE VEHICLE

The 2003 Chevrolet Suburban was a four wheel drive, four-door multi-purpose vehicle (VIN: 3GNFK16Z93G------). The case vehicle was equipped with a 5.3 L, V8 engine; 4-speed automatic transmission with overdrive and four wheel, anti-lock brakes. The front seating row was equipped with driver and passenger bucket seats with adjustable head restraints, integrated lap-and-shoulder safety belts with seat belt usage sensors; knee bolsters, dual stage driver and front right passenger air bags and front seat back-mounted side impact air bags. The back seating row was equipped with a split bench seat with manual, lap-and-shoulder safety belts; adjustable head restraints in the outboard positions and an integrated, lap-and-shoulder safety belt and an integral head restraint in the center seat position. In addition, the back seat was equipped with a LATCH system for securing child safety seats. The case vehicle's wheelbase was 330 centimeters (129.9 inches). The odometer reading at the time of the inspection is unknown because the vehicle was equipped with an electronic odometer. The driver estimated the case vehicle's odometer reading was approximately 117,482 (73,000 miles) at the time of the crash.

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 safety belt usage to determine the front air bag inflation level appropriate for the severity of the crash. For the front right seat, 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).

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's initial impact with the Silverado involved approximately two thirds of the frontal plane (**Figure 5**). The case vehicle's front bumper, bumper fascia, grille, radiator, left fender, left turn lamp and headlamp assemblies and hood were directly damaged and crushed rearward. Direct damage began at the left front bumper corner and extended 122 centimeters (48 inches), along the front bumper. Residual maximum crush was measured as 68 centimeters

Figure 5: Overview of damage to case vehicle from front right corner

(26.8 inches) occurring at C_2. The secondary impact with the front bumper of the Silverado involved the case vehicle's left front door. The direct damage involved the lower center portion of the left front door. The left front door sheet metal was crushed inward and the door buckled. The table below shows the case vehicle's front crush profile.

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	1	122	68	153	53	68	52	40	21	3	-15	0
in		48.0	26.8	60.2	20.9	26.8	20.5	15.7	8.3	1.2	-5.9	0.0

The case vehicle's left side wheelbase was reduced 20 centimeters (7.9 inches) while the right side wheelbase was unaltered by the crash. Induced damage involved portions of the bumper, hood, left fender and left front door as well as the right fender, windshield and forward portion of the roof and left "A"-pillar. The left front door was jammed closed due to the front impact and was pried open by rescue personnel.

The recommended tire size was: P265/70R17, and the case vehicle was equipped with tires of this 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	Flat	Flat	207	30	5	6	Unknown	Yes	Yes
RF	221	32	207	30	6	8	None	No	No
LR	228	33	207	30	5	6	None	No	No
RR	228	33	207	30	6	8	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior (**Figure 6** and **Figure 7** below) revealed evidence of occupant contact on the left windshield , left "A"-pillar, driver's knee bolster, and the ignition key was bent forward. Two intrusions were documented to the driver's occupant space. The toe pan intruded longitudinally 4 centimeters (1.6 inches) and the front left instrument panel cover was dislodged and intruded longitudinally 3 centimeters (1.2 inches). There was no deformation of the steering wheel rim (**Figure 8** below), but the entire steering wheel was tilted forward slightly at the top and the energy absorbing steering column appeared to be slightly compressed.

Damage Classification: Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FYEW-3** (**350** degrees) for the initial impact with the Silverado and **09-**

LPMW-2 (**280** degrees) for the secondary impact to the left front door. The WinSMASH reconstruction program, missing vehicle algorithm, was used to determine the case vehicle's Delta Vs for the front impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 47 km.p.h. (29.2 m.p.h.), -46.3 km.p.h. (28.8 m.p.h.), and 8.2 km.p.h. (5.1 m.p.h.). In addition, the EDR data indicated that the case vehicle sustained a maximum longitudinal Delta V of -50.70 km.p.h. (-31.50 m.p.h.) occurring 150 milliseconds after algorithm enable. The case vehicle was towed due to damage.

Figure 6: Overview of steering wheel, windshield and instrument panel

AUTOMATIC RESTRAINT SYSTEM

The case vehicle's driver air bag was located in the steering wheel hub. Prior to this contractor's inspection, the air bag had been cut from the air bag module. From what was left, it could be determined that the cover flaps opened at the designated tear points (**Figure 9** below), and there was no evidence of damage during the deployment to the cover flaps. The module cover consisted of symmetrical "I"-configuration cover flaps made of pliable vinyl. Each cover flap was 7 centimeters (2.8 inches) in width at the top and 5 centimeters (2 inches) in width at the bottom. In addition, each flap was 11 centimeters (4.3 inches) in height as measured along the center, vertical tear seam. Due to the removal of the air bag's fabric no information regarding the air bag or the vent ports could be obtained. However, it was determined that there were two tethers, each measuring 9 centimeters (3.5 inches) in width. It is unknown if there was any damage to the air bag's fabric. However, the driver was unrestrained and his kinematics indicate that he impacted the air bag during the crash.

Figure 7: Case vehicle's steering wheel and left and center instrument panel and windshield

Figure 8: Left side view of steering wheel and steering column

The front right air bag was located in the middle of the instrument panel (**Figure 10** below) and did not deploy as a result of this crash. The case vehicle's front right occupant detection system properly determined the absence of an occupant and suppressed deployment of the front right air bag.

The seat back-mounted side impact air bags were located in the outboard side of the driver and front right passenger's seat. The driver's side impact air bag did not deploy because the impact to the left front door was most likely not severe enough to require its deployment.

Figure 9: Driver's air bag module flaps, steering wheel is rotated counterclockwise approximately 140 degrees

Figure 10: Overview of front right instrument panel, arrow shows location of front right passenger's air bag

CRASH DATA RECORDING

The case vehicle's SDM was harvested from the vehicle, and the EDR download was completed subsequent to the vehicle inspection. The downloaded data indicated that a non-deployment and a deployment event were recorded. The EDR reports for both events are presented in **Figures 13-20** at the end of this report. The non-deployment event was most likely associated with the secondary impact to the case vehicle's left front door. The pre-crash data for this event indicates that one additional time increment of pre-crash data was recorded [i.e., at 1 second prior to algorithm enable (AE)] in addition to that recorded for the deployment event (i.e., the pre-crash data for -1 to -4 seconds prior to AE for the deployment event are identical to the pre-crash data for-2 to -5 seconds prior to AE for the non-deploy event). The non-deployment pre-crash data indicated that the brake switch circuit was on at 1 second prior to AE. This could indicate inertial actuation of the brake switch due to the initial impact, contact of the brake pedal by the driver during the impact, or the driver may have applied the brakes less than one second prior to the impact.

The EDR data show that the SIR warning lamp was recorded off, and the driver's seat belt switch circuit was recorded unbuckled. In addition, the maximum SDM recorded longitudinal velocity change for the deployment event was recorded as -50.7 km.p.h. (-31.51 m.p.h.) occurring 150 milliseconds after AE. The driver's air bag deployment was commanded at approximately 10 milliseconds after AE. The maximum SDM recorded longitudinal velocity change for the non-deployment event was recorded as -0.43 km.p.h. (-0.69 m.p.h.) occurring 100 milliseconds after AE. The system status report for the deployment event shows that the first stage deployment criteria was met 5 milliseconds after AE, the second stage deployment criteria was met at 7.5 milliseconds after AE and deployment of the front right passenger air bag was suppressed. Lastly, the pre-crash data indicate that the case vehicle was traveling (60 m.p.h.) prior to the crash.

Immediately prior to the crash the case vehicle's driver [52-year-old, White (non-Hispanic) male; 188 centimeters and 88 kilograms (74 inches, 195 pounds)] was seated upright, but leaning to the right. His back was against the seat back, his feet were on the floor, his right hand was on the steering wheel and his left arm was on the driver's door arm rest. His seat track was located between its middle and rearmost positions, the seat back was slightly reclined, and the tilt steering column was located in its center position. In addition, the driver was not wearing glasses or contact lenses at the time of the crash.

Figure 11: Overview of driver contacts to windshield (arrow), left "A"-pillar and knee bolster

Based on this contractor's vehicle inspection and supported by the EDR data, the case vehicle's driver was not using his integrated, three-point, lap-and-shoulder safety belt system. Inspection of the seat belt assembly showed no evidence of loading. In addition, the vehicle inspection showed that the driver impacted his head on the windshield adjacent to the left "A"-pillar (**Figure 11**).

Figure 12: Displaced knee bolster, contacted by driver's knees

The case vehicle's driver made no known pre-crash avoidance maneuvers. His pre-impact body position most likely did not change significantly just prior to impact. The case vehicle's impact with the Silverado caused the driver to continue forward and slightly leftward along a path opposite the case vehicle's 350 degree direction of principal force as the case vehicle decelerated. Both of the driver's knees and lower legs impacted his knee bolster (**Figure 12**) causing multiple abrasions, contusions and lacerations. His face and chest impacted his deployed air bag causing a contusion and abrasion to his nose and a contusion to his chin. He rode down the air bag, loaded the steering assembly and traveled over and to the left of the air bag and impacted his head on the windshield causing a nonanatomic brain injury, as well as a large laceration to the left side of his head and a "spider-web" fracture pattern to the windshield. It appeared his left shoulder also impacted the left "A"-pillar displacing the "A"-pillar cover to the left and bruising the shoulder. The driver's left forearm impacted the instrument panel lacerating the forearm. His right arm impacted the instrument panel bruising both the forearm and upper

arm. The driver then moved to the left opposite the case vehicle's 280 degree direction of principal force as the Silverado's front right bumper corner impacted the driver's door. As a result, the driver's left arm and left thigh most likely impacted the door. The driver then moved back into his seat and remained in his seat at the case vehicle came to final rest. The driver's door was pried open and he was removed from the case vehicle by rescue personnel. The deployment of the driver's air bag mitigated his interaction with the steering assembly and reduced his chest injury potential.

CASE VEHICLE DRIVER INJURIES

The driver sustained police reported "B" (non-incapacitating) injuries and was transported by ambulance to a local hospital where he was treated and released. The driver received follow-up treatment, but no additional injuries were diagnosed. The driver had not returned to work as of the date of this contractor's interview (i.e., September 27, 2005). The total number of lost work days due to the crash is not known.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with amnesia, possible loss of con-sciousness	moderate 160410.2,0	Front left windshield's glazing	Certain	Emergency room records
2	Laceration, large, 6 to 10 cm (2.4 to 3.9 in), left anterior scalp, "fishhook-shaped", involving subcutaneous tissue {full thick-ness}	minor 190602.1,5	Front left windshield's glazing	Certain	Emergency room records
3	Abrasion nose, upper lateral left side	minor 290202.1,4	Air bag, driver's	Probable	Emergency room records
4	Contusion {bruise} nose, not further specified	minor 290402.1,4	Air bag, driver's	Probable	Interviewee (same person)
5	Abrasion chin, not further specified	minor 290202.1,8	Air bag, driver's	Probable	Interviewee (same person)
6	Contusion {bruise}, 10.2 cm (4 in) on left shoulder, not further specified	minor 790402.1,2	Left "A"-pillar	Certain	Interviewee (same person)
7	Laceration, 5.1 cm (2 in) left forearm from elbow downward	minor 790602.1,2	Left instrument panel and below	Possible	Emergency room records
8	Contusion, large, right distal forearm and/or wrist area	minor 790402.1,1	Left instrument panel and below	Possible	Emergency room records
	Contusion, large, right upper arm and proximal forearm, not further specified				Interviewee (same person)

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
9	Abrasion left knee and proximal lower leg, not further specified	minor 890202.1,2	Knee bolster, driver's, left of steering column	Certain	Emergency room records
10	Abrasion right knee and leg {most likely proximal lower leg}, not further specified	minor 890202.1,1	Knee bolster, driver's, right of steering column	Certain	Emergency room records
11	Contusions {bruising} left and right knees and proximal shins	minor 890402.1,3	Knee bolster, driver's	Certain	Interviewee (same person)
12	Lacerations left knee and proximal lower leg, not further specified	minor 890600.1,2	Knee bolster, driver's, left of steering column	Certain	Emergency room records

OTHER VEHICLE

The 2001 Chevrolet K2500 Silverado was a four wheel drive, four-door pickup (VIN: 1GCHK23G01F------). The Silverado was equipped with redesigned driver and front right passenger air bags, which deployed as a result of this vehicle's impact.

Exterior Damage: A CDC could not be determined for the Silverado because it was not inspected, and there were no available photographs of the damaged vehicle. The WinSMASH reconstruction program, missing vehicle algorithm, was used to determine the Silverado's Delta Vs for the front impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 42.0 km.p.h. (26.1 m.p.h.), -41.4 km.p.h. (25.7 m.p.h.), and -7.3 km.p.h. (4.5 m.p.h.). The Silverado was towed due to damage.

Chevrolet's Occupants: According to the police crash report, the Silverado's driver [49-year-old, (unknown race and/or ethnic origin) male]; was restrained by his manual, three-point, lap-and-shoulder safety belt system. The driver was not transported by ambulance to the hospital, and did not sustain any police reported injuries as a result of this crash.

SDM Data Limitations

SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 250 times.
The second type of SDM recorded crash event is the Deployment Event. It also contains Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within 25.4 seconds of one another. Deployment Events cannot be overwritten or cleared from the SDM. Once the SDM has deployed the air bag, the SDM must be replaced.
The data in the Non-Deployment Event file will be locked after a Deployment Event, if the Non-Deployment Event occurred within 5 seconds before the Deployment Event. If multiple Non-Deployment Events occur within 5 seconds prior to a Deployment Event, then the most severe Non-Deployment Event will be recorded and locked. If multiple Non-Deployment Events precede a Deployment Event, and multiple Non-Deployment Events occur within 5 seconds of each other (but not necessarily all within 5 seconds of the Deployment Event), and subsequent Non-Deployment Events are less severe than prior Non-Deployment Events, and the last of the multiple Non-Deployment Events occurs within 5 seconds of a Deployment Event, then the most severe of the Non-Deployment Events (which may have occurred more than 5 seconds prior to the Deployment Event) will be recorded and locked.

SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Forward Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. For Deployment Events and Deployment Level Events, the SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. For Non-Deployment Events, the SDM will record the first 150 milliseconds of data after algorithm enable.
-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.
-SDM Recorded Vehicle Speed accuracy can be affected if the vehicle has had the tire size or the final drive axle ratio changed from the factory build specifications.
-Brake Switch Circuit Status indicates the status of the brake switch circuit.
-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if the SDM receive an invalid message from the module sending the pre-crash data.
-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit. If the vehicle's electrical system is compromised during a crash, the state of the Belt Switch Circuit may be reported other than the actual state.
-The Time Between Non-Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than 25.4 seconds, "N/A" is displayed in place of the time.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-Multiple Events Associated with this Record: This parameter will indicate whether one or more associated events

Figure 13: Case vehicle's SDM Data Limitations

preceded the recorded event.
-One or More Associated Events Not Recorded: If a single event is recorded, this parameter will indicate whether one or more associated events, prior to the recorded event, was not recorded.
If two associated events are recorded, this parameter for the first event will indicate whether one or more associated events, prior to the first event, was not recorded.
If two associated events are recorded, this parameter, for the second event, will indicate whether one or more associated events, between the first and second events, was not recorded.

SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the vehicle's communication network, to the SDM.
-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the vehicle's communication network, to the SDM.
-The SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture. Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle's communication network.

Figure 14: Case Vehicle's SDM Data Limitations continued

3GNFK16Z93Gxxxxxx System Status At Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Deployment	4372
Ignition Cycles At Investigation	4375
Maximum SDM Recorded Velocity Change (MPH)	-31.51
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	150
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	5
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	7.5
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	Suppressed
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	Suppressed
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)	-1.55	-3.72	-6.20	-8.99	-12.40	-18.29	-22.63	-25.42	-27.59	-29.14	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	60	1664	25	OFF
-4	60	1664	20	OFF
-3	60	1664	25	OFF
-2	60	1664	25	OFF
-1	60	1664	30	OFF

Figure 15: Case vehicle's System Status at Deployment report

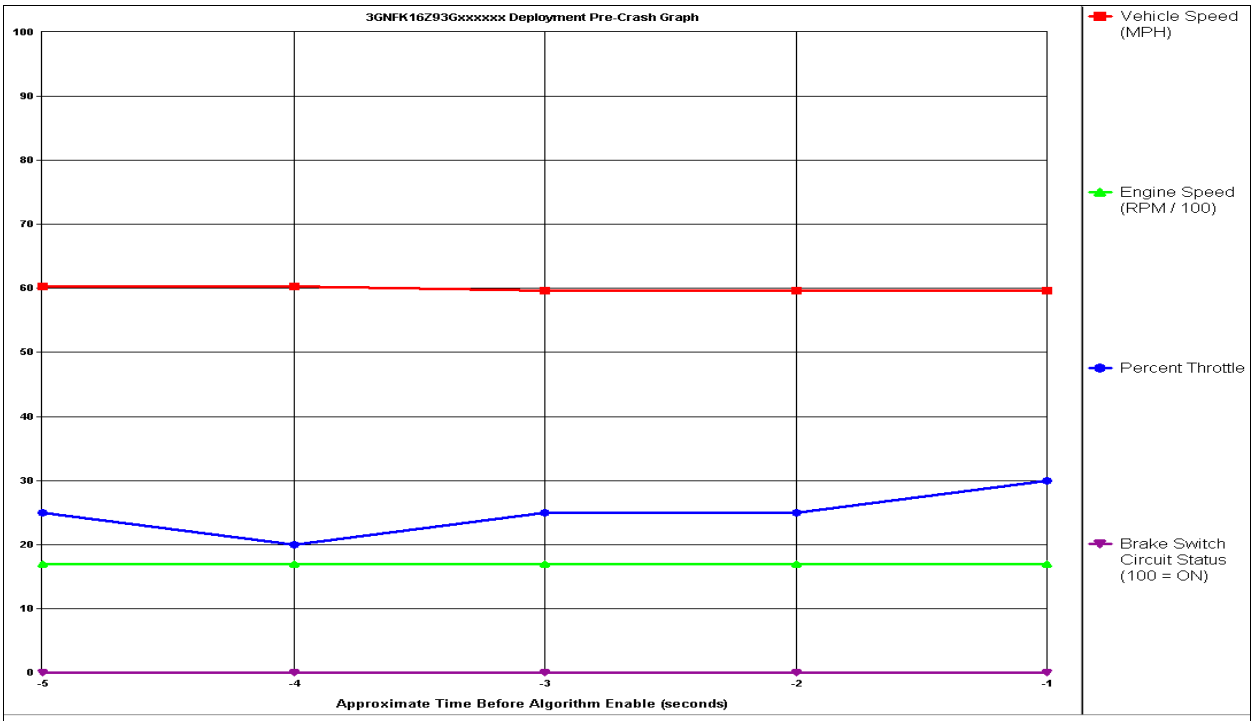


Figure 16: Case vehicle's Deployment Pre-Crash Graph

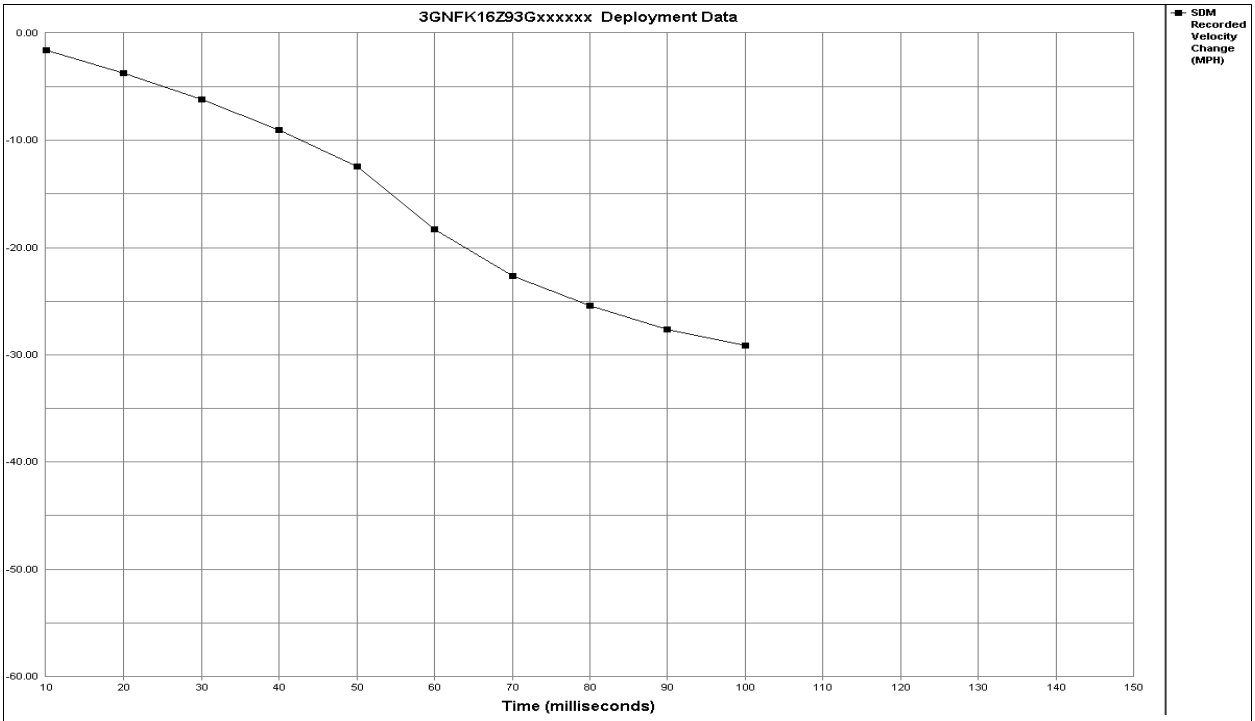


Figure 17: Case vehicle's deployment SDM Recorded Velocity Change graph

3GNFK16Z93Gxxxxxx System Status At Non-Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Non-Deployment	4372
Ignition Cycles At Investigation	4375
Maximum SDM Recorded Velocity Change (MPH)	-0.43
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	100
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	-0.31	-0.31	-0.31	-0.31	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	60	1664	20	OFF
-4	60	1664	25	OFF
-3	60	1664	25	OFF
-2	60	1664	30	OFF
-1	60	1600	0	ON

Figure 18: Case vehicle's System Status at Non-Deployment report

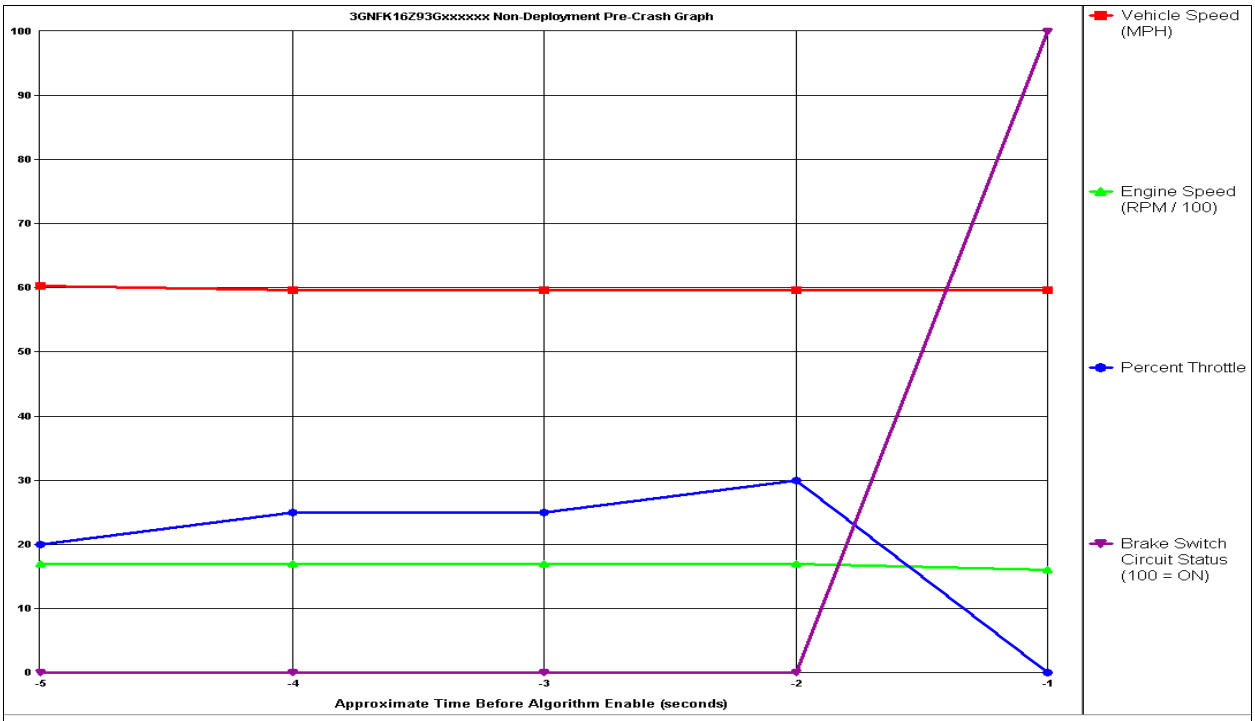


Figure 19: Case vehicle's Non-Deployment Pre-Crash Graph

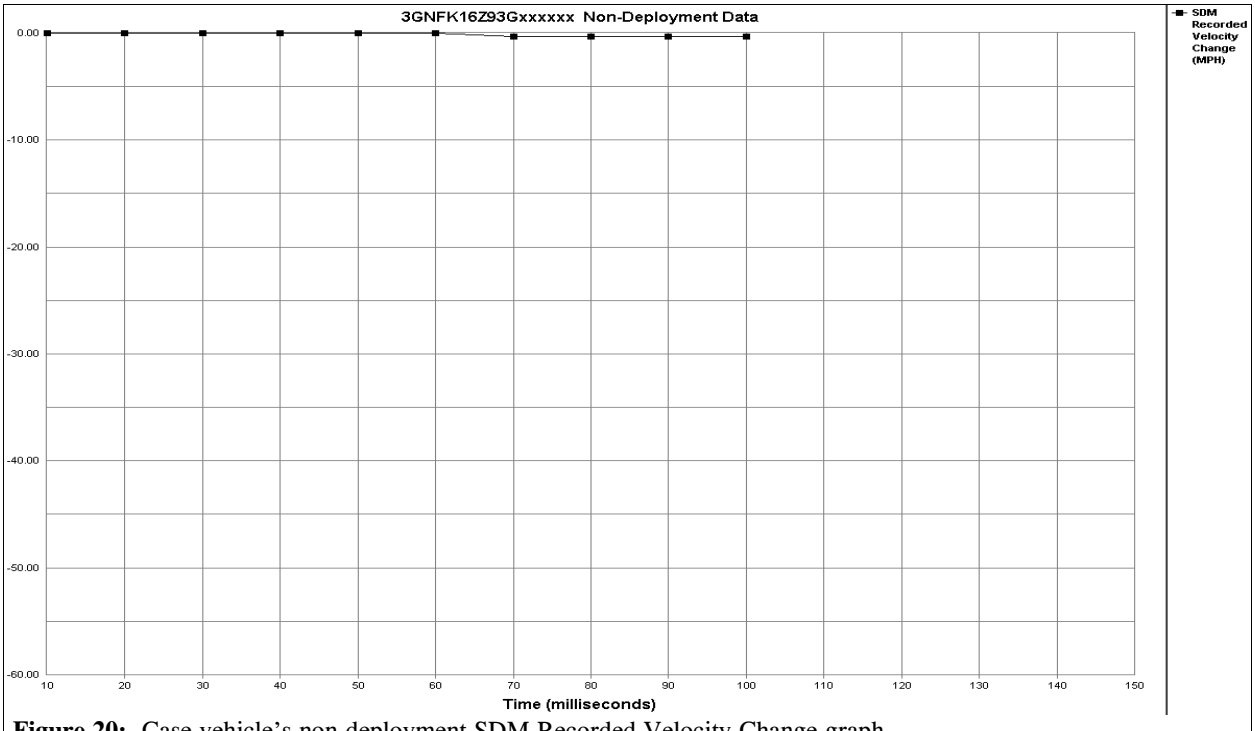
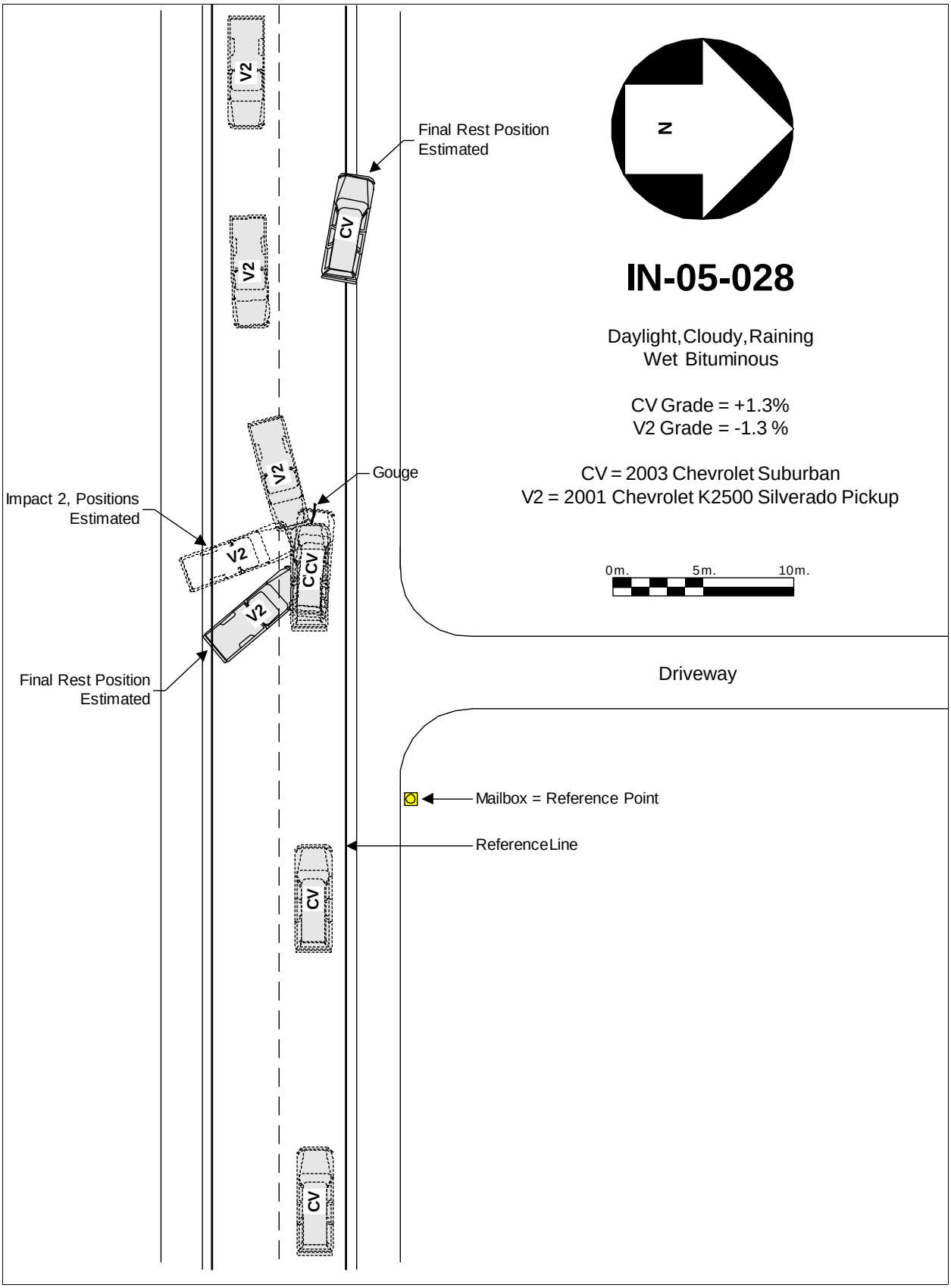


Figure 20: Case vehicle's non-deployment SDM Recorded Velocity Change graph


N
IN-05-028
Daylight, Cloudy, Raining
Wet Bituminous
CV Grade = +1.3%
V2 Grade = -1.3 %
CV = 2003 Chevrolet Suburban
V2 = 2001 Chevrolet K2500 Silverado Pickup
0m.
5m.
10m.
Final Rest Position Estimated
Gouge
Impact 2, Positions Estimated
Final Rest Position Estimated
Driveway
Mailbox = Reference Point
Reference Line
V2
CV