



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 CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - NASS-2003-50-042C
LOCATION - Texas
VEHICLE - 2003 Chevrolet Silverado C1500
CRASH DATE - June 2003

Submitted:
March 17, 2004
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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. <i>Supplementary Notes</i> SCI/NASS combination investigation involving a 2003 Chevrolet Silverado pickup truck, equipped with Certified Advanced 208-Compliant (CAC) safety features, that impacted the back of a semi-trailer					
16. <i>Abstract</i> This report covers a SCI/NASS combination investigation of an air bag deployment crash involving a 2003 Chevrolet Silverado C1500 four-door pickup truck (case vehicle) and a 1999 Peterbilt truck-tractor hauling a semi-trailer (other vehicle). This crash is of special interest because the case vehicle's manufacturer has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The case vehicle's driver (50-year-old male) and front right passenger (32-year-old male), both unrestrained, both sustained minor or moderate injuries as a result of the crash. The case vehicle was traveling east in the inside eastbound through lane of a five-lane, undivided, city roadway. The tractor-trailer rig was also traveling east, ahead of the case vehicle and at a slower speed, in the same lane of the same roadway. The weather was clear, it was dark but lighted and the straight, level concrete road surface was dry and without defects. The case vehicle driver did not attempt any avoidance actions prior to the crash. The front of the case vehicle impacted and underrode the back of the semi-trailer, causing the case vehicle's driver and front right passenger air bags to deploy. The case vehicle became wedged under the back of the semi-trailer and was dragged along as the Peterbilt's driver steered into the right lane and brought the rig to a controlled stop. The case vehicle was towed due to disabling damage and the tractor-trailer rig was driven away. The case vehicle driver sustained contusions and abrasions on his head and extremities and declined treatment at the scene. The front right passenger sustained lacerations, contusions and abrasions on his extremities and was transported via ambulance to a hospital where he was treated and released. The back left passenger (28-year-old male) was unrestrained and pitched forward against the back of the front seats. His injuries included: fracture of the left orbit, fracture of the maxilla on the left and various abrasions and contusions. He was transported via ambulance to a hospital where he was admitted for one day.					
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This NASS/SCI combination investigation was brought to the NHTSA's attention in early June 2003 by NASS CDS sampling activities and was designated for SCI June 24. This crash involved a 2003 Chevrolet C1500 Silverado pickup (case vehicle) and a 1999 Peterbilt 379 truck-tractor towing a Wabash semi-trailer (other vehicle). The crash occurred in June 2003, at 2:50 a.m., in Texas, and was investigated by the applicable municipal police. This crash is of special interest because the case vehicle's manufacturer has certified that it meets the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. In addition, the case vehicle was equipped with an Event Data Recorder (EDR) that was successfully downloaded in the field. The case vehicle's driver (50-year-old male, white, non-Hispanic) and front right passenger (32-year-old male, white, non-Hispanic), both unrestrained, both sustained minor or moderate injuries as a result of the crash. The finished NASS case was received on March 17, 2004. This report is based on the NASS investigation, the EDR report, and this contractor's evaluation of the evidence.

CRASH CIRCUMSTANCES

The case vehicle was traveling east in the inside eastbound through lane of a five-lane, undivided, city roadway, approaching a four-leg intersection with no controls for east-west traffic, and intended to continue east (i.e., there were two through lanes in each direction and a center left turn lane). The Peterbilt tractor-trailer rig was also traveling east, ahead of the case vehicle and at a slower speed, in the inside eastbound through lane of the same city roadway, approaching the same intersection, and intended to continue east. The weather was clear, it was dark but lighted and the straight, level concrete road surface was dry and without defects (**Figure 1**). The police crash report indicates that the case vehicle was traveling at high speed and that alcohol use by the case vehicle's driver was a contributing factor in this crash. The case vehicle driver did not attempt any avoidance maneuvers prior to the crash. The crash occurred in the inside, eastbound lane of the roadway.

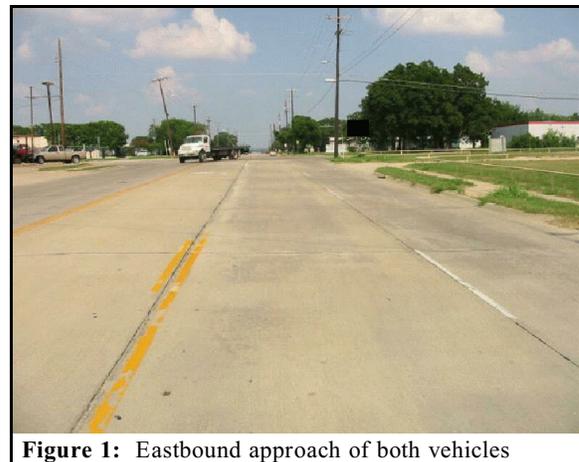


Figure 1: Eastbound approach of both vehicles

The front of the case vehicle impacted and underrode the back of the semi-trailer that was being hauled by the Peterbilt truck-tractor, causing the case vehicle's driver and front right passenger frontal air bags to deploy. The case vehicle became wedged under the back of the semi-trailer and was dragged along as the Peterbilt's driver steered into the right lane and brought the rig to a controlled stop.

CASE VEHICLE

The case vehicle was a 2003 Chevrolet C1500 Silverado rear wheel drive (4x2), six-passenger, four-door, extended cab pickup truck (VIN: 2GCEC19V431-----), equipped with a

Case Vehicle (continued)

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4.8 liter V8 gasoline engine and an automatic transmission with a column-mounted selector lever. The case vehicle was equipped with four wheel, anti-lock disc brakes, dual-stage air bag inflators, driver seat belt buckle sensing, front right passenger weight sensing and an original equipment air bag suppression switch for the front right air bag. The pickup was fitted with an aftermarket ladder rack and a large tool chest, and was loaded with a ladder and construction tools. Its wheelbase was 364 centimeters [143.5 inches] and the odometer reading showed 11,405 kilometers [7,087 miles]. The case vehicle was towed due to damage.

The case vehicle sustained heavy direct contact damage across the entire front (**Figures 2 and 3**). The residual damage exhibited the features of a classic heavy truck rear underride impact, with maximum bumper-level crush 12 centimeters [4.7 inches] and maximum above-bumper crush 39 centimeters [15.4 inches], both at the right headlight area. The tractor-trailer rig was not inspected and the configuration of the trailer's back surface is not known, but the imprint of an underride guard can be readily seen in the case vehicle's above-bumper crush pocket (**Figure 4**). It appears that the trailer's underride guard engaged the case vehicle's engine block and the rear of the case vehicle probably pitched upward during maximum penetration. The case vehicle's frame rails forward of the front axle were bent upward as a result of the pitching as the case vehicle's front was wedged under the back of the trailer's cargo bed (**Figures 2 and 3**). The bumper sustained direct contact across its entire width except the extreme left-most area and was crushed rearward, more heavily on the right. The grille and right headlamp assembly were shattered and broken away, with the left headlamp intact but displaced. The leading edge of the hood, the radiator support bracket and the top of the radiator were crushed rearward against the engine block. The hood was buckled nearly double and the trailing edge of the hood was forced rearward, causing heavy cracking of the windshield glazing across the entire width. There was no other glazing damage. The leading edge of the right fender



Figure 2: Case vehicle's front and left side; note, direct contact heavier on right



Figure 3: Case vehicle's front and right side; note, front frame rails shifted upward



Figure 4: Case vehicle's front straight on; note imprint of underride guard in hood

was crushed rearward and the right front tire was restricted by the deformed body panels. The left front fender was also moved rearward, but less than on the right, and the left front tire was not restricted. None of the tires were damaged and the wheelbase was not changed on either side.

The CDC for the case vehicle's single impact was determined to be **32-FDEW-2 (0)**, indicating a 12 o'clock direction of force incremented by + 20 to reflect upward shifting of the frame rail ends in the front. Maximum crush was 39 centimeters [15.4 inches] at C5 on the leading edge of the hood. This crash is out of scope for the WinSMASH reconstruction program (heavy truck impact). The case vehicle's barrier equivalent speed (BES) was calculated based on the case vehicle's crush profile using the crush averaging technique, indicating BES = 25 km.p.h. [15.5 m.p.h.], which seems reasonable but slightly low. This contractor judges that the crash severity for the case vehicle was moderate (24-40 km.p.h. [15-25 m.p.h.]).

The case vehicle manufacturer's recommended tires of size P255/70R16 for this model and the case vehicle was equipped with four tires of the recommended size. The tire inspection findings are presented in the following table.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	207	30	207	30	8	10	None	No	No
RF	159	23	207	30	9	11	None	Yes	No
LR	276	40	241	35	7	9	None	No	No
RR	276	40	241	35	7	9	None	No	No

Inspection of the case vehicle's interior revealed numerous areas of intrusion and evidence of occupant contact. The driver's knee bolster intruded 16 centimeters [6.3 inches] longitudinally. The instrument panel intruded longitudinally 15 centimeters [6.0 inches] on the right, 7 centimeters [2.8 inches] in the center and 5 centimeters [2.0 inches] on the left. The right rear corner of the hood broke through the windshield and intruded 3 centimeters [1.2 inches] at the base of the right upper A-pillar. In addition, the rear seat occupant impacted the back of the front seat, causing deformation of the seat back and back-to-front intrusion by the front seat back into the front seat area (**Figure 5**), 15 centimeters [6.0 inches] at the center and 11 centimeters [4.3 inches] at the left. The top left

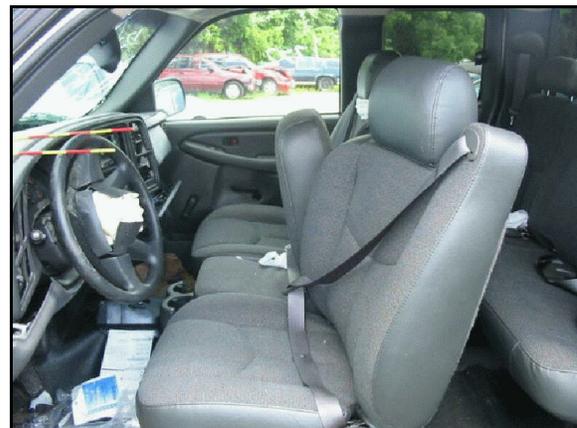


Figure 5: Case vehicle's front seat row viewed from left; note, seat back bent forward and steering wheel rim deformed

portion of the steering wheel rim was bent forward 13 centimeters [5.1 inches], due to contact by the driver's chest, and the steering column tilt mechanism was broken (**Figure 5**). The driver's head impacted the left sunvisor, leaving a skin and blood transfer. The front right passenger's knees impacted the glove box door, leaving scuff marks.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with advanced dual-stage frontal air bags at the driver and front right passenger seat positions, with unknown type occupant sensing (i.e., seat weight sensing versus seat cushion bladder) in the front right passenger's seat, and an original equipment air bag suppression switch for the passenger's air bag that was set in the "AUTO" mode. Both air bags deployed as a result of the case vehicle's single impact.



Figure 6: Front of driver's air bag

The driver's air bag was located in the steering wheel hub with the cover flaps in the I-configuration. Each cover flap measured 12 centimeters [4.7 inches] vertically and 7 centimeters [2.8 inches] horizontally. The cover flaps opened at the tear points and there was no evidence of damage to the cover flaps or the adjacent structures. The deployed driver's air bag was round with a diameter of 58 centimeters [22.8 inches] (**Figure 6**). There were two tether straps stitched near the center and two vent ports of unknown diameter on the back, at the 11 and 1 o'clock positions. There was mud smeared on the front of the air bag, but this probably occurred later when the case vehicle was being prepared for towing. There was a small amount of blood smeared on the back of the driver's air bag, near the top. There was no evidence of damage to the air bag.



Figure 7: Front of front right passenger's air bag

The front right passenger's air bag was located in the mid-instrument panel position with a single cover flap hinged at the top. The cover flap measured 39 centimeters [15.3 inches] horizontally and 15 centimeters [5.9 inches] vertically. The cover flap opened at the tear points and there was no evidence of damage to the cover flap or the adjacent structures. The deployed passenger's air bag was rectangular, measuring 45 centimeters [17.7 inches] horizontally and 50 centimeters [19.7 inches] vertically (**Figure 7**). There was a single tether strap stitched across the entire width near the front-top, and two vent ports of unknown diameter near the center on the side panels. There was a single droplet of blood on the left side near the bottom edge and no other evidence of contact. There was no evidence of damage to the passenger's air bag.

The case vehicle was equipped with an Event Data Recorder (EDR) that was successfully downloaded. The EDR recorded a deployment event and a non-deployment event. The Sensing and Diagnostic Module (SDM) reports, with Data Limitations, are included as **Figures 8 - 14**.

The SDM System Status reports for the deployment (**Figure 8**) and the non-deployment (**Figure 11**) events show that the SIR Warning Lamp was OFF, indicating no faults in the air bag system, and the driver's seat belt was not buckled. The events were recorded during ignition cycle 1,288 and the download was accomplished on ignition cycle 1,297. The deployment event System Status report (**Figure 8**) shows that there was not a non-deployment event prior to the deployment event (Time Between Deployment and Non-Deployment Events = N/A), which indicates that the non-deployment event recording is an artifact of the single impact, probably reflecting the prolonged duration of the crash pulse as the case vehicle first impacted the underride guard and then penetrated beneath the semi-trailer. The non-deployment event is not discussed further.

The SDM System Status report for the deployment event (**Figure 8**) and the associated Pre-Crash Graph (**Figure 9**) show that the case vehicle was traveling 61 km.p.h. [38 m.p.h.] at five seconds prior to algorithm enable (AE) and its speed increased over the five second interval to 66 km.p.h. [41 m.p.h.] at one second prior to AE. The case vehicle driver did not apply the brakes during the recorded interval and the throttle remained constant at 27 percent. First stage deployment of the driver and front right passenger air bags was commanded at 17.5 milliseconds [0.0175 seconds] after AE. The threshold for second stage deployment was not reached. The maximum longitudinal velocity change was recorded as -41.8 km.p.h. [-25.98 m.p.h.] at 182.5 milliseconds [0.1825 seconds] after AE. The velocity change data (**Figure 8**) and the associated graph (**Figure 10**) show gradual deceleration to -4.0 km.p.h. [-2.48 m.p.h.] at 50 milliseconds [0.050 seconds] after AE, followed by rapid deceleration to -30.9 km.p.h. [-19.22 m.p.h.] at 110 milliseconds [0.110 seconds] after AE when the SDM stopped recording.

CASE VEHICLE DRIVER'S KINEMATICS

The case vehicle driver (50-year-old male, white, non-Hispanic, 183 centimeters, 77 kilograms [72 inches, 170 pounds]) was not restrained by his available, active, integrated, three-point, lap-and-shoulder, safety belt system. The driver admitted that he fell asleep and had no recollection about his posture, and he may have been slumped in his seat. The seat back was slightly reclined, the seat track was adjusted at the rearmost position and the tilt steering wheel adjustment is not known.

The driver did not attempt any pre-crash avoidance actions. The front of the case vehicle impacted the back of the semi-trailer, causing the driver to move forward, toward the 12:00 o'clock direction of force, and causing the driver's air bag to deploy. The case vehicle's rear end pitched upward as its front became wedged under the back of the semi-trailer's cargo deck, causing the driver to move upward as well as forward. Simultaneously, the back left occupant impacted the back of the driver's seat back, causing back-to-front intrusion by the driver's seat back into the driver's seat area and propelling the driver further forward. The driver encountered

the deployed air bag with his chest and abdomen, causing the air bag to deflate as he moved forward and upward, deforming the steering wheel rim and breaking the tilt mechanism. His right arm impacted the steering wheel rim/spokes and he sustained a contusion on his right forearm. His head struck the front header causing a contusion of his scalp in the right parietal area. The driver stated that he sustained an episode of unconsciousness, but this could not be verified by any medical authority. His right knee impacted the knee bolster, causing contusions and lacerations. His position at final rest is not known.

CASE VEHICLE DRIVER'S INJURIES

The driver declined treatment at the scene and did not seek any medical attention.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion, right forearm	minor 790402.1,1	Steering wheel rim and spokes	Certain	Interviewee
2	Contusion, right knee	minor 890402.1,1	Knee bolster	Certain	Interviewee
3	Laceration, right knee	minor 890602.1,1	Knee bolster	Certain	Interviewee
4	Scalp contusion, right parietal area	minor 190402.1,1	Front header	Certain	Interviewee

CASE VEHICLE FRONT RIGHT PASSENGER'S KINEMATICS

The front right passenger (32-year-old male, white, non-Hispanic, 178 centimeters, 102 kilograms [70 inches, 225 pounds]) was not restrained by his available, active, integrated, three-point, lap-and-shoulder, safety belt system. He was asleep and his posture is not known, and he may have been slumped in his seat. The seat back was slightly reclined and the seat track was adjusted between the middle and rearmost positions.

The driver did not attempt any pre-crash avoidance actions. The front of the case vehicle impacted the back of the semi-trailer, causing the front right passenger to move forward, toward the 12:00 o'clock direction of force, and causing the passenger's air bag to deploy. The case vehicle's rear end pitched upward as its front became wedged under the back of the semi-trailer's cargo deck, causing the front right passenger to move upward as well as forward. He engaged the deployed air bag with his chest and abdomen while pitching upward and forward. His legs contacted the glove box door, causing contusions and abrasions on his right knee and a laceration on his left lower leg. His head impacted the front header, resulting in a brief episode of unconsciousness, and his left shoulder contacted the rear view mirror, causing a contusion. His hands/arms flailed, contacting the air bag and the right instrument panel, causing bilateral contusions and abrasions. His position at final rest is not known.

CASE VEHICLE FRONT RIGHT PASSENGER'S INJURIES

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The front right passenger was transported via ambulance to a hospital, where he was treated and released.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Unconsciousness known to be less than one hour	moderate 160414.2,0	Front header	Certain	Emergency Room
2	Superficial lacerations, hands, bilaterally	minor 790602.1,3	Right instrument panel	Probable	Emergency Room
3	Abrasion, right knee	minor 890202.1,1	Glove box door	Certain	Emergency Room
4	Superficial laceration, left lower leg	minor 890602.1,2	Glove box door	Certain	Emergency Room
5	Contusions, hands, bilaterally	minor 790402.1,3	Right instrument panel	Certain	Interviewee
6	Contusion, right knee	minor 890402.1,1	Glove box door	Certain	Interviewee
7	Contusion, left shoulder	minor 790402.1,2	Back seat occupant (V1-O3)	Certain	Interviewee

CASE VEHICLE BACK LEFT PASSENGER'S KINEMATICS

The case vehicle's back left passenger (28-year-old male, white, Hispanic, 170 centimeters, 64 kilograms [67 inches, 141 pounds]) was not restrained by his available, active three-point, lap-and-shoulder, safety belt system. He was asleep, lying back across the bench seat with his feet on the floor. The seat back and seat track were not adjustable.

The case vehicle driver did not attempt any pre-crash avoidance actions. The front of the case vehicle impacted the back of the semi-trailer, causing the back left passenger to move forward, toward the 12:00 o'clock direction of force. The case vehicle's rear end pitched upward as its front became wedged under the back of the semi-trailer's cargo deck, causing the back left passenger to move upward as well as forward. His face and chest impacted the back of the front seat back, causing the seat back to intrude forward into the driver's seat area. He sustained a fracture of the left orbit and a contusion of his left eyelid, a fracture of his maxilla on the left, an abrasion on his forehead, and was knocked unconscious for a short time. His position at final rest is not known.

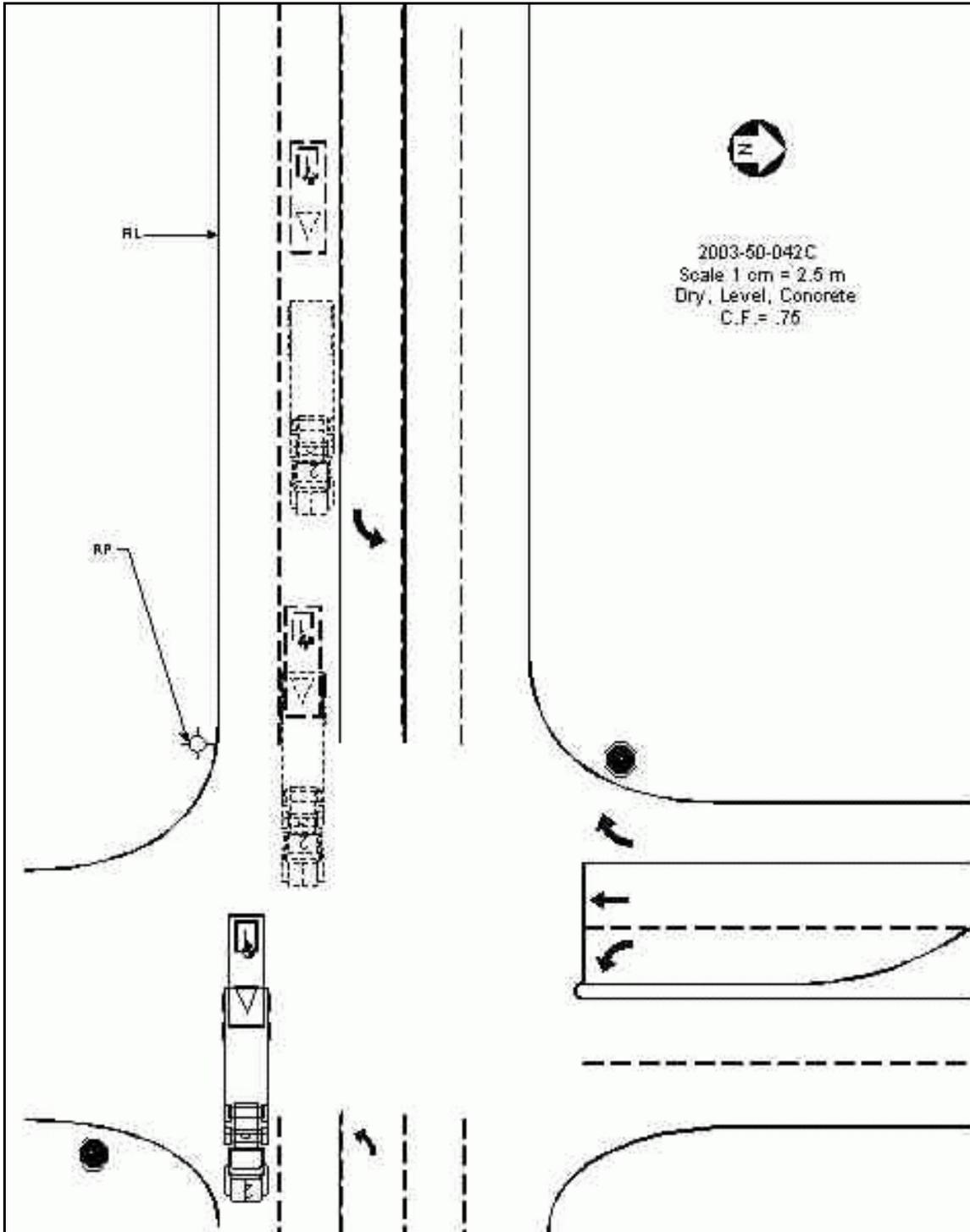
CASE VEHICLE BACK LEFT PASSENGER'S INJURIES

The back left passenger was transported via ambulance to hospital, where he was admitted for one day for treatment of his injuries.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Closed fracture, left orbit	moderate 251202.2,2	Back surface, front seat back	Certain	Hospitalization Records
2	Fracture, left maxilla	moderate 250800.2,2	Back surface, front seat back	Certain	Hospitalization Records
3	Abrasion, forehead	minor 290202.1,7	Back surface, front seat back	Certain	Emergency Room
4	Contusion, left eyelid	minor 297202.1,2	Back surface, front seat back	Certain	Emergency Room
5	Unconsciousness known to be less than one hour	moderate 160414.2,0	Back surface, front seat back	Certain	Emergency Room

OTHER VEHICLE

The other vehicle was a 1999 Peterbilt 379, 6x4 truck-tractor (VIN: 1XP5DR9X3XD-----) hauling a 14.6 meter [48 foot], van-type 1996 Wabash semi-trailer (VIN: 1JJV482U9TL-----). The tractor-trailer rig was driven from the scene. The Peterbilt's driver (50-year-old male) and unknown-positioned passenger (32-year-old male) were police-reported as not injured.



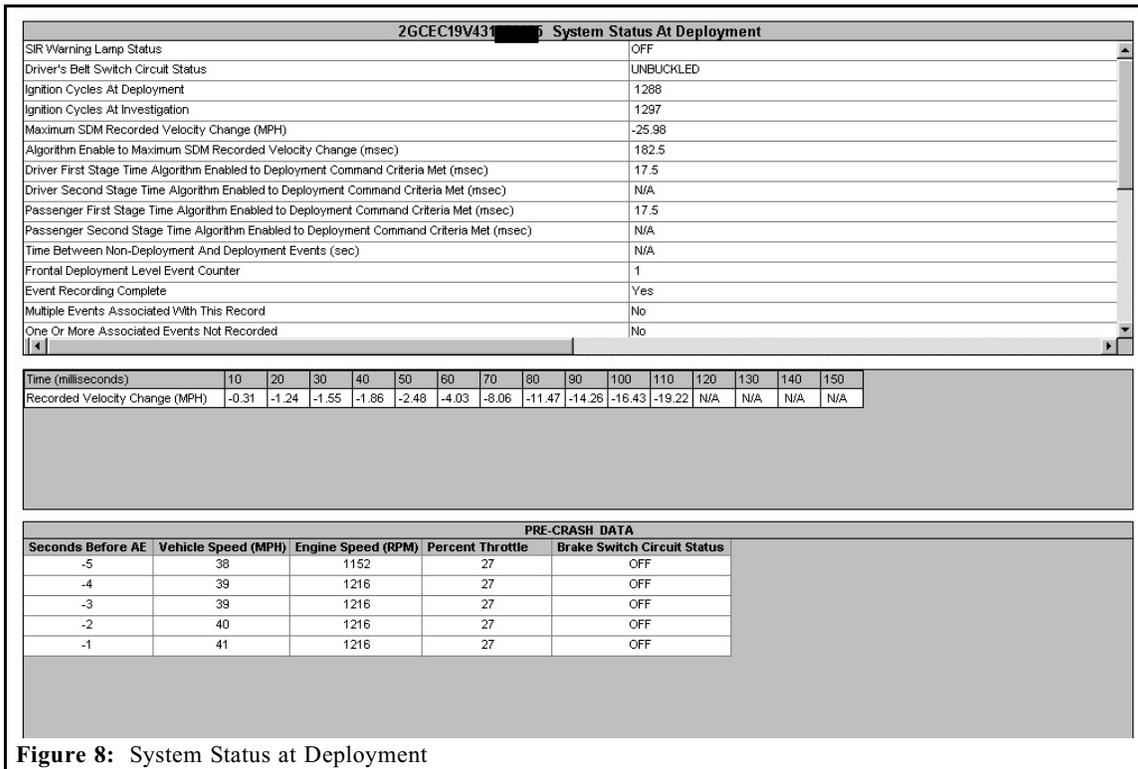


Figure 8: System Status at Deployment

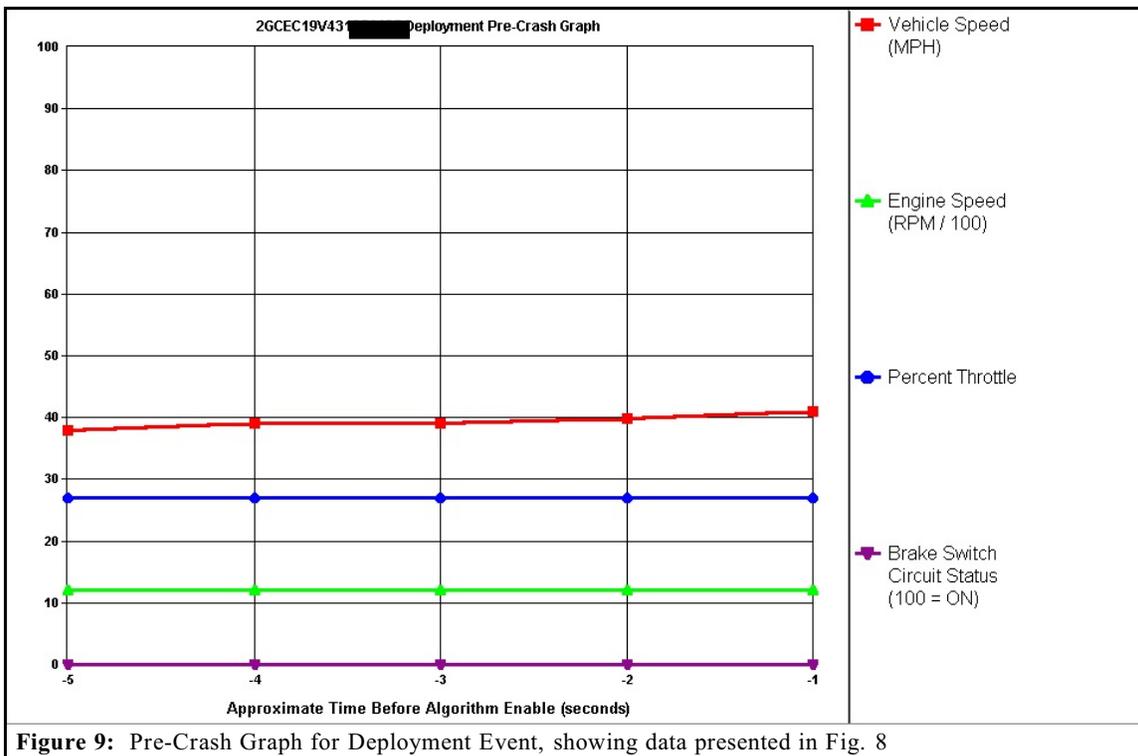


Figure 9: Pre-Crash Graph for Deployment Event, showing data presented in Fig. 8

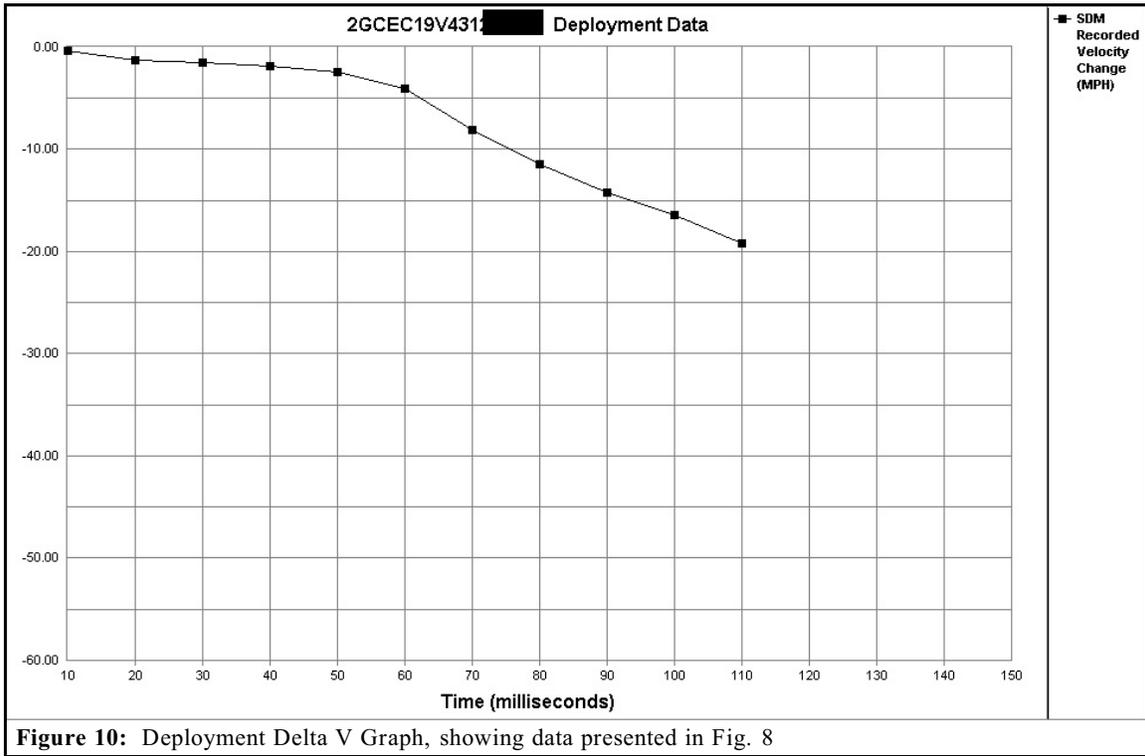


Figure 10: Deployment Delta V Graph, showing data presented in Fig. 8

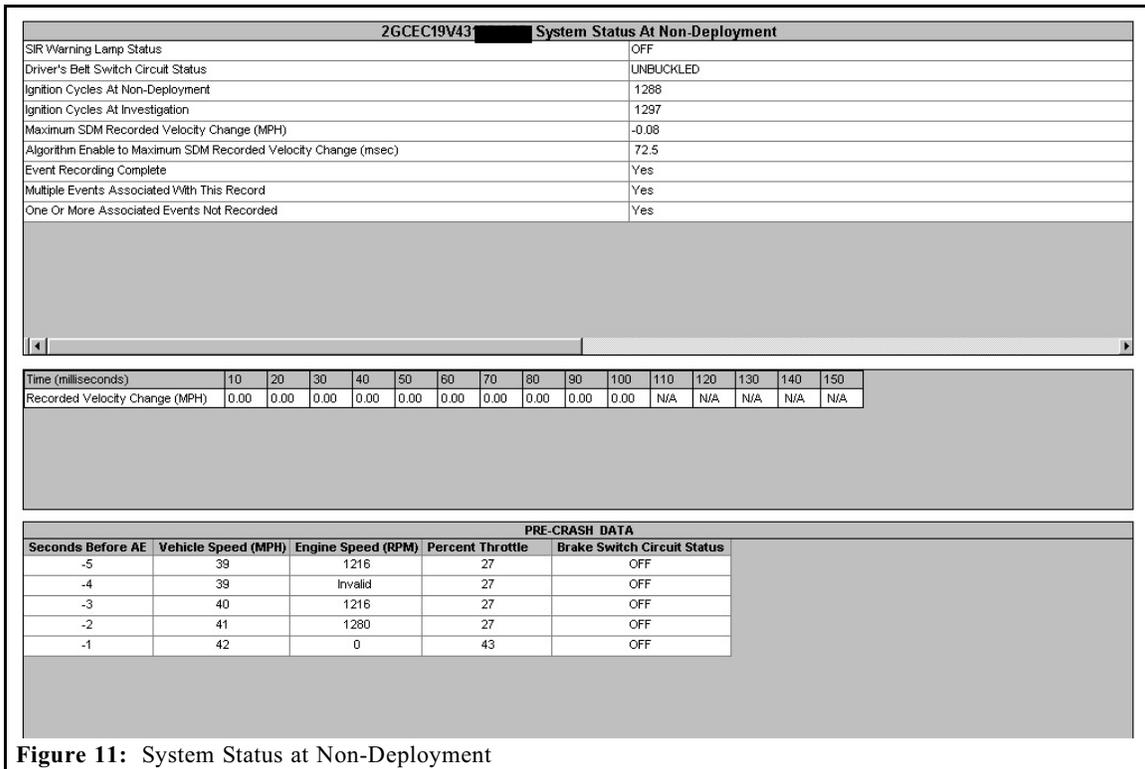


Figure 11: System Status at Non-Deployment

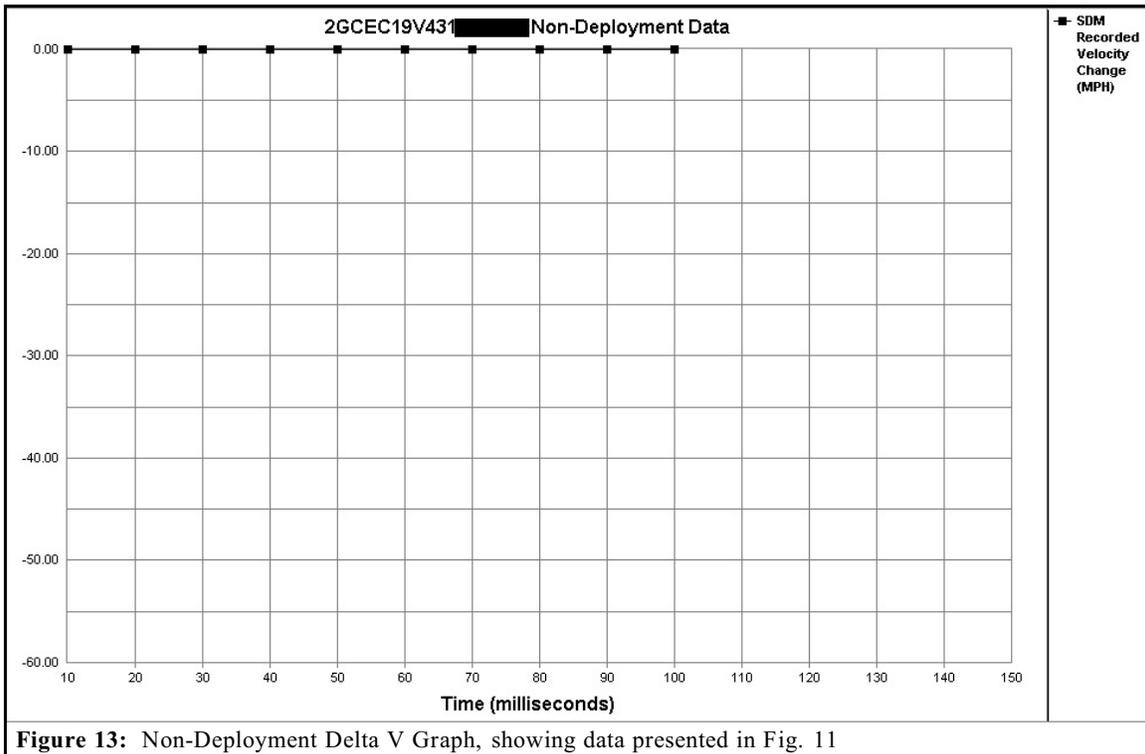
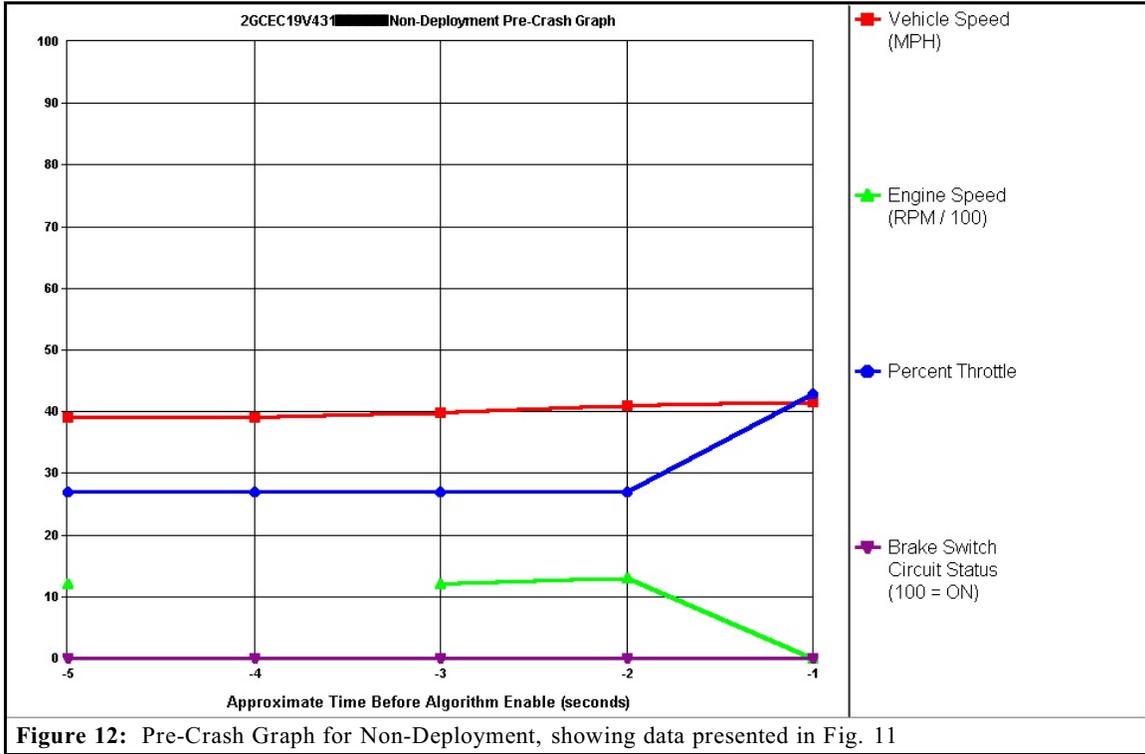


Figure 14: SDM Data Limitations

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 five seconds of one another. Deployment events can not 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 file will be locked after a deployment, if the non-deployment occurred within 5 seconds before the deployment or a deployment level event occurs within 5 seconds after the deployment.

SDM Data Limitations:

-SDM Recorded Vehicle Forward Velocity Change is one of the measures used to make air bag deployment decisions. SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. 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. The SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. The SDM will also record 150 milliseconds of data after non-deployment criteria is met.

-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 does not receive a valid message.

-Driver's Belt Switch Circuit Status indicates the status of the driver's seat belt switch circuit

-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.

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 Class 2 data link, to the SDM.

-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the Class 2 data link, to the SDM.

-In most vehicles, the Driver's Belt Switch Circuit is wired directly to the SDM. In some vehicles, the Driver's Belt Switch Circuit Status data is transmitted from the Body Control Module (BCM), via the Class 2 data link, to the SDM.