

CRASH DATA RESEARCH CENTER
Calspan Corporation
Buffalo, NY 14225

**ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH
INVESTIGATION
CALSPAN CASE NO: CA04-001**

VEHICLE: 2003 CHEVROLET C1500 SILVERADO PICK-UP TRUCK

**LOCATION: MARYLAND
CRASH DATE: DECEMBER, 2003**

Contract No. DTNH22-01-C-17002

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<p>16. Abstract This investigation focused on the Certified Advanced Compliant (CAC) occupant protection system in a 2003 Chevrolet C1500 Silverado pick-up truck. A CAC vehicle is certified by the manufacturer to be compliant to Advanced Air Bag portion of Federal Motor Vehicle Safety Standard. (FMVSS 208). This advanced occupant protection system was comprised of dual-stage frontal air bags, seat track position sensors for both front seats, front safety belt buckle switches and a front right occupant detection sensor. The vehicle's Sensing and Diagnostic control Module (SDM) tailored the deployment of the frontal air bags based the crash severity and inputs from these sensors. The Chevrolet was involved in a minor front-to-rear under-ride collision with a 1999 Mack tractor/semi-trailer. The front of the Chevrolet struck the back plane of the semi-trailer during a back-up in traffic on the interstate highway. The frontal air bags in the Chevrolet did not deploy as a result of the crash. The 50-year old unrestrained male driver of the Chevrolet was uninjured and was not transported. The 60-year old unrestrained front right passenger in the Chevrolet sustained a police reported incapacitating injury and was transported to a local hospital. However, the hospital did not have any records of treating this patient and she declined an interview. The exact nature and extent of her injury was not known. The 37-year old driver of the tractor trailer was not injured in the event. The tractor trailer was driven from the crash scene at the conclusion of the police investigation and was not inspected.</p>			
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**ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION
CALSPAN CASE NO: CA04-001**

**VEHICLE: 2003 CHEVROLET C1500 SILVERADO PICK-UP TRUCK
LOCATION: MARYLAND
CRASH DATE: DECEMBER, 2003**

BACKGROUND

This investigation focused on the Certified Advanced 208-Compliant (CAC) occupant protection system in a 2003 Chevrolet C1500 Silverado pick-up truck, **Figure 1**. This advanced occupant protection system was comprised of dual-stage frontal air bags, seat track position sensors for both front seats, front safety belt buckle switches and a front right occupant detection sensor. A CAC vehicle is certified by the manufacturer to be compliant to Advanced Air Bag portion of Federal Motor Vehicle Safety Standard. (FMVSS 208). The vehicle's Sensing and Diagnostic control Module (SDM) tailored the deployment of the frontal air bags based the crash severity and inputs from these sensors. The Chevrolet was involved in a minor front-to-rear under-ride collision with a 1999 Mack tractor/semi-trailer. The front of the Chevrolet struck the back plane of the semi-trailer during a back-up in traffic on the interstate highway. The frontal air bags in the Chevrolet did not deploy as a result of the crash. The 50-year old unrestrained male driver of the Chevrolet was uninjured and was not transported. The 60-year old unrestrained front right passenger in the Chevrolet sustained a police reported incapacitating injury and was transported to a local hospital. However, the hospital did not have a record of treating this patient and she declined an interview. The exact nature and/or extent of her injury was not known. The 37-year old driver of the tractor trailer was not injured in the event. The tractor trailer was driven from the crash scene at the conclusion of the police investigation and was not inspected.



Figure 1: Front left view of the damaged Chevrolet.

The Crash Investigation Division of the National Highway Traffic Safety Administration received notification of this crash and assigned an on-site crash investigation to the Special Crash Investigations team at General Dynamics on January 22, 2004. The case was assigned due to the agency's interest in vehicles equipped with these CAC systems. The Chevrolet Silverado was considered a total loss by its insurance company and was located in a salvage yard. Cooperation was established with the insurance carrier for the vehicle and the Chevrolet was available for inspection. The Chevrolet was equipped with an Event Data Recorder (EDR) that was downloaded as a supplement to the crash investigation. The on-site portion of this investigation took place on January 26, 2004.

VEHICLE DATA

2003 Chevrolet C1500 Silverado Pick-Up Truck

The 2003 Chevrolet C1500 Silverado was identified by the Vehicle Identification Number (VIN): 1GCEC14X93Z (production sequence deleted). The two wheel drive, 454 kg (1/2 ton) long box, regular cab pick-up was configured with a 338 cm (133 in) wheelbase. The Gross Vehicle Weight Rating (GVWR) was 2,903 kg (6,400 lb). The power train consisted of a 4.3 liter/V6 engine linked to a four-speed automatic transmission with overdrive. The vehicle was equipped with base model equipment to include power steering, power assist four-wheel disc brakes with ABS, manual windows and manual door locks. The manual restraint system consisted of integrated 3-point lap and shoulder belts in the outboard positions. The center position was lap belt equipped. The Supplemental Restraint System consisted of a CAC frontal air bag system. The vehicle's date of manufacture was October 2002. The digital odometer reading was unknown. The pick-up was equipped with Goodyear Wrangler ST P235/75R16 tires on OEM steel wheels. The vehicle manufacturer recommended tire pressure was 241 kPa (35 PSI). The specific measured tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	Tire Flat	9 mm (11/32)	No	Punctured
LR	186 kPa (27 PSI)	8 mm (10/32)	No	None
RF	Tire Flat	9 mm (11/32)	Yes	Debeaded
RR	131 kPa (19 PSI)	8 mm (10/32)	No	None

SUMMARY

Crash Site

This two-vehicle crash occurred during the night time hours in December, 2003. At the time of the crash, it was dark without artificial lighting and there were no adverse weather conditions. The road surface was dry. The crash occurred on the southbound lanes of a four-lane limited access interstate highway. At the crash site, the southbound roadway was configured with four lanes. The police report indicated the crash occurred during a lane change from the outboard lane to the right center lane by the Chevrolet. The speed limit in the area of the crash was 89 km/h (55 mph). **Figure 2** is a southbound view of the roadway.



Figure 2: Southbound view at the crash site.

CRASH SEQUENCE

Pre-Crash

The 2003 Chevrolet C1500 Silverado pick-up truck was southbound in the outboard lane of the highway. The Chevrolet was driven by a 50-year old unrestrained male. A 60-year old unrestrained female was the vehicle's front right passenger. Reportedly at the time of the crash, the Chevrolet was towing a 1986 Ford Taurus mounted on a tow dolly. (The Ford Taurus was not inspected during this investigation.) The 1999 Mack tractor/semi-trailer was southbound in the right center lane driven by a 37-year old restrained male. The crash occurred when the Chevrolet initiated a lane change to the left due to a back-up in traffic. The downloaded EDR data indicated the Chevrolet was traveling 92 km/h (57 mph) five seconds prior to Algorithm Enable (AE) and had decelerated by braking to 40 km/h (25 mph) one second prior to AE.

Crash

The front plane of the Chevrolet impacted the back plane of the semi-trailer in a front-to-rear configuration. The nature of the damage suggested the Chevrolet was rotated slightly clockwise at impact. This orientation may have resulted from a loss of control of the towed vehicle. The Chevrolet underrode the back of the trailer due to the mismatch of the profiles of the respective vehicle. As a result of the under-ride, the primary damage sustained by the Chevrolet was above the elevation of the front bumper. The force of the impact was not sufficient to warrant the deployment of the Chevrolet's advanced frontal air bags. The WINSMASH program's barrier equivalent algorithm was used to calculate a Barrier Equivalent Speed (BES) for the Chevrolet. The calculated BES for the Chevrolet was 14 km/h (8.9 mph). The maximum longitudinal delta V recorded by the Chevrolet's EDR was 13 km/h (8.01 mph). **Figure 7**, at the end of this narrative report, is a schematic of the crash.

Post-Crash

The Chevrolet sustained disabling damage and was towed from the scene. The vehicle was subsequently considered a total loss by its insurance carrier. The tractor/semi-trailer was not damaged and was driven from the crash scene upon the completion of the police investigation. The 50-year old driver of the Chevrolet was not injured and was not transported. The 60-year old female front right passenger was police reported as being transported to a local hospital with a police reported incapacitating injury. A subsequent search of the reported hospital's medical records did not find a record of treating this patient. The front right passenger declined an interview. The nature and extent of her injury could not be identified.

EXTERIOR DAMAGE

2003 Chevrolet C1500 Silverado Pick-Up Truck

Figures 3 through 5 are the left lateral, right lateral and frontal views of the Chevrolet. The direct damage measured 140 cm (55.1 in). This direct damage extended from the left bumper corner to the right bumper corner. The damage pattern was indicative of an under-ride impact into the back plane of the semi-trailer with the maximum deformation occurring at the elevation of the upper radiator support. The damaged components included the front bumper, center grille, headlamp assemblies, hood and right front fender. The front bumper was deflected downward with the maximum deformation located at its left corner. The left end of the bumper deflected

inboard and rearward puncturing the left front tire. The residual crush measured along the front bumper was as follows: C1 = 13 cm (5.1 in), C2 = 1 cm (0.4 in), C3 = 0, C4 = 0, C5 = 0, C6 = 0.

The residual above-bumper crush from contact with the back plane of the trailer began at an elevation 51 cm (20 in) above the ground and extended vertically to 109 cm (43 in) above the ground reference. The maximum crush at this location measured 26 cm (10.2 in). The residual profile along the upper radiator support was as follows: C1 = 0, C2 = 5 cm (2.0 in), C3 = 12 cm (4.7 in), C4 = 14 cm (5.5 in), C5 = 26 cm (10.2 in), C6 = 24 cm (9.4 in). The hood buckled and folded in a V-shape pattern. The longitudinal contact length to the surface of the deformed hood measured 28 cm (11.0 in) at its right aspect. The length of the deformed right fender measured 79 cm (31 in). For reference, the length of the un-deformed left fender measured 119 cm (47 in). The right wheelbase was reduced 10 cm (4.0 in) and the right front tire was debanded. The left wheelbase measurement was unchanged. The principle direction of the impact force was in the 11 o'clock sector (an estimated 340 degrees). There was no evidence of cab-to-bed contact. The windshield was not damaged and there was no damage to the side glazings. The left door remained closed during the impact and was operational post-crash. The right door was removed post-crash and was located in the pick-up bed; it was not damaged.



Figure 3: Left lateral view of the Chevrolet.



Figure 4: Right lateral view.

The Collision Deformation Classification was 11-FDEW-1. The Barrier Algorithm of the WINSMASH model was used to assess the crash severity (delta V) based on an average of the above referenced profiles. The crush profile used in that analysis was: C1 = 13 cm (5.1 in), C2 = 1 cm (0.4 in), C3 = 0, C4 = 7 cm (2.8 in), C5 = 13 cm (5.1 in), C6 = 12 cm (4.7 in). The calculated BES for the Chevrolet was 14 km/h (8.9 mph). The computed BES was in general agreement with the delta V recorded by the Event Data Recorder. The maximum recorded delta V was -



Figure 5: Front view.

13 km/h (-8.01 mph). This maximum value was recorded 185 milliseconds after algorithm enable.

Refer to the EDR report attached to the end of this document for further detail.

INTERIOR DAMAGE

2003 Chevrolet C1500 Silverado Pick-Up Truck

Figure 6 is an interior view of the Chevrolet. There was no intrusion or interior damage related to the exterior crash forces.

The driver seat was located in a full rear track position. The total seat track travel measured 22 cm (8.8 in). The seat back angle measured 12 degrees. The horizontal distance from the center of the steering wheel rim measured 38 cm (15.0 in) above the seat bight was 70 cm (27.5 in).

The 4-spoke steering wheel was rotated 90 degrees clockwise at inspection. The tilt adjustment was in the center position. There was no deformation of the steering wheel rim. There was no shear capsule displacement. No contacts were identified on the driver's knee bolster.

The front right seat was adjusted to the full rear track position. The seat back was upright; its angle measured 0 degrees. The horizontal distance from the seat back to the vertical of the mid-mount passenger air bag module measured 73 cm (28.6 in). There were no occupant contacts identified for the front right passenger.



Figure 6: Left interior view.

MANUAL RESTRAINT SYSTEM

2003 Chevrolet C1500 Silverado Pick-Up Truck

The manual restraint system in the subject vehicle consisted of integrated 3-point lap and shoulder belts with continuous loop webbing and sliding latch plates for the two outboard positions. The center position was equipped with a lap belt.

The driver's restraint was stowed within the ELR retractor upon inspection. The retractor was operational. Examination of the latch plate revealed minor indications of historical use. Inspection of the safety belt webbing was unremarkable. There was no crash related evidence identified on the webbing or any of the hardware surfaces. The SCI inspection of the vehicle determined the driver was unrestrained at the time of the crash. This determination was consistent with the downloaded EDR data; the EDR data indicated the driver safety belt was unbuckled.

At inspection, the front right passenger restraint was stowed within a switchable ELR/ALR retractor. The retractor was operational. Examination of the webbing was unremarkable. There was no crash related evidence on the webbing or the fiction surfaces of the hardware. Evidence of historical use was identified on the surface of the latch plate. The front right passenger was unrestrained at the time of the crash.

CERTIFIED ADVANCED 208-COMPLIANT (CAC) AIRBAG SYSTEM

2003 Chevrolet C1500 Silverado Pick-Up Truck

The Supplemental Restraint System in the 2003 Chevrolet C1500 Silverado pick-up truck consisted of a CAC frontal air bag system. A CAC vehicle is certified by the manufacturer to be compliant to Advanced Air Bag portion of Federal Motor Vehicle Safety Standard. (FMVSS 208). The deployment of the dual-stage air bags was controlled by a Sensing and Diagnostic Module (SDM) that had Event Data Recording (EDR) capabilities. The EDR recorded five seconds of pre-crash data in addition to the crash event data. The EDR was downloaded as a supplement to this investigation. The SDM assessed the severity of the crash and tailored the frontal air bag deployment based on input from following: seat position sensors (for both the driver and the front right passenger seats), front right passenger detection sensor, seat belt buckle switches, a seat belt tension retractor sensor (for the front right manual restraint) and the instrument panel mounted front right passenger air bag suppression switch. The driver air bag module was located in the center hub of the steering wheel. The front right passenger air bag was a mid-mount design located in the right aspect of the instrument panel. The front right passenger air bag suppression switch was in the "Auto" position.

In this crash, the EDR recorded a Non-Deployment event. The CAC frontal air bags in the vehicle were not commanded to deploy. The recorded data indicated the air bag warning lamp was "OFF" and the driver seat belt was unbuckled. The maximum recorded delta V of the non-deployment event was -13 km/h (-8.01 mph), 185 milliseconds after Algorithm Enable. The recorded delta V data indicated that the crash was a long duration low level event and did not warrant frontal air bag deployment. The five seconds of recorded pre-crash data indicated the Chevrolet was decelerating throughout the time period by braking. The Chevrolet was traveling

57 mph five seconds prior to Algorithm Enable (AE) and had decelerated to 25 mph one second prior to AE. The downloaded EDR data is attached to the end of this report.

OCCUPANT DEMOGRAPHICS

2003 Chevrolet C1500 Silverado Pick-Up Truck

Age/Sex:	50-year old/Male	60-year old/Female
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Seat Position:	Full rear track	Full rear track
Restraint Use:	Unrestrained	Unrestrained
Usage Source:	SCI inspection, EDR	SCI inspection
Medical Treatment:	Not injured	Reportedly transported to a local hospital, Medical records unavailable, Injury status unknown

DRIVER INJURY

2003 Chevrolet C1500 Silverado Pick-Up Truck

The 50-year old driver of the Chevrolet was not injured in the crash.

DRIVER KINEMATICS

2003 Chevrolet C1500 Silverado Pick-Up Truck

The 50-year old male driver of the Chevrolet was seated in a presumed normal posture with the seat in a full rear track position. He was unrestrained at the time of the crash. The driver was braking for at least 5 seconds prior to the impact. He may have been anticipating a crash and was probably bracing. The (relatively) low level impact force did not displace the driver forward to a great degree. He was able to prevent any significant interior contact by bracing with his arms and legs. He exited the vehicle without assistance and was uninjured.

FRONT RIGHT PASSENGER INJURY

2003 Chevrolet C1500 Silverado Pick-Up Truck

The police reported hospital had no record of treating this patient. Her injury status is unknown.

FRONT RIGHT PASSENGER INJURY

2003 Chevrolet C1500 Silverado Pick-Up Truck

The 60-year old female front right passenger in the Chevrolet was seated in a presumed normal posture with the seat in a full rear track position. She was unrestrained at the time of the crash. The lack of interior contact evidence suggests that she was able to minimize her interior contacts through probable bracing with her arms and legs. The relatively minor severity of the impact force did not displace the front passenger forward to a significant degree. The passenger's reported injury may have resulted from the efforts of probable bracing.

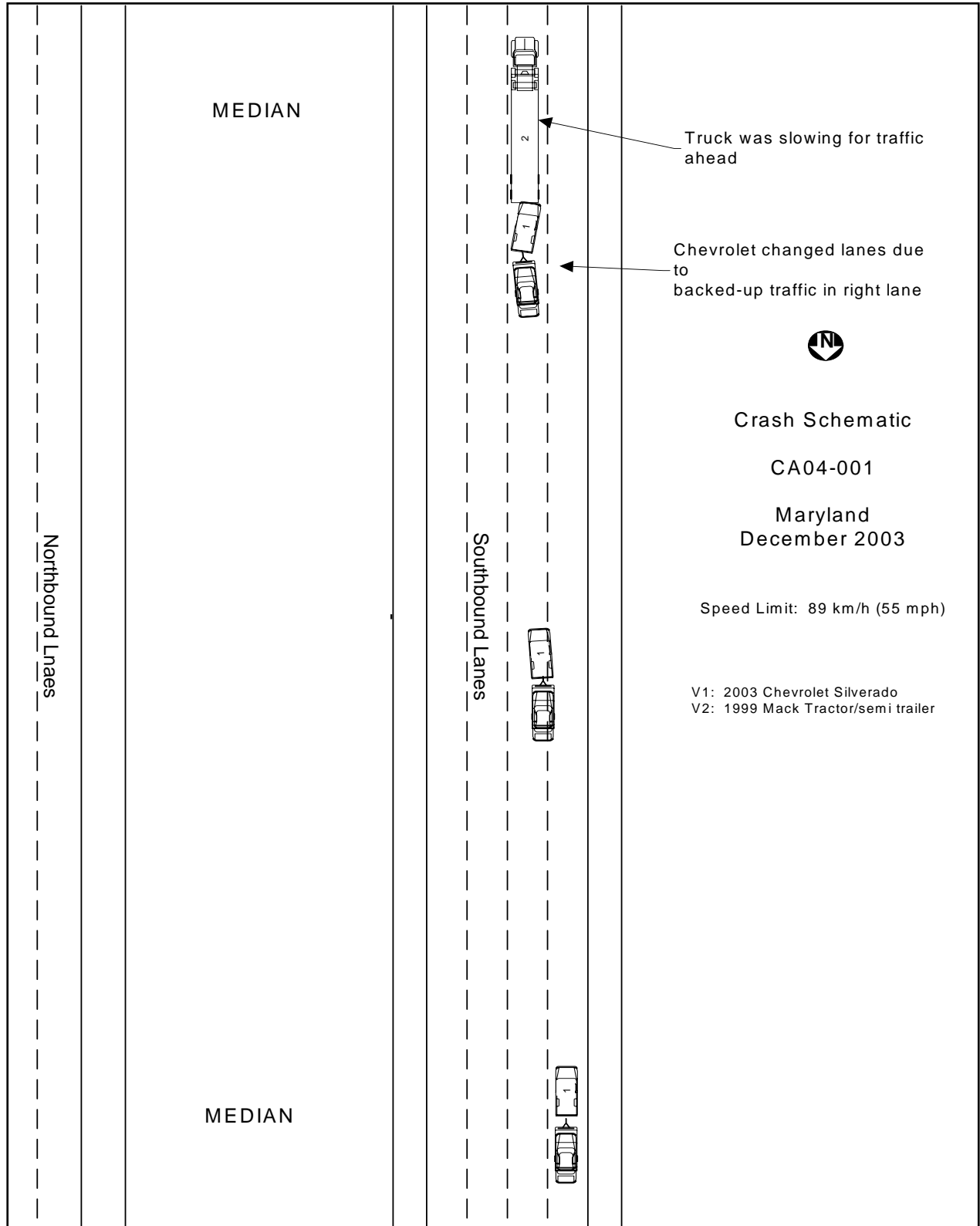


Figure 7: Crash Schematic.

ATTACHMENT A

EDR DATA

CDR File Information

Vehicle Identification Number	1GCEC14X93Zxxxxxx
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	CA04-001 CDR FILE.CDR
Saved on	Monday, January 26 2004 at 12:35:54 PM
Data check information	326B6C56
Collected with CDR version	Crash Data Retrieval Tool 2.24
Collecting program verification number	70CD83DD
Reported with CDR version	Crash Data Retrieval Tool 2.24
Reporting program verification number	70CD83DD
Interface used to collected data	Block number: 00 Interface version: 39 Date: 10-09-03 Checksum: 0300
Event(s) recovered	Non-Deployment

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. 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 deployments 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-deployments, 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 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:

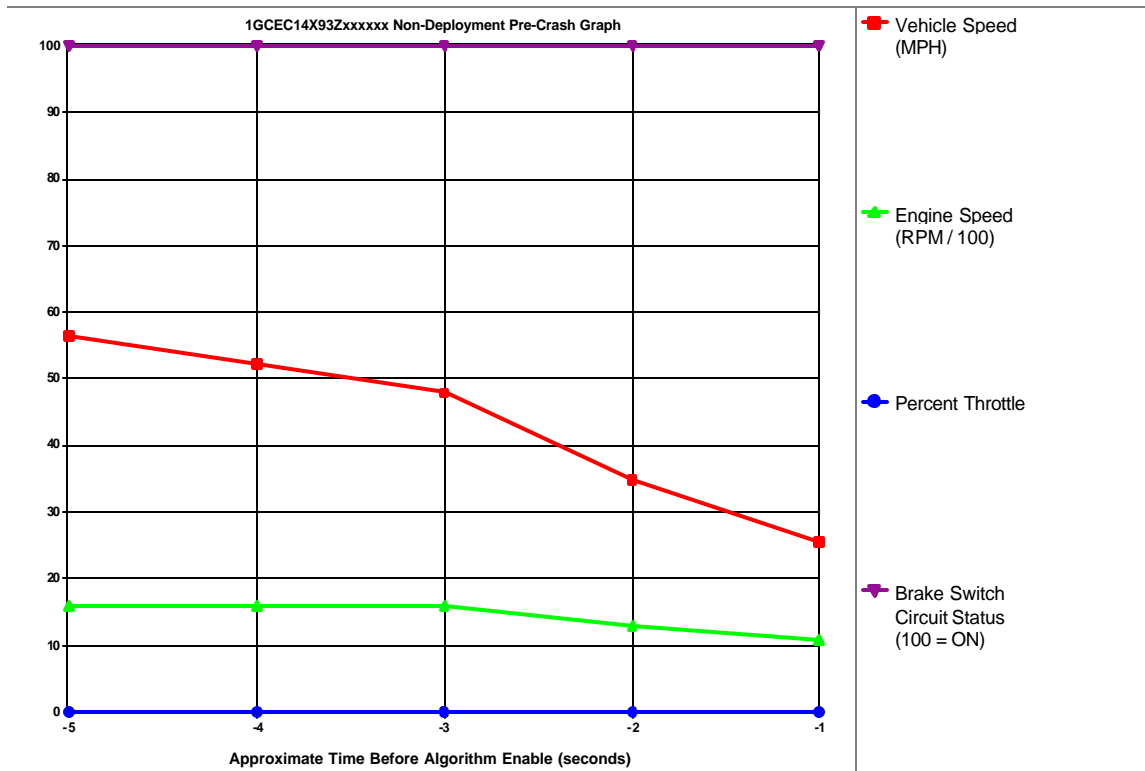
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the Class 2 data link, to the SDM.

-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.

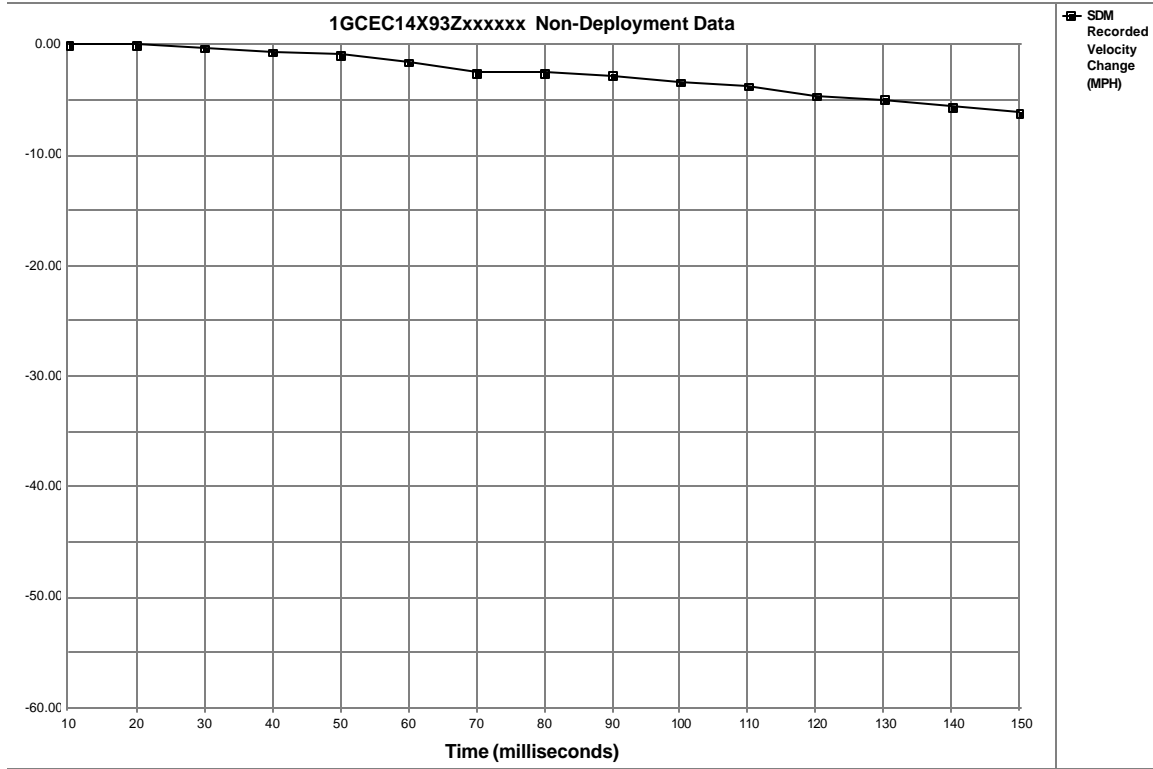
-In most vehicles, the Driver's Belt Switch Circuit is wired directly to the SDM. In some vehicles, the Driver's Belt Switch Circuit Status data is transmitted from the Body Control Module (BCM), via the Class 2 data link, to the SDM.

System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Non-Deployment	1041
Ignition Cycles At Investigation	1042
Maximum SDM Recorded Velocity Change (MPH)	-8.01
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	185
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	57	1600	0	ON
-4	52	1600	0	ON
-3	48	1600	0	ON
-2	35	1344	0	ON
-1	25	1088	0	ON



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	-0.31	-0.62	-0.93	-1.55	-2.48	-2.48	-2.79	-3.41	-3.72	-4.65	-4.96	-5.58	-6.20

Hexadecimal Data

This page displays all the data retrieved from the air bag module.
It contains data that is not converted by this program.

```
$01 F1 26 C4 F8 AE 5A
$02 F1 F1 00 00 B8 00
$03 41 53 32 32 39 33
$04 4B 35 51 51 37 31
$05 00 00 00 00 00 00
$06 15 19 24 46 00 00
$07 00 00 00 00 00 00
$08 00 00 00 00 00 00
$09 00 00 00 00 00 00
$0A 00 00 00 00 00 00
$0B 00 00 00 00 00 00
$0C 00 00 00 00 00 00
$0D 00 00 00 00 00 00
$0E 00 00 00 00 00 00
$0F 00 00 00 00 00 00
$10 FF 7D FC 00 00 00
$11 7C 7B 7D 7D 7C 7E
$12 A5 92 91 24 24 01
$13 FF 02 00 00 00 00
$14 03 03 00 00 6C 00
$15 FA FA FA FA FA FA
$16 FA FA FA FA FA FA
$17 FA FA 00 00 00 00
$18 00 0F 05 AC F1 00
$19 09 00 0A 00 00 64
$1A 00 00 00 00 00 00
$1B 00 00 00 00 00 00
$1C 00 0C 00 00 00 00
$1D 00 00 00 00 00 00
$1F FF 00 00 00 00 00
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$27 08 08 09 0B 0C 0F
$28 10 12 14 00 FF 7D
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$2A FF FF FF FF FF FF
$2B FF FF FF FF FF FF
$2C FF FF FF FF FF FF
$2D FF FF 00 00 00 00
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\$3D FF FF 00 00 00 00
\$40 29 38 4D 54 5B 00
\$41 FC 00 00 00 00 00
\$42 00 00 11 15 19 19
\$43 19 00 7D 80 00 00
\$44 29 38 4D 54 5B 00
\$45 FC 00 00 00 00 00
\$46 00 00 11 15 19 19
\$47 19 00 7D 80 00 00
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\$49 FF FF FF FF FF FF
\$4A FF FF FF FF FF FF
\$4B FF FF FF FF 00 00
\$4C FF FF FF FF FF FF
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\$51 FF FF FF FF FF FF
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\$53 FF FF FF FF FF FF
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