On Site Advanced 208-Compliant Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS02032
2003 Chevrolet Silverado pickup
Washington
December, 2002

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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.

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16. Abstract

This was a two vehicle, rear-end type collision on a freeway. The crash occurred in December, 2002 at 2059 hours in the state of Washington. The crash took place on a three-lane divided northbound freeway. North and south roadways are separated by a concrete wall. The weather was clear and there were no roadway defects indicated. The asphalt roadway was dry. The posted speed limit is 72 km/h (45 mph) and there were no traffic controls present. The case vehicle was a 2003 Chevrolet Silverado LS C1500 four door extended cab pickup that was driven by a restrained 62-year-old male. The other vehicle was a 2000 Ford Focus station wagon. The case vehicle was traveling northbound in the far right lane. The Focus had stalled and come to a stop in the far right lane with its emergency flashers activated. The driver of the Focus was out of the vehicle and on the roadway shoulder. The driver of the case vehicle did not see the Focus until it was too late and the case vehicle rear-ended the Focus. The driver's air bag in the case vehicle deployed on impact. The front right passenger's air bag did not deploy. No injuries were reported by the driver of the case vehicle. The case vehicle sustained moderate front end damage. Both vehicles were towed from the scene. The case vehicle was later declared a total loss by the insurance company and was going to be sold at an auto salvage auction.

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Dynamic Science, Inc.
Crash Investigation
Case Number: DS02032

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BACKGROUND:

Description:	This Advanced 208-Compliant Vehicle Investigation was identified by the local National Automobile Sampling System Primary Sampling Unit. The multi-stage air bags were certified by the manufacturer to meet the Advanced Air Bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) 208. The case was reported to DSI on December 18, 2002 with instructions to locate the vehicle for an on-scene investigation. All field work was completed on February 1, 2003.
Investigation Type:	On Site Advanced 208-Compliant Investigation
Crash Location:	Washington
Crash Date:	December, 2002
Notification Date:	December 18, 2002
Field Work Completed:	February 1, 2003

SUMMARY

Crash Site

This was a two vehicle, rear-end type collision on a freeway. The crash occurred in December, 2002 at 2059 hours in the state of Washington. The crash took place on a three-lane divided northbound freeway. North and south roadways are separated by a concrete wall. The weather was clear and there were no roadway defects indicated. The asphalt roadway was dry. The posted speed limit is 72 km/h (45 mph) and there were no traffic controls present.

Figure 1. Approximate impact area (north)

Figure 2. Exterior damage–case vehicle

Pre-Crash

The case vehicle was a 2003 Chevrolet Silverado LS C1500 four door extended cab pickup that was driven by a restrained 62-year-old male (178 cm/70 in, 104 kg/229 lbs). The other vehicle was a 2000 Ford Focus station wagon. The case vehicle was traveling northbound in the far right lane. The Focus had stalled and come to a stop in the far right lane with its emergency flashers activated. The driver of the Focus was out of the vehicle and on the roadway shoulder.

Crash

The driver of the case vehicle did not see the Focus until it was too late and the case vehicle rear-ended (12FDEW1) the Focus. The driver's air bag in the case vehicle deployed on impact. The front right passenger's air bag did not deploy. The total velocity change for the case vehicle as calculated by the Missing Vehicle algorithm of the WinSmash collision model was 24.0 km/h (14.9 mph)[1]. The longitudinal and lateral delta V components were -24.0 km/h (-14.9 mph) and 0 km/h (0 mph), respectively. The results fit the collision model, but appear high.

Post-Crash

No injuries were reported by the driver of the case vehicle.

The case vehicle sustained moderate front end damage. Both vehicles were towed from the scene. The case vehicle was later declared a total loss by the insurance company and was going to be sold at a auto salvage auction.

[1]Calculated using stiffness values derived from NCAP test 3214

VEHICLE DATA - 2003 Chevrolet Silverado LS 1500 extended cab 4x2 pickup

The 2003 Chevrolet Silverado LS 1500 extended cab 4x2 pickup was equipped with a four-speed automatic transmission, rear wheel drive, 4-wheel disc brakes, 4-wheel ABS, a tilt steering wheel, cruise control, rear opening driver and passenger side rear doors, and power windows.

VIN:	1GCEC19TX3Zxxxxxx
Odometer:	2570 km (1597 miles)
Engine:	5.3 L, V8
Reported Defects:	None
Cargo:	None

The 2003 Chevrolet Silverado pickup was equipped with General Ameritrac P255/70R16 tires. The specific tire data is as follows:

Tire	Tread	Pressure	Recommended pressure
LF	8 mm (10/32 in)	193 kPa (28 psi)	303 kPa (44 psi)
LR	8 mm (10/32 in)	193 kPa (28 psi)	303 kPa (44 psi)
RF	9 mm (11/32 in)	200 kPa (29 psi)	303 kPa (44 psi)
RR	9 mm (11/32 in)	200 kPa (29 psi)	303 kPa (44 psi)

The front seating positions in the 2003 Chevrolet Silverado pickup were configured with fabric covered bucket seats adjustable head restraints. The rear seating positions were configured with a split bench seat with adjustable head restraints for the outboard positions.

VEHICLE DAMAGE

Exterior Damage - 2003 Chevrolet Silverado pickup

Damage Description:	Minor to moderate frontal damage to bumper and grille. The police report indicated that the vehicle had been towed due to damage. Vehicle declared a total loss by insurance company.	
CDC:	12FDEW1	
Delta V:	Total	24.0 km/h (14.9 mph)
	Longitudinal	-24.0 km/h (-14.9 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	25,771 joules (19,008 ft lbs)

During the initial impact, the case vehicle sustained 170 cm (67 in) of direct and induced contact damage that extended across the entire frontal end width of the vehicle. The impact energy was managed by the forward structures of the vehicle. The damaged components included the bumper fascia and reinforcement bar, upper and lower radiator supports, the grille area, and the hood. Six crush measurements were documented at the bumper level: Cl= 4 cm (2 in), C2=10 cm (4 in), C3= 19 cm (7 in), C4=19 cm (7 in), C5=11 cm (4 in), C6= 7 cm (3 in). A Collision Deformation Classification of 12FDEW1 was assigned to the damage. The principal direction of force was within the 12 o'clock sector and was an estimated 0 degrees. There was no reduction of either wheelbase. All doors remained closed and operational, and there was no glazing damage.

Figure 3. Front, case vehicle

Interior Damage - 2003 Chevrolet Silverado pickup

There was no interior damage beyond the deployed driver's air bag and the displaced plastic cover for the driver's shoulder harness. There was no intrusion and there were no occupant contacts.

MANUAL RESTRAINT SYSTEMS - 2003 Chevrolet Silverado pickup

Figure 4. Driver's displaced plastic cover

The case vehicle was equipped with seat integrated driver's and front right passenger's manual restraint system which consisted of continuous loop 3-point lap and shoulder safety belts with sliding latch plates. The driver's safety seat belt contained an emergency locking retractor that was integrated into the driver's bucket seat. The driver's safety seat belt showed evidence of loading. The webbing was frayed and the plastic cover around where the belt retracted into was dislodged. The front right passenger's safety seat belt contained a switchable retractor (emergency locking to automatic locking) that was integrated into the front right passenger's bucket seat. The metal tongue portion of the seat belt latch showed evidence of historical usage in the form of latch scratching. The front right seat was also equipped with Lower Anchors and Tethers for Children (LATCH). The 2nd row bench seat with a folding back was equipped with manual restraint system which consisted of continuous loop 3-point lap and shoulder safety belts with sliding latch plates using switchable emergency/automatic locking retractors at both outboard seat positions. The 2nd row middle seat was equipped with a manual lap safety seat belt with a locking latch plate. The 2nd row middle seat was equipped with a LATCH system.

FRONTAL AIR BAG SYSTEM - 2003 Chevrolet Silverado pickup

The case vehicle was equipped with advanced, dual stage driver and front right passenger air bags. The driver's air bag was mounted in the steering wheel hub. The driver's air bag was circular and measured 65 cm (26 in.) in diameter. The air bag had a maximum deflated excursion of 23 cm (9 in). It was equipped with two internal tether straps and two vent ports. The vent ports were 2.5 cm (1 in) in diameter and were located at the 11 and 1 o'clock positions. The dual module cover flaps opened in an "I" type configuration. The left and right flaps each measured 12 cm (5 in) high by 7 cm (3 in) wide. There were no indications of any damage to driver's air bag or the module cover flaps. On the face of the air bag there were vinyl transfers to the membrane from expansion within the module. The face of the air bag exhibited 12 horizontal and 10 vertical folds. The front right passenger air bag was a mid instrument panel mount and did not deploy. The passenger air bag switch was set to AUTO and the front right seat was unoccupied. The front right seat weight sensor sensed that no occupant was in the front right seat, and the SDM suppressed the front right passenger's air bag.

Figure 5. Driver's advanced air bag

Figure 6. Non-deployed front right advanced air bag

The case vehicle was equipped with advanced occupant protection systems. The systems consists of the SDM, dual stage driver and front right passenger air bags with passenger air bag Off Switch, a front right Passenger Sensing System, and a driver's seat belt latch usage detector. The system is controlled by the SDM. The primary function of the SDM is to control the deployment of the occupant protection system. The system records the vehicle's forward velocity change. The SDM will record 100 milliseconds of data after the deployment criteria is met and up to 50 milliseconds of data before deployment criteria is met.

Figure 7. Front right passenger air bag cut off switch

The SDM data was downloaded using the Vetronix Crash Data Retrieval System. The Vetronix report[2] indicated that:

1. The SIR warning lamp status was OFF.
2. The driver's belt switch circuit status was BUCKLED.
3. Ignition cycles at deployment were 666.
4. Ignition cycles at investigation were 675.
5. Maximum SDM recorded velocity change was -11.15 km/h (-6.93 mph).
6. The time from algorithm enable (AE) to maximum recorded velocity change was 117.5 milliseconds
7. Driver first stage time algorithm enabled to deployment command criteria met was 35 milliseconds.
8. There was no driver's second stage deployment.
9. The front right passenger air bag was suppressed[3].
10. The brake switch circuit status was ON three seconds prior to AE.
11. The vehicle speed was 84 km/h (52 mph) five seconds prior to AE. The vehicle speed had decelerated to 52 km/h (32 mph) one second prior to AE.

[2] See Attachment 1

[3]The air bag suppression switch was set to AUTOMATIC.

VEHICLE DATA - 2000 Ford Focus

Description:	2000 Ford Focus station wagon	
VIN:	1FAFP36P6YWxxxxxx	
Odometer:	Unknown	
Engine:	2.0 L, 4 cylinder	
Reported Defects:	None	
Cargo:	Unknown	
Damage Description:	Moderate rear end damage. Vehicle towed from the scene.	
CDC:	Unknown	
Delta V:	Total	38.0 km/h (23.6 mph)
	Longitudinal	38.0 km/h (23.6 mph)
	Latitudinal	0 km/h (0 mph)
	Energy	84,576 joules (62,380 ft lbs)

OCCUPANT DEMOGRAPHICS - 2003 Chevrolet Silverado pickup

	Driver
Age/Sex:	62/Male
Seated Position:	Front left
Seat Type:	Fabric covered bucket seat. Seat adjusted to the rear most track position. Seat back slightly reclined.
Height:	178 cm (70 in)
Weight:	104 kg (229 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	>20 years
Body Posture:	Normal, upright
Hand Position:	Both hands on steering wheel, unknown clock direction
Foot Position:	Right foot on brake, left on floorboard.
Restraint Usage:	Integral lap and shoulder belt available, used.
Air bag:	Steering wheel mounted air bag available, deployed.

OCCUPANT INJURIES - 2003 Chevrolet Silverado pickup

	Injury	OIC Code	Injury Mechanism	Confidence Level
Driver:	Not injured			

OCCUPANT KINEMATICS - 2003 Chevrolet Silverado pickup

The 62-year-old male driver of the case vehicle was seated in a normal, upright fashion. He was seated in a fabric covered bucket seat. The seat adjusted to the rear most track position. The seat back slightly reclined. The driver was wearing the seat-integrated 3-point lap and shoulder belt. He had both hands on the steering wheel. At some prior to impact, the driver noticed the stopped Ford Focus. The driver began braking with his right foot. The vehicle began to decelerate and the driver likely exhibited some forward motion. At impact with the Ford Focus, the driver's air bag deployed and the driver exhibited a forward trajectory. He engaged and loaded the lap and shoulder belt–causing minor damage to the plastic shoulder harness egress area in the driver's seat back. His face and torso likely engaged the deployed air bag, though there were no indications of contact. The driver did not sustain any injuries.

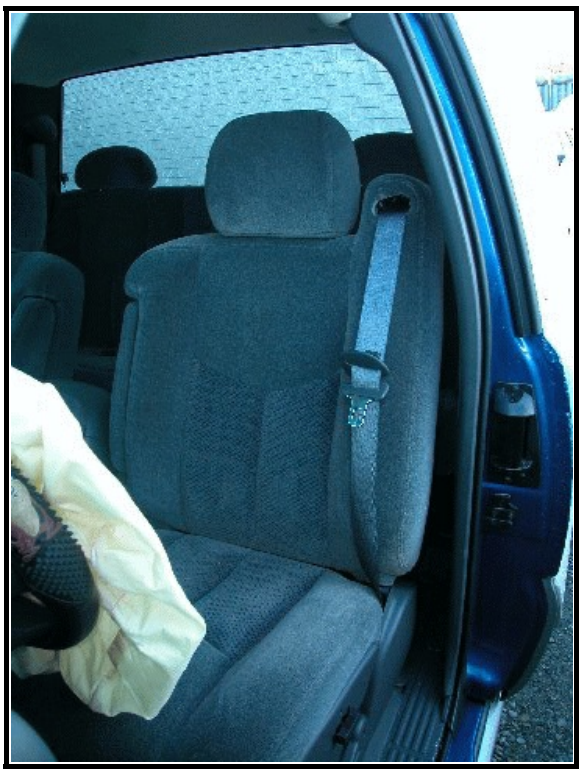


Figure 8. Driver's seat/shoulder belt

Attachment 1 - Scene Diagram

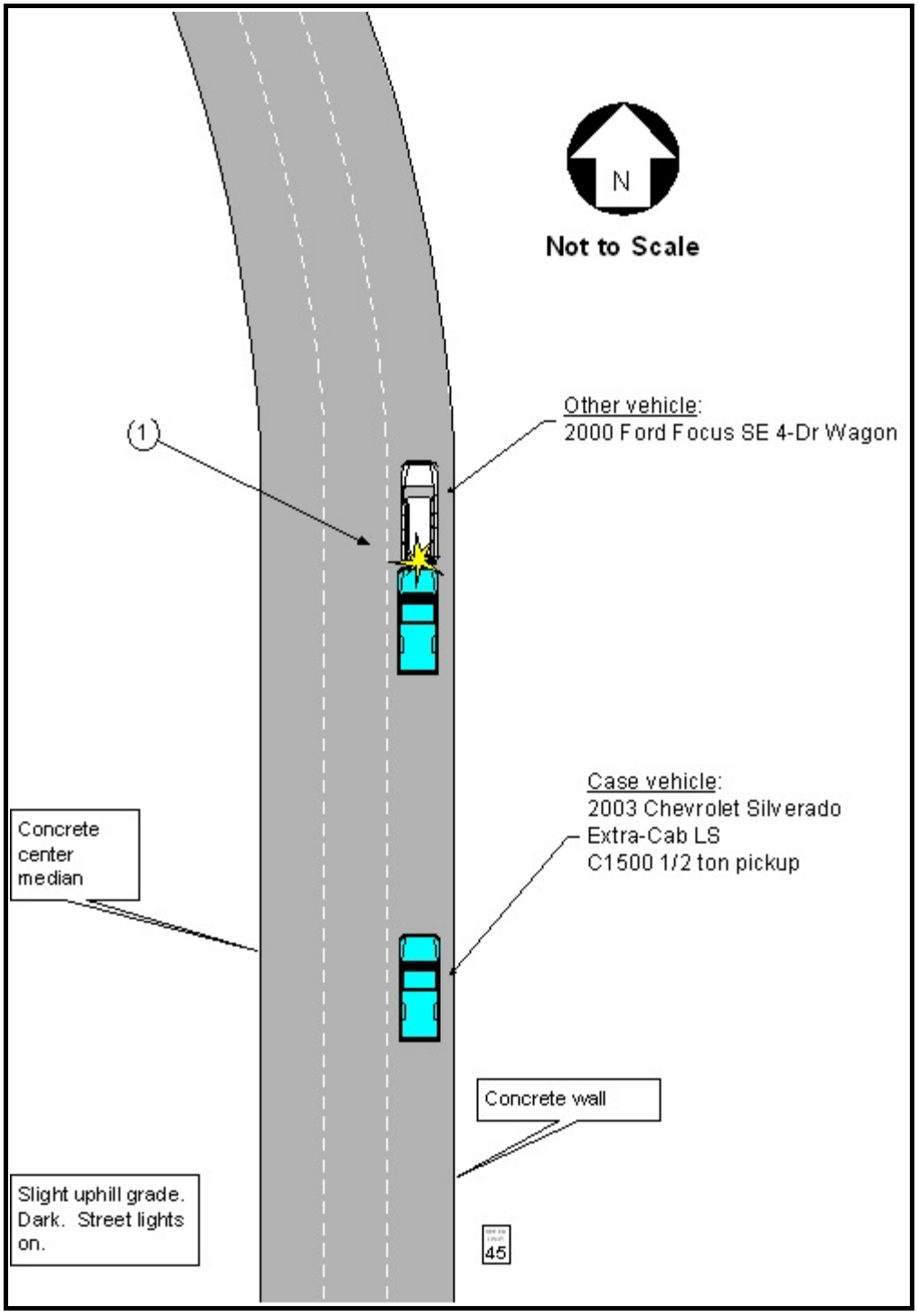


Figure 9. Scene diagram

Attachment 2. Vetronix output

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM

Vehicle Identification Number	1GCEC19TX3Zxxxxxx
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	DS02-032.CDR
Saved on	12/23/02 8:24:59 AM
Data check information	87008E0
Collected with CDR version	Crash Data Retrieval Tool 1.680
Collecting program verification number	337F4D2C
Reported with CDR version	Crash Data Retrieval Tool 1.680
Reporting program verification number	337F4D2C
Event(s) recovered	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.

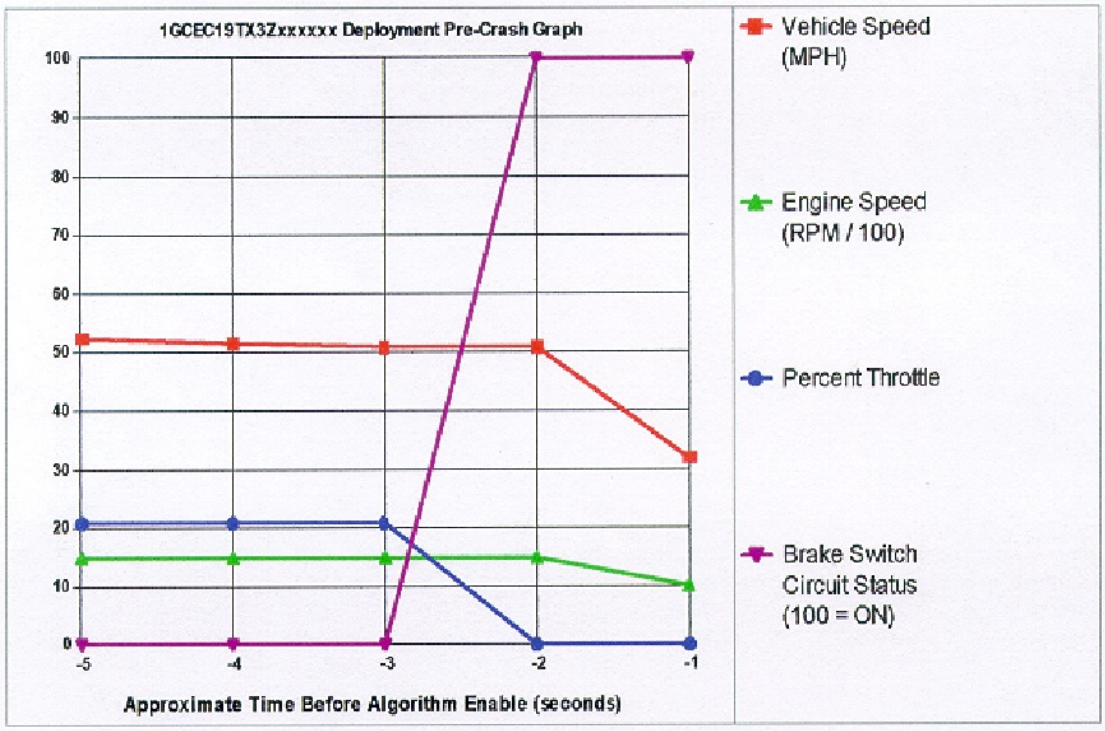
SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change is one of the measures used to make air bag deployment decisions. SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. This 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 for any of the four Pre-Crash data parameters (Vehicle Speed, Engine Speed, Percent Throttle, and Brake Switch Circuit Status).
-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.

Vetronix CDR CRASH DATA RETRIEVAL SYSTEM

System Status At Deployment

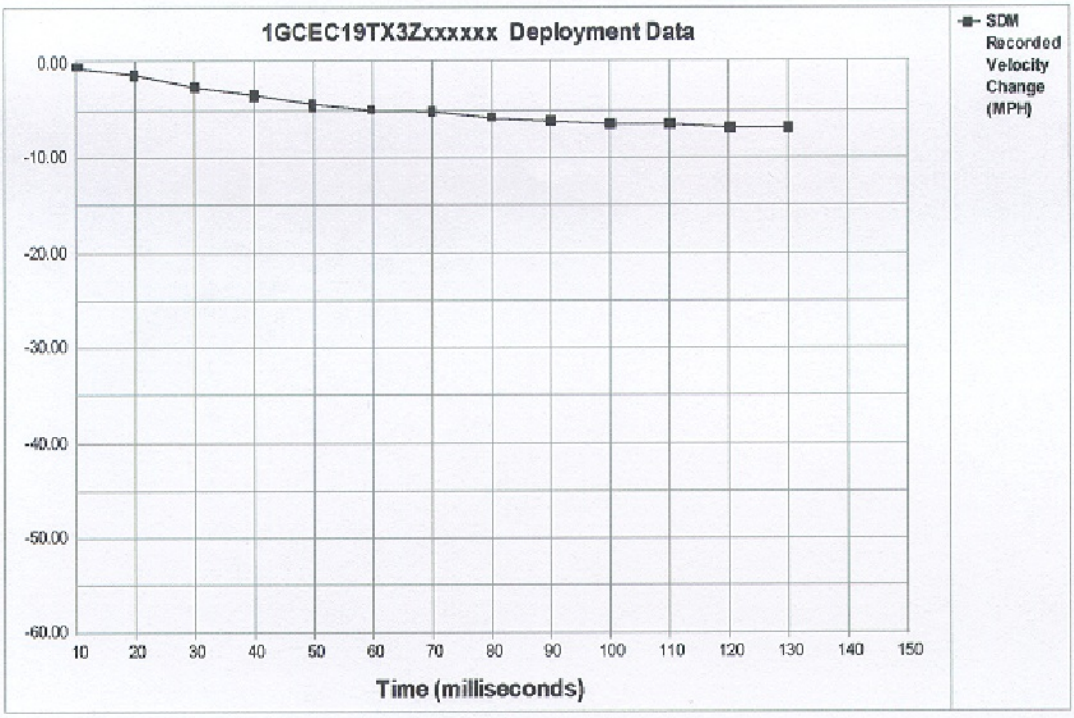
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	666
Ignition Cycles At Investigation	675
Maximum SDM Recorded Velocity Change (MPH)	-6.93
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	117.5
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	35
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Time Between Non-Deployment And Deployment Events (sec)	N/A
Frontal Deployment Level Event Counter	1
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	52	1536	21	OFF
-4	52	1536	21	OFF
-3	51	1536	21	OFF
-2	51	1472	0	ON
-1	32	960	0	ON

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.62	-1.24	-2.48	-3.41	-4.34	-4.96	-5.27	-5.89	-6.20	-6.51	-6.51	-6.82	-6.82	N/A	N/A