Certified Advanced 208 Compliant Investigation / Vehicle to Object
Dynamic Science, Inc. / Case Number: DS04023
2004 Chevrolet Silverado
Washington
October, 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.

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16. Abstract

This on-site investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) supplemental restraint system in a 2004 Chevrolet Silverado pickup. The vehicle was being driven by a 64-year-old male. The front right seat was occupied by a 61-year-old female. The crash occurred on a two-lane, elevated exit from a northbound interstate highway. The exit begins as a straight roadway that transitions to a sharp right hand curve. The curve is bordered on both sides by concrete walls. The Silverado departed the road on the left side and struck a concrete wall. The impact resulted in sufficient longitudinal deceleration to command the deployment of the frontal air bag system. The driver was not injured. The front right occupant sustained a rib fracture, a hip contusion, and a neck strain. There was no on scene treatment. The Silverado was towed from the scene and later declared a total loss.

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Dynamic Science, Inc.
Crash Investigation
Case Number: DS04023

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BACKGROUND:

Description: This on-site investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) supplemental restraint system in a 2004 Chevrolet Silverado pickup. The multi-stage air bags were certified by the manufacturer to meet the advanced air bag requirement of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The vehicle was being driven by a 64-year-old male. The front right seat was occupied by a 61-year-old female. The Silverado departed the road on the left side and struck a concrete wall. The impact resulted in sufficient longitudinal deceleration to command the deployment of the frontal air bag system. The driver was not injured. The front right occupant sustained a rib fracture, a hip contusion, and a neck strain. There was no on scene treatment. The Silverado was towed from the scene.

This CAC case was identified during a review of GES police reports. The case was faxed to DSI on November 24, 2004 with instructions to locate the vehicle. Since the time of the crash the vehicle had been moved to a repair facility, declared a total loss, and then moved to a salvage facility. DSI located the vehicle and obtained permission to conduct the inspection. All field work was completed on December 6, 2004.

Investigation Type:	Certified Advanced 208 Compliant
Crash Location:	Washington
Crash Date:	October, 2004
Notification Date:	November 24, 2004
Field Work Completed:	December 6, 2004

SUMMARY

Crash Site

This single vehicle crash occurred in October, 2004 at 1049 hours in the state of Washington. The crash occurred on a two-lane, elevated exit from a northbound interstate highway. The exit begins as a straight roadway that transitions to a sharp right hand curve. The curve is bordered on both sides by concrete walls. On the left side there is a painted yellow line that is 0.9 m (3 ft) from the wall. The two travel lanes are separated by a solid white line. The off-ramp terminates at a

Figure 1. Area of impact with concrete wall--north

T intersection which is controlled by a tri-color traffic signal. The weather was clear and the concrete roadway was dry. There is a cautionary speed limit of 24 km/h (15 mph).

Figure 2. Looking back view from area of impact–south

Pre-Crash

The case vehicle is a 2004 Chevrolet Silverado K1500 extended[1] cab 4x4 pickup truck (VIN: 2GCEK19TX411xxxxxx) that was being driven by a lap and shoulder belt restrained 64-year-old male (183 cm/72 in, 62 kg/136 lbs). The front right seat was occupied by a lap and shoulder belt restrained 61-year-old female (163 cm/64 in, 79 kg/174 lbs). The front right air bag shut off switch was in the AUTO position.

The Silverado was traveling northbound and exited the freeway. The vehicle was traveling within the confines of the elevated off-ramp. According to the Electronic Data Recorder (EDR) readout, the vehicle was traveling at 103 km/h (64 mph) five seconds before Algorithm Enable (AE). The driver had applied his brakes.

Figure 3. Front, 2004 Chevrolet Silverado

Crash

The case vehicle entered the right hand curve too fast and the vehicle departed the roadway to the left. It first struck the concrete wall with its front left (12FLEW2). The total velocity change for the case vehicle as calculated by the barrier algorithm of the WinSmash collision model was 20.6 km/h (12.8 mph). The longitudinal and lateral delta V components were -20.5 km/h (-12.7 mph) and 1.8 km/h (1.1 mph), respectively. Both front air bags deployed at this time. The case vehicle glanced off the wall slightly and then lightly engaged the wall with its left rear tire and the left rear most portion of the pickup box (12LBES1).

Figure 4. Left, 2004 Chevrolet Silverado

[1]Extendeds have rear-hinged back doors that don't open independently of the fronts.

Post-Crash

The vehicle came to rest on the roadway facing northeast. Both occupants were able to exit the vehicle on their own. The driver reported soreness to his lower back. The front right occupant sustained a fracture to the 8th anterior rib on the left side, a neck strain, and a contusion to the left hip. Neither party was treated at the scene. The front right occupant went to her doctor several days later. She has also gone to her chiropractor to seek treatment for the neck strain.

The case vehicle was towed from the scene and was later declared a total loss.

Figure 5. Left side, impact 2

VEHICLE DATA - 2004 Chevrolet Silverado K1500 extended cab 4x4 pickup truck

The 2004 Chevrolet Silverado K1500 series pickup was identified by its Vehicle Identification Number (VIN): 2GCEK19TX411xxxxxx. The Silverado extended cab pickup was equipped with a 5.3 liter, V-8 engine, four-wheel drive, power 4 wheel disc brakes with 4 wheel ABS, 4 speed electronically controlled automatic transmission, power steering, tilt steering wheel, and daytime running lights. There were no reported defects.

The 2004 Chevrolet Silverado was equipped with Goodyear Wrangler ST P245/75R16 tires. The specific tire data is as follows:

Tire	Tread	Measured Pressure	Restricted	Damage	Maximum pressure
LF	9 mm (11/32 in)	138 kPa (20 psi)	No	No	241 kPa (35 psi)
LR	6 mm (8/32 in)	221 kPa (32 psi)	No	No	241 kPa (35 psi)
RF	7 mm (9/32 in)	262 kPa (38 psi)	No	No	241 kPa (35 psi)
RR	5 mm (6/32 in)	234 kPa (34 psi)	No	No	241 kPa (35 psi)

The three front seating positions in the 2004 Chevrolet Silverado were configured with a cloth covered, 40/20/40 split bench seat. The seat was adjusted to one stop from the rear most track position. The outboard seat positions were equipped with adjustable head restraints that were in the full down position and were not damaged. The three second row seating positions were configured with a cloth covered bench seat. The outboard seat positions were equipped with adjustable head restraints that were in the full down position and were not damaged.

Figure 6. Overview of vehicle interior

VEHICLE DAMAGE

Exterior Damage - 2004 Chevrolet Silverado

Damage Description:	Moderate front end damage. Rearward crush damage to the left bumper, left grille, and left fender. Direct damage extends 83.0 cm (32.6 in) down left side and includes rim damage.	
CDC:	Impact 1: 12FLEW2 Impact 2: 12LBES1	
Delta V (impact 1):	Total	20.6 km/h (12.8 mph)
	Longitudinal[2]	-20.5 km/h (-12.7 mph)
	Latitudinal	1.8 km/h (1.1 mph)
	Energy	37,622 joules (27,748 ft lbs)

The Chevrolet Silverado sustained moderate front end damage as a result of the initial impact with the concrete wall. The direct damage began the left bumper corner and extended laterally 44.0 cm (17.3 in). The combined direct and induced damage measured 176.0 cm (69.3 in) and involved the entire front bumper. Six crush measurements were documented at the bumper level as follows: C1=37.0 cm (14.6 in), C2=18.0 cm (7.1 in), C3=7.0 cm (2.8 in), C4=1.0 cm (0.4 in), C5=0 cm (0 in), C6=0 cm (0 in).

Figure 7. Front left, Chevrolet Silverado

[2]The results are inconsistent with the EDR readout. The reasons for this are not known.

Interior Damage - 2004 Chevrolet Silverado

The interior damage to the Chevrolet Silverado was limited to the residual damage from air bag deployments. There was no intrusion. All the doors remained closed and operational. All the glazing remained in place. There was a U shaped fracture to the windshield which based out below the level of the mirror. There was no steering wheel rim deformation. There were no visible occupant contacts.

MANUAL RESTRAINT SYSTEMS - 2004 Chevrolet Silverado

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 metal tongue portion of the seat belt latch showed evidence of historical usage in the form of latch scratching. 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 2nd row bench seat 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.

Figure 8. Integral driver's lap and shoulder belt

FRONTAL AIR BAG SYSTEM - 2004 Chevrolet Silverado

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 deployed driver's air bag was vaguely oblong and measured 65.8 cm (25.9 in.) high by 50.0 cm (19.7 in) wide. It was equipped with one internal tether strap and two vent ports (11 and 1 o'clock positions). The dual module cover flaps opened in an "I" type configuration. There were no indications of any damage to driver's air bag or the module cover flaps. There were 20 horizontal folds and 9 vertical folds. The front right passenger air bag was a mid instrument panel mount. The deployed front right passenger air bag was generally rectangular and measured 61.0 cm (24.0 in) high by

Figure 9. Deployed driver's air bag

50.0 cm (19.7 in) wide. There was a single module cover that measured 38.5 cm (15.2 in) wide by 12.0 cm (4.7 in) high. There were two vent ports (3 and 9 o'clock positions). There were no tethers. There was no damage nor any contacts to either the air bag or the module cover.

Figure 10. Deployed front right passenger 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 a 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. The SDM data was downloaded using the Vetronix Crash Data Retrieval System. The Vetronix report indicates that there were two events (See Attachment 2).

Deployment Event

1. The SIR warning lamp status was OFF.
2. The driver's belt switch circuit status was BUCKLED.
3. Ignition cycles at deployment were 1367.
4. Ignition cycles at investigation were 1393.
5. Maximum SDM recorded velocity change was -10.83 km/h (-6.73 mph).
6. The time from algorithm enable (AE) to maximum recorded velocity change was 160 milliseconds
7. Driver first stage time algorithm enabled to deployment command criteria met was 25 milliseconds.
8. There was no driver's second stage deployment.
9. Passenger first stage time algorithm enabled to deployment command criteria met was 25 milliseconds.
10. There was no passenger second stage deployment.
11. The brake switch circuit status was ON five seconds before AE.
12. The vehicle speed was 103 km/h (64 mph) five seconds before AE. The vehicle speed decelerated to 55 km/h (34 mph) one second before AE.

Non Deployment Event

1. The SIR warning lamp status was OFF.
2. The driver's belt switch circuit status was BUCKLED.
3. Ignition cycles at deployment were 1367.
4. Ignition cycles at investigation were 1393.
5. Maximum SDM recorded velocity change was -3.02 km/h (-1.88 mph).
6. The time from algorithm enable (AE) to maximum recorded velocity change was 102.5 milliseconds.
7. The brake switch circuit status was ON five seconds before AE.
8. The vehicle speed was 103 km/h (64 mph) five seconds before AE. The vehicle speed decelerated to 55 km/h (34 mph) one second before AE.

OCCUPANT DEMOGRAPHICS - 2004 Chevrolet Silverado

	Occupant 1	Occupant 2
Age/Sex:	64/Male	61/Female
Seated Position:	Front left	Front right
Seat Type:	40/20/40 split bench, cloth covered, seat adjusted to between mid and rear most track position, head restraint in full down position	40/20/40 split bench, cloth covered, seat adjusted to between mid and rear most track position, head restraint in full down position
Height:	183 cm (72 in)	163 cm (64 in)
Weight:	62 kg (136 lbs)	79 kg (174 lbs)
Occupation:	Not working	Not working
Pre-existing Medical Condition:	Unknown	Unknown
Alcohol/Drug Involvement:	None	None
Driving Experience:	Greater than 25 years	NA
Body Posture:	Normal, upright	Normal, upright
Hand Position:	Both hands on steering wheel	Unknown
Foot Position:	Right foot on brake, left on floor	Both feet on floor
Restraint Usage:	Integral lap and shoulder belt available, used	Integral lap and shoulder belt available, used
Air bag:	Steering wheel mounted air bag available, deployed	Mid instrument panel mounted air bag available, deployed

OCCUPANT INJURIES -2004 Chevrolet Silverado

	Injury	OIC Code	Injury Mechanism	Confidence Level
Driver:	Soreness to lower back	Not codeable		
RF Occupant:	Fracture, 8th anterior rib on the left side	450212.1,2	Shoulder harness	Certain
	Neck strain	640278.1,6	Shoulder harness	Certain
	Contusion, left hip	590402.1,2	Lap belt	Certain

OCCUPANT KINEMATICS - 2004 Chevrolet Silverado

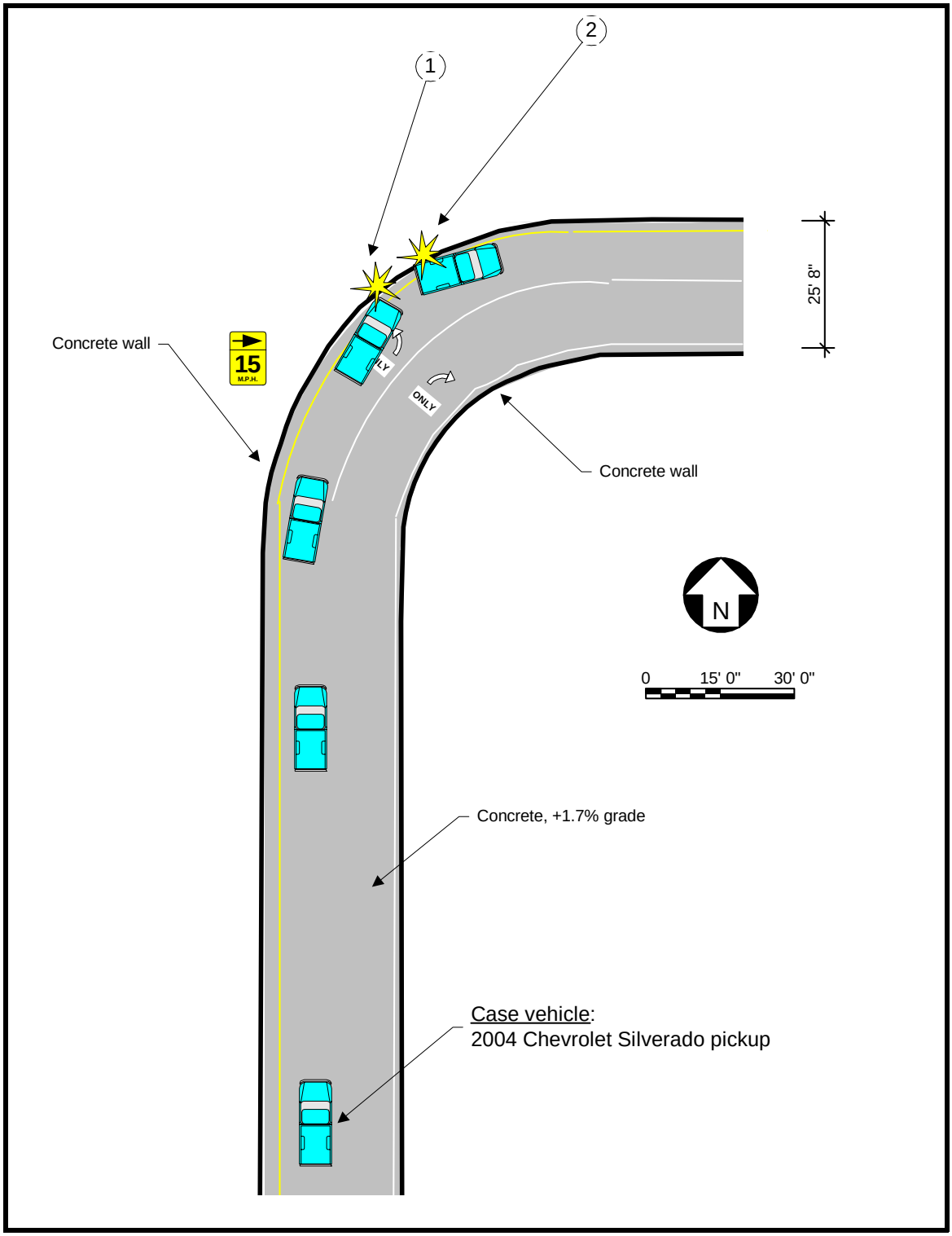
Driver kinematics:

The 64-year-old male driver of the Chevrolet Silverado was seated in an upright posture and restrained by the 3-point manual lap and shoulder belt. The 40/20/40 cloth covered split bench seat was adjusted to between the mid and rear most track position. The seat back was slightly reclined and the head restraint was in the full down position. The driver was actively braking with his right foot; his left foot was on the floor. Both hands were on the steering wheel and the driver was steering to the right. At impact with the concrete wall, the frontal air bags deployed. The driver initiated a forward and slightly left trajectory. He engaged and loaded the manual lap and shoulder belt. There was likely some contact from the deployed air bag, but there was no residual evidence of contact. There was a second impact with the wall that was relatively minor. The driver remained in place until the vehicle came to rest. The driver complained of pain to his lower back. He was able to exit the vehicle on his own. He was uninjured and was not treated.

Front right seat occupant kinematics:

The 61-year-old female front right passenger was seated in an upright posture and restrained by the 3-point manual lap and shoulder belt. The 40/20/40 cloth covered split bench seat was adjusted to between the mid and rear most track position. The seat back was slightly reclined and the head restraint was in the full down position. The driver was actively braking and steering to the right. This occupant was likely leaning to the left prior to impact. At impact with the concrete wall, the frontal air bags deployed. This occupant initiated a forward and slightly left trajectory. She engaged and loaded the manual lap and shoulder belt–causing a contusion to the left hip from the lap belt and a fracture to the anterior 8th rib from the shoulder belt. Her head pitched forward which likely caused the neck strain. She engaged the deployed air bag with her face, there were no facial injuries from this contact.

Attachment 1. Scene Diagram



Attachment 2. EDR report

CDR File Information

Vehicle Identification Number	2GCEK19TX41xxxxxx
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	DS04023WITHOUTSEQUENCENUMBER.CDR
Saved on	Monday, December 6 2004 at 10:08:17 AM
Data check information	EF3603DB
Collected with CDR version	Crash Data Retrieval Tool 2.50
Collecting program verification number	30CAB595
Reported with CDR version	Crash Data Retrieval Tool 2.50
Reporting program verification number	30CAB595
Interface used to collected data	Block number: 00 Interface version: 3F Date: 08-06-04 Checksum: 6700
Event(s) recovered	Deployment 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 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 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.

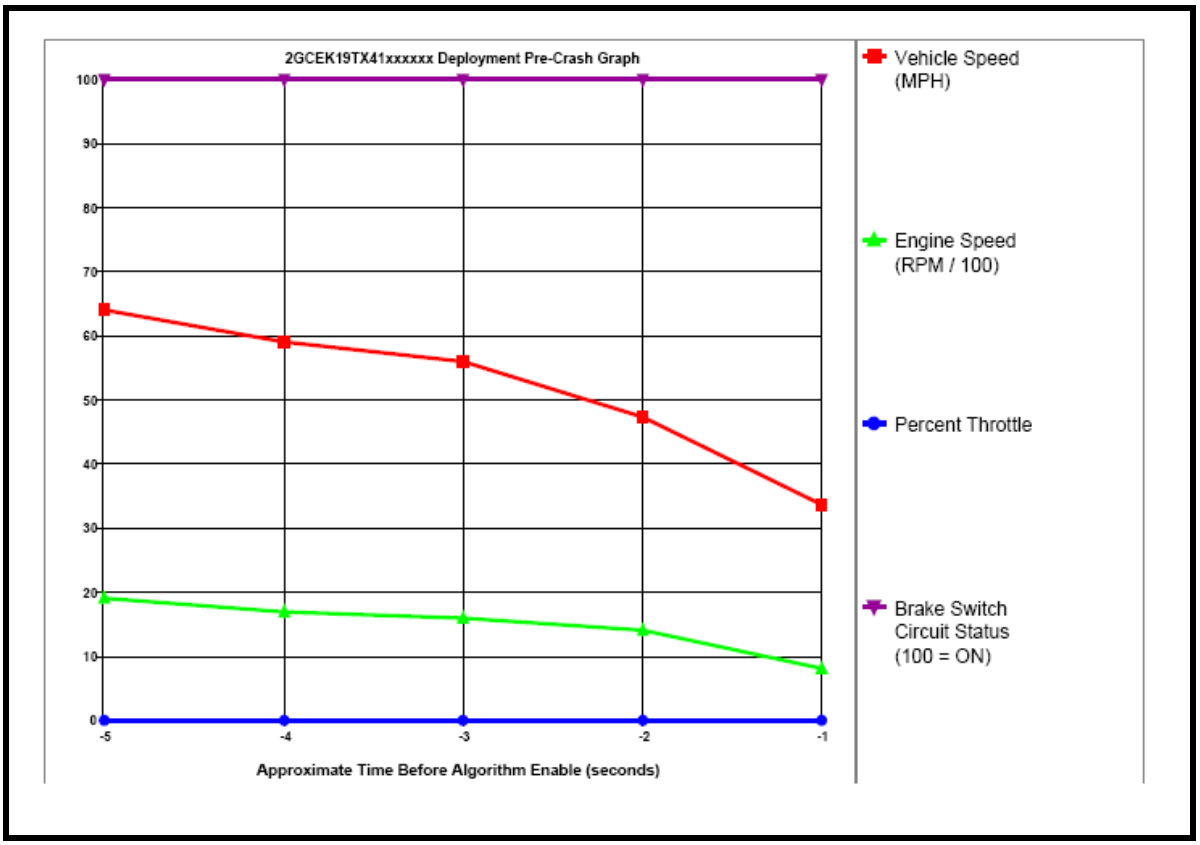
SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Forward Velocity Change is the change in velocity during the recording time and is not the speed 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.

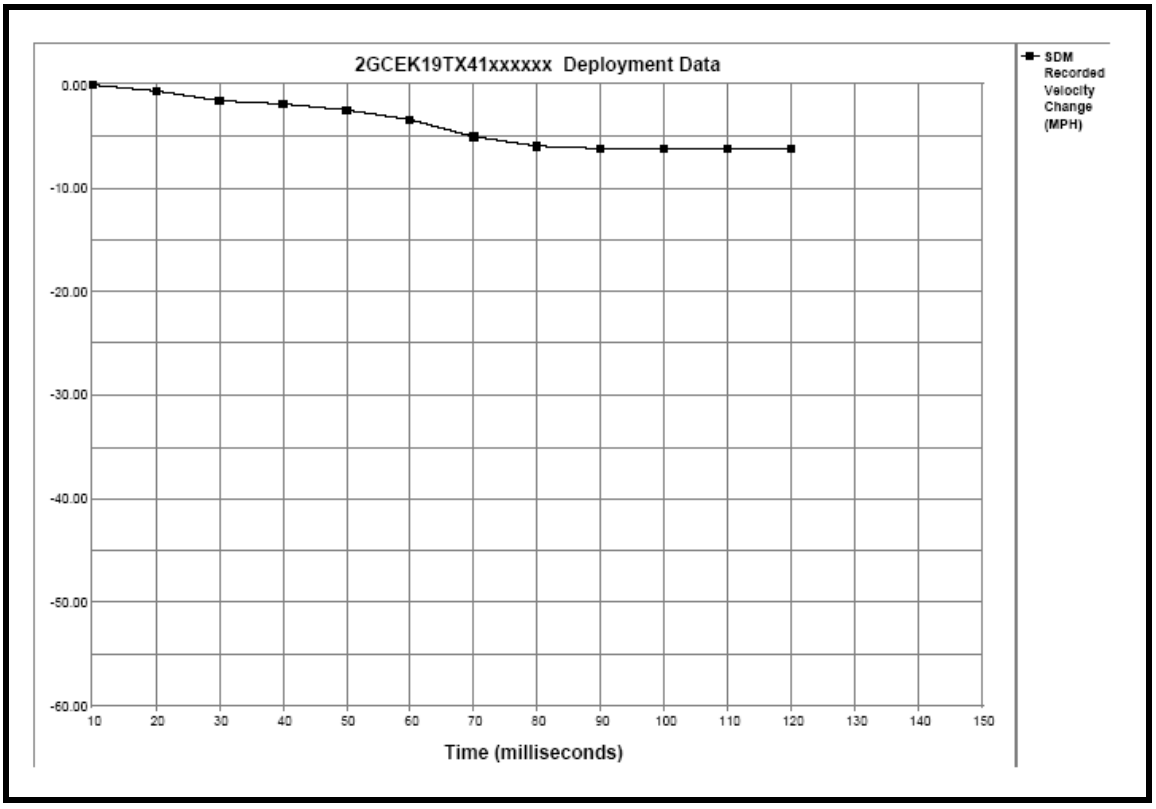
System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	1367
Ignition Cycles At Investigation	1393
Maximum SDM Recorded Velocity Change (MPH)	-6.73
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	160
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	25
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)	25
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	64	1856	0	ON
-4	59	1728	0	ON
-3	56	1600	0	ON
-2	47	1408	0	ON
-1	34	832	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	-0.62	-1.55	-1.86	-2.48	-3.41	-4.96	-5.89	-6.20	-6.20	-6.20	-6.20	N/A	N/A	N/A


2GCEK19TX41xxxxxx Deployment Pre-Crash Graph
100
90
80
70
60
50
40
30
20
10
0
-5
-4
-3
-2
-1
Approximate Time Before Algorithm Enable (seconds)
Vehicle Speed (MPH)
Engine Speed (RPM / 100)
Percent Throttle
Brake Switch Circuit Status (100 = ON)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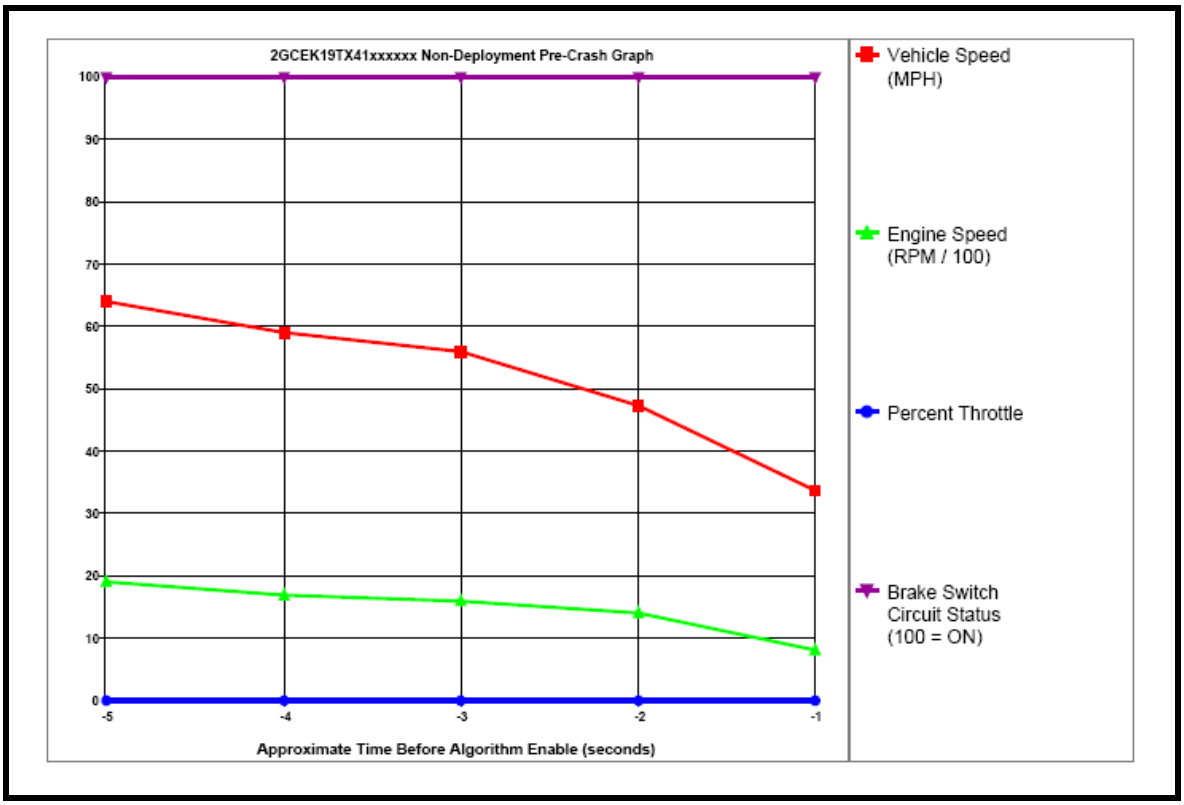
50
60
70
80
90
100
110
120
130
140
150
Time (milliseconds)
SDM Recorded Velocity Change (MPH)

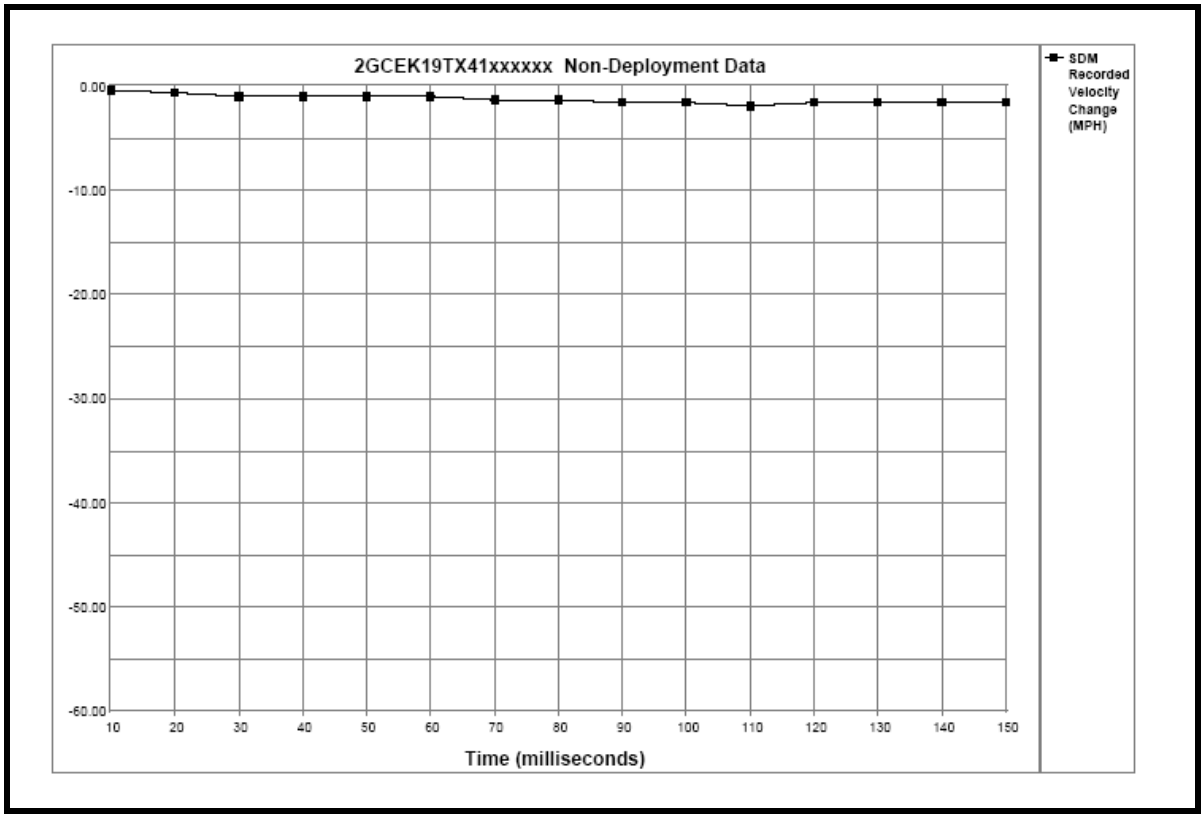
System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Non-Deployment	1367
Ignition Cycles At Investigation	1393
Maximum SDM Recorded Velocity Change (MPH)	-1.88
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	102.5
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	64	1856	0	ON
-4	59	1728	0	ON
-3	56	1600	0	ON
-2	47	1408	0	ON
-1	34	832	0	ON

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.31	-0.62	-0.93	-0.93	-0.93	-0.93	-1.24	-1.24	-1.55	-1.55	-1.86	-1.55	-1.55	-1.55	-1.55


2GCEK19TX41xxxxxx Non-Deployment Pre-Crash Graph
100
90
80
70
60
50
40
30
20
10
0
-5
-4
-3
-2
-1
Approximate Time Before Algorithm Enable (seconds)
Vehicle Speed (MPH)
Engine Speed (RPM / 100)
Percent Throttle
Brake Switch Circuit Status (100 = ON)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100
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120
130
140
150
Time (milliseconds)
SDM Recorded Velocity Change (MPH)