

CRASH DATA RESEARCH CENTER
Calspan Corporation
Buffalo, NY 14225

CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA10034

VEHICLE: 2008 CHEVROLET SILVERADO CREW CAB 4X2

LOCATION: NORTH CAROLINA

CRASH DATE: AUGUST 2010

Contract No. DTNH22-07-C-00043

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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 are 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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<p>16. <i>Abstract</i> This on-site investigation focused on the multiple-event/rollover crash of a 2008 Chevrolet Silverado. The Chevrolet was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system. The Chevrolet was not equipped with optional side impact or Inflatable Curtain (IC) air bags. The manufacturer of the Chevrolet certified that the vehicle was compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system includes dual-stage frontal air bags for the driver and front right passenger positions, seat track positioning sensors, retractor pretensioners, and a front right occupant presence sensor. The crash occurred when the Chevrolet departed the inboard lane of the interstate and the front of the Chevrolet impacted a W-beam guardrail. The driver's and front right passenger's frontal air bags deployed as a result of the impact. The vehicle traveled through the grass median and overrode a second W-beam guardrail into oncoming traffic lanes. The Chevrolet entered a clockwise yaw and tripped into a left side leading 10-quarter turn rollover. The restrained 26-year-old male driver was transported to a local hospital for treatment of minor severity soft tissue injuries. The restrained 22-year-old female front right passenger was transported to a local hospital where she was admitted for treatment of a closed-head injury and soft tissue injuries.</p>			
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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA10034
VEHICLE: 2008 CHEVROLET SILVERADO CREW CAB 4X2
LOCATION: NORTH CAROLINA
CRASH DATE: AUGUST 2010

BACKGROUND

This on-site investigation focused on the multiple-event/rollover crash of a 2008 Chevrolet Silverado (**Figure 1**). The Chevrolet was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system. The Chevrolet was not equipped with optional side impact or Inflatable Curtain (IC) air bags. The manufacturer of the Chevrolet certified that the vehicle was compliant with the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The CAC system includes dual-stage frontal air bags for the driver and front right passenger positions, seat track



Figure 1: Right front oblique view of the 2008 Chevrolet Silverado

positioning sensors, retractor pretensioners, and a front right occupant presence sensor. The crash occurred when the Chevrolet departed the inboard lane of the interstate and the front of the Chevrolet impacted a W-beam guardrail. The driver's and front right passenger's frontal air bags deployed as a result of the impact. The vehicle traveled through the grass median and overrode a second W-beam guardrail into oncoming traffic lanes. The Chevrolet entered a clockwise yaw and tripped into a left side leading 10-quarter turn rollover. The restrained 26-year-old male driver was transported to a local hospital for treatment of minor severity soft tissue injuries. The restrained 22-year-old female front right passenger was transported to a local hospital where she was admitted for treatment of a closed-head injury and soft tissue injuries.

The crash was identified through an online search of a regional vehicle salvage facility on September 2, 2010. Based on the rollover of the late model year vehicle and the extent of the crush to the roof, this case was assigned for an on-site investigation on September 3, 2010. The on-site investigation was initiated on September 7, 2010. This investigation involved the inspection and documentation of the Chevrolet and the crash site, and a detailed interview with the driver/owner of the vehicle. The Event Data Recorder (EDR) of the Chevrolet had been removed from the vehicle for imaging by the local police department. The police department provided an electronic copy of the imaged data, along with on-scene images and the scene/evidence measurements taken the day of the crash. The imaged EDR data file is included as Attachment A of this report.

SUMMARY

Vehicle Data

2008 Chevrolet Silverado

The 2008 Chevrolet Silverado Crew Cab LT 4x2 was manufactured in August 2008 and was identified by the Vehicle Identification Number (VIN) 2GCEC13J281 (production sequence deleted). The vehicle was purchased new by the driver in October, 2008 and had been driven 79,324 km (49,300 mi) at the time of the crash. The rear-wheel drive Chevrolet was powered by a 5.3-liter, V-8 engine linked to a four-speed automatic transmission. The braking system consisted of power-assisted front disc and rear drum brakes with four-wheel antilock and electronic brakeforce distribution. The Chevrolet was also equipped with an indirect Tire Pressure Monitoring System (TPMS) and Electronic Stability Control (ESC). The Chevrolet was equipped with four Goodyear Eagle LS-2 tires, size P275/55R20. The tires were mounted on five-spoke OEM alloy wheels. The tire size matched the vehicle manufacturer recommendation. The vehicle manufacturer recommended cold tire pressure was 207 kPa (30 PSI) for the front and rear. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Tire/Wheel Damage
Left Front	Tire Flat	9 mm (11/32 in)	Tire de-beaded, wheel fractured
Left Rear	Tire Flat	9 mm (11/32 in)	Tire de-beaded, wheel deformed
Right Rear	Tire Flat	9 mm (11/32 in)	Tire de-beaded, wheel deformed, 4x4 cm square hole and 4 cm x 10 cm triangular hole in tire sidewall.
Right Front	Tire Flat	9 mm (11/32 in)	Tire de-beaded

The interior of the Chevrolet was configured with cloth-surfaced six passenger seating. The front seat was a split bench with a center fold-down back that formed a large arm rest and center console when folded forward. The four outboard seats were equipped with adjustable head restraints. The driver head restraint was 6 cm (2.4 in) above the full-down position. All other head restraints were in the full-down position at the time of the SCI inspection. Both front seat tracks were power-adjustable and located in the full-rear position. The driver's seat back angle was 22 degrees aft of vertical. The front right seat back angle was 25 degrees aft of vertical at the time of the SCI inspection. Further investigation and the driver interview revealed the seat back was reclined approximately 45 degrees at the time of the crash and the front right passenger was sleeping. The second row consisted of a 60/40 split bench with cushions that folded vertically to increase cargo space. There was an aftermarket amplifier and speaker box mounted under the left side (60%) of the rear seat cushion. The three second row seats were equipped with Lower Anchors and Tethers for Children (LATCH) lower anchors.

The vehicle's occupant safety systems consisted of three-point lap and shoulder belts for the front outboard and three rear seating positions, a lap belt with a locking latch plate for the front center seating position, front outboard safety belt retractor pretensioners, and CAC dual-stage frontal air bags.

CRASH SITE

This crash occurred during daylight hours on a four-lane north/south interstate highway divided by two W-beam guardrails and a grass median. The roadway was straight in the pre-crash area and transitioned to a large radius right curve immediately prior to the roadside departure (**Figure 2**). There was a positive grade of 1% in the area of the crash. The concrete-surfaced traffic lanes were 4.4 m (14.4 ft) in width and were bordered by asphalt shoulders 4 m (13.1 ft) in width. A rumble strip had been applied onto the shoulder. Outboard of the asphalt shoulders stood metal W-beam guardrails 86 cm (34 in) in height. There was a maintenance opening in the guardrail at the point of the roadside departure. The grass median measured 3.9 m (9.9 ft) in width. The speed limit in the area in which this crash occurred was 105 km/h (65 mph). The environmental conditions were cloudy and dry. A crash schematic is included as **Figure 10** of this report and includes measurement data points taken by the police reconstruction team the day of the crash.

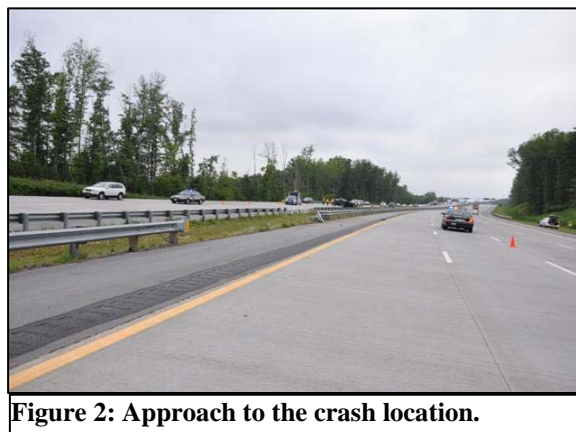


Figure 2: Approach to the crash location.

CRASH SEQUENCE

Pre-crash

The restrained 26-year-old male driver of the Chevrolet was operating the vehicle northbound in lane three of the divided roadway. As the vehicle approached the area of the crash, it was traveling at an EDR reported speed of 129 km/h (80 mph) 2 seconds prior to the Algorithm Enable (AE). The driver reported in the interview that he was traveling home from a weekend trip and was fatigued. He had been driving for approximately 5 hours prior to the crash and was approximately 30 minutes from his destination. All windows in the Chevrolet were up during the pre-crash travel. The front right passenger had fallen asleep in her seating position. The driver fell asleep and as the roadway curved to the right, the vehicle traveled off the left side of the travel lane. When the Chevrolet passed over the rumble strip on the paved shoulder, the driver woke up and reported that he attempted to apply the brakes and then placed his right hand in front of the passenger in an attempt to hold her in place. A 5.5 m (18.0 ft) skid mark attributed to the right front tire was identified on the shoulder. The Chevrolet departed the left side of the roadway in the area of the maintenance opening in the W-beam guardrail section and approached the blunt end of the guardrail section at a shallow angle.

Crash

The front bumper of the Chevrolet impacted the blunt end of the guardrail (**Figure 3**). There was evidence of a guardrail post impact on the front bumper located 17 cm (6.7 in) left of the vehicle centerline. The direction of force was within the 12 o'clock sector. This initial impact resulted in the actuation of the safety belt pretensioners and deployed the frontal air bags in the Chevrolet. The Barrier algorithm of the WinSmash program was used to calculate a Barrier Equivalent Speed of 22 km/h (14 mph) for the first point of impact. The guardrail collapsed and the Chevrolet was redirected into an upward trajectory by the initial impact. The vehicle overrode the first guardrail and traveled through the grass median. The Chevrolet impacted and overrode the top of the second guardrail protecting the southbound traffic lanes with its undercarriage. The vehicle was redirected into a clockwise yaw as it entered the southbound traffic lanes. The Chevrolet yawed approximately 60 degrees Clockwise (CW) and tripped into a left side leading rollover. Based on scene evidence, the Chevrolet rolled 10-quarter turns over a distance of 47 m (154 ft). The vehicle came to rest on its roof facing northeast on the most-inboard southbound lane. **Figure 4** is an overall police image of the crash site.



Figure 3: Trajectory view of the Chevrolet at Event 1.



Figure 4: Overall police image of the crash site.

Post-crash

A passing motorist alerted emergency personnel to the crash via cellular telephone. There were four cellular telephones present in the Chevrolet but the driver was unable to locate any of them. The driver remembered hearing the tone from the connecting “OnStar” system but never spoke to an “OnStar” representative. He stated in the interview that he contacted “OnStar” at a later time and they had a record of the crash but not the air bag deployment.

The driver unbuckled his safety belt and exited the vehicle through the disintegrated left front window. He went around to the passenger side but was unable to open the passenger door. At this point, he remembers several vehicles stopping to assist. One individual introduced himself as an EMT and asked the driver to sit down on the roadside. The EMT evaluated the driver and then entered the vehicle to evaluate the front right passenger. Police, emergency medical and

tow personnel responded to the crash site. The front right passenger was removed from the vehicle while unconscious by emergency medical personnel. The driver and front right passenger were transported by ground ambulance to a local hospital where the driver was treated in the emergency department for minor severity soft tissue injuries and released the same day. The front right passenger was admitted for the treatment of closed-head injuries and soft tissue injuries. She remained in the hospital for three days. The Chevrolet was towed from the scene due to disabling damage. The vehicle was transferred from the local tow yard to a regional vehicle salvage facility for auction, where it was inspected.

2008 CHEVROLET SILVERADO 1500

Exterior Damage

The Chevrolet sustained moderate damage to its front plane as a result of the initial impact with the guardrail (**Figure 5**). On the front plane, the direct and induced damage extended the full width of the bumper beam. The maximum bumper level crush was located at C3, 17 cm (6.7 in) left of the centerline and measured 20 cm (7.9 in). A residual crush profile was documented along the full width of the damaged front bumper. This profile was as follows: C1 = 12 cm (4.7 in), C2 = 12 cm (4.7 in), C3 = 20 cm (7.9 in), C4 = 8 cm (3.1 in), C5 = 5 cm (2 in), C6 = 16 cm (6.3 in). The Collision Deformation Classification (CDC) for this impact was 12FDEW1.

The forward aspect of the Chevrolet's undercarriage impacted the top of the second guardrail as the vehicle overrode the structure. This non-horizontal damage was outside the scope of the WinSMASH program. **Figure 4** was taken on-scene and depicts the undercarriage damage to the Chevrolet. The CDC assigned for the second event was 00UFDW99.



Figure 5: Frontal damage to the Chevrolet taken during the SCI inspection.



Figure 6: View of the Chevrolet at final rest taken by the police investigator depicting the undercarriage damage.

The top plane sustained the highest level of deformation in the rollover, Event 3, (**Figure 7**). On the top plane, the direct damage extended aft from the leading edge of the hood 368 cm (145 in) and across the full lateral width of the top from the left roof side rail to the right roof side rail.

The greatest vertical deformation was located on the right side of the windshield header, at the junction with the right roof side rail. The residual vertical deformation measured 22 cm (8.7 in). The greatest lateral deformation was located at the right roof side rail at the junction with the right A-pillar. The resultant lateral deformation measured 8 cm (3.1 in). The CDC assigned to the rollover event was 00TYDO4.



Figure 7: Rollover damage to the top plane of the Chevrolet.

The left front and both rear doors remained closed throughout the crash sequence and were operational post-crash. The right front door was jammed shut by the deformation of the right roof side rail, the windshield header and the right A-pillar. The AS-2 deep tint backlight and all side windows (AS-2 front, AS-2 deep tint rear) disintegrated during the crash sequence. The AS-1 windshield was completely fractured but held in place by the laminate. The windshield integrity loss occurred post-crash. The driver stated in the interview that he was attempting to remove a wallet and cellular phone that had become lodged at the front right corner of the instrument panel, near the A-pillar and used the claw of a hammer to open the windshield laminate to reach the items.

Interior Damage

The Chevrolet sustained moderate severity interior damage that was attributed to passenger compartment intrusion, occupant contact and air bag deployment. There was a scuff mark that measured 14 cm (5.5 in) long and 7 cm (2.8 in) wide on the left roof side rail located 17 cm (6.7 in) forward of the left B-pillar and 6 cm (2.4 in) right of the left door. This contact was attributed to the driver's head but did not result in an injury. There was a scuff mark on the left side of the center seat back/console that was 18 cm (7.1 in) long and 10 cm (3.9 in) high. This scuff mark began at the upper corner of the armrest and 16 cm (6.3 in) forward of the rear of the armrest. This contact was attributed to the right side of the driver's abdomen but also did not result in injury. There was body fluid and hair on the right roof side rail. This contact area measured 18 cm (7.1 in) long and 8 cm (3.1 in) wide and began 21 cm (8.3 in) forward of the right B-pillar. There was a second contact consisting of body fluid and hair on the roof of the vehicle over the front right seating position. This contact was located 69 to 76 cm (27.2 to 29.9 in) right of the left roof side rail and 45 to 59 cm (17.7 to 23.2 in) aft of the windshield header. These two areas were attributed to the passenger's head. A large area of pooled body fluid was present over the front right passenger seat at the location in which the inverted passenger had come to rest. The roof, right roof side rail, windshield and backlight header had all intruded vertically. The occupant compartment intrusion is listed on the following table:

Position	Component	Direction	Magnitude
Row 1 Left	Roof	Vertical	9 cm (3.5 in)
Row 1 Left	Roof side rail	Vertical	6 cm (2.4 in)
Row 1 Left	Windshield header	Vertical	5 cm (2 in)
Row 1 Center	Roof	Vertical	15 cm (5.9 in)
Row 1 Center	Windshield Header	Vertical	12 cm (4.7 in)
Row 1 Right	B-pillar	Lateral	16 cm (6.3 in)
Row 1 Right	Windshield header	Vertical	20 cm (7.9 in)
Row 1 Right	Roof side rail	Vertical	21 cm (8.3 in)
Row 1 Right	A-pillar	Lateral	17 cm (6.7 in)
Row 1 Right	Roof	Vertical	19 cm (7.5 in)
Row 2 Left	Backlight header	Vertical	1 cm (0.4 in)
Row 2 Center	Backlight header	Vertical	4 cm (1.6 in)
Row 2 Right	C-pillar	Lateral	16 cm (6.3 in)
Row 2 Right	Backlight header	Vertical	6 cm (2.4 in)
Row 2 Right	Roof side rail	Vertical	6 cm (2.4 in)
Row 2 Right	Roof	Vertical	6 cm (2.4 in)

Manual Restraint Systems

The Chevrolet was equipped with 3-point lap and shoulder belts for the front outboard and all three rear seating positions. The front center seat was equipped with a fixed lap belt and a locking latch plate. The front outboard and rear belts all utilized a continuous loop of webbing and sliding latch plates. The upper D-rings for the front outboard seats were height adjustable. The left D-ring was in the full-up position and the right D-ring was in the full-down position. The driver's belt retracted onto an Emergency Locking Retractor (ELR). All the other belts retracted onto switchable ELR/Automatic Locking Retractors (ALR). Both front safety belts utilized retractor pretensioners which actuated during this crash sequence. The front safety belts were both in use at the time of the crash, restraining the driver and front right passenger.

The front left belt webbing contained two areas of crash related evidence. A frictional abrasion attributed to the latch plate was located 50 to 54 cm (19.7 to 21.3 in) above the plastic trim slot on the outboard side of the seat. (The lower floor anchor was not visible due to this trim component.) The belt was stretched and the waffling was noted 64 to 80 cm (25.2 to 31.5 in) above the plastic trim slot reference point. The left front belt webbing had a total of 154 cm (60.6 in) spooled out and locked by the actuation of the retractor pretensioner.

The front right belt webbing was cut by EMS during the removal of the passenger. The belt webbing was cut 89 cm (35 in) above the plastic trim slot on the outboard aspect of the seat. Examination of the front right belt webbing revealed two areas of crash related evidence. A frictional abrasion attributed to the latch plate was located 64 to 68 cm (25.2 to 26.8 in) above

the plastic trim slot reference. An area of abrasion and creasing (**Figure 8**) was located 138 to 159 cm (54.3 to 62.6 in) above the reference point. This region of evidence was related to the pre-crash positioning of the shoulder portion of the belt behind the front right head restraint. The driver reported that the passenger wished to go to sleep and placed the shoulder portion of the webbing behind the head restraint. The actuation of the pretensioner removed the slack in the webbing which resulted in contact between the vertical bars of the head restraint and the webbing. Additionally, the belt webbing was found gathered in the D-ring.



Figure 8: Abrasion to the right front webbing from contact with head restraint posts.

The front row center safety belt and the third row belts were not in use at the time of the crash.

Frontal Air Bag System

The Chevrolet was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front right passenger air bags, seat track positioning sensors, front seat retractor pretensioners, and safety belt buckle switches. The manufacturer of the Chevrolet certified that this vehicle was compliant with the advanced air bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Both frontal air bags deployed during this crash sequence.

The driver's air bag was concealed within the center hub of the four-spoke steering wheel by two cover flaps. The I-configuration cover flaps opened as designed and measured 5 cm (2 in) in width and 18 cm (7.1 in) in height. The driver's air bag measured 60 cm (23.6 in) in diameter and was vented by two vent ports located on the back side of the air bag at the 10 and 2 o'clock positions. The air bag was tethered by two straps at the 12 and 6 o'clock positions. There were two 15 cm (6.3 in) black plastic deployment scuff marks on the rear of the air bag at the 5 and 7 o'clock positions.

The passenger frontal air bag was concealed within the upper aspect of the right instrument panel by a single cover flap measuring 38 cm (15 in) in width and 18 cm (7.1 in) in length. The air bag measured 40 cm (15.7 in) in width and had a vertical column of body fluid on the front aspect. The fluid transfer measured 16 cm (6.3 in) in width and began 5 cm (2 in) left of the right edge of the air bag. Due to the post-crash intrusion of the windshield, it was not possible to fully inspect the passenger air bag.

The frontal air bags were controlled by a Sensing Diagnostic Module (SDM) that was located under the center console. The SDM had Event Data Recording (EDR) capabilities. The SDM was removed from the vehicle by the police investigators for imaging of the EDR data. An electronic copy of the imaged data was obtained by the SCI investigator. The data was imaged utilizing the Bosch Crash Data Retrieval tool and software version 3.3. The data has been reported utilizing software version 3.7 and is attached to the end of this report.

The EDR recorded a deployment and a non-deployment record. Analysis of the data indicated that the deployment event occurred first followed by the non-deployment event. The time between the events was greater than 5 seconds. At the time of the non-deployment event, the air bag indicator lamp was “On” and there was one diagnostic trouble code (B0052). The trouble code was related to the air bag deployment. Further, the data indicated that one associated non-deployment event was not recorded. This event followed the recorded non-deployment event. These non-deployment events were probably related to ground impacts during the rollover sequence.

The deployment event was related to the first guardrail impact. At the time of the deployment, the air bag indicator lamp was “Off” and both front safety belts were buckled. There were no diagnostic trouble codes. A two-stage air bag deployment was commanded 5 milliseconds after AE. The recorded longitudinal delta-V was -22.5 km/h (-14.0) mph at 220 milliseconds. The velocity change was still increasing at the end of the recording. The recorded lateral delta-V was -1.0 km/h (-0.6 mph).

The EDR recorded 2.5 seconds of pre-crash vehicle parameters. A field within the EDR data indicated that the pre-crash data was related to the deployment event. The vehicle’s speed throughout the pre-crash recording was 129 km/h (80 mph).

DRIVER DEMOGRAPHICS/DATA

Driver Age/Sex:	26-year-old/Male
Height:	191 cm (75 in)
Weight:	79 kg (175 lb)
Eyewear:	Sunglasses
Seat Track Position:	Full-rear
Manual Safety Belt Use:	3-point lap and shoulder safety belt
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Exited unassisted through disintegrated LF window
Mode of Transport from Scene:	Ground ambulance
Type of Medical Treatment:	Treated in the emergency department of a local hospital and released the same day.

Driver injuries

Injury	Injury Severity (AIS 2005/08)	Injury Source
Cervical strain (1)	Minor (640278.1,6)	Left roof side rail
15cm contusion of the left shoulder (2)	Minor (710402.1,2)	Safety belt
5 cm (2 in) laceration on left knee (1)	N/A	Post-crash egress
3 small lacerations < 2 cm (0.8 in) on right knee (1)	N/A	Post-crash egress

Source of injury data: (1)-Emergency room records and (2)-interview

Driver Kinematics

The 26-year-old male driver of the Chevrolet was seated in a full-rear track position and was restrained by the manual 3-point lap and shoulder belt system. He was operating the Chevrolet northbound in lane three of the divided highway. The driver was fatigued prior to the crash. He was returning from a weekend trip and had been driving 5 hours at the time of the crash. He was approximately ½ hour from his destination. The driver fell asleep and the vehicle drifted left at the entry to a right curve. The driver woke up as the Chevrolet passed over the rumble strip off the left side of the roadway. He stated in the interview that he attempted to apply the brakes and placed his right hand in front of his passenger to attempt to hold her in place.

At the impact with the guardrail, the safety belt retractor actuated and the frontal air bag deployed. The driver initiated a forward trajectory within the front left seating position. The driver loaded the safety belt with his lower abdomen and chest, resulting in the contusion to his left shoulder. The driver stated in the interview that he remembered seeing the first guardrail disappear under the front of his vehicle.

As the vehicle traversed the median, overrode the second guardrail and rolled over, the driver rode down the forces of the crash sequence by loading the locked safety belt and his seat. This loading was evidenced by the safety belt webbing abrasions and scuff marks to the interior. The driver's right flank loaded and scuffed the center console/seat back. Due to his height, his head contacted and scuffed the left roof side rail. The head contact to the side rail resulted cervical strain (indirect contact injury).

When the Chevrolet came to rest on its roof, the driver was still restrained by the safety belt within the front left seating position. He released the safety belt and fell onto the roof of the vehicle. He exited the vehicle through the disintegrated front left window, resulting in the lacerations to his knees.

The driver was immediately concerned with the condition of his passenger. He went to the right front door but was unable to open it. He could hear her breathing at this time. Several other vehicles had stopped and a bystander stopped the driver, identified himself as an EMT and asked the driver to sit down. The EMT evaluated the driver and then entered the Chevrolet to evaluate the passenger. After EMS arrived, the driver was transported by ground ambulance to a local hospital where he was treated in the emergency department and released the same day.

FRONT RIGHT OCCUPANT DEMOGRAPHICS/DATA

Occupant Age/Sex: 22-year-old/Female
 Height: 160 cm (63 in)
 Weight: 57 kg (125 lb)
 Eyewear: None
 Seat Track Position: Full-rear
 Manual Safety Belt Use: Lap only, shoulder portion around the back of the seat
 Usage Source: SCI vehicle inspection
 Egress from Vehicle: Removed by EMS while unconscious
 Mode of Transport from Scene: Ground ambulance
 Type of Medical Treatment: Admitted to the trauma unit of a local hospital for three days.

Front Right Occupant Injuries

Injury	Injury Severity (AIS 2005/08)	Injury Source
Concussion w/ brief loss of consciousness	Moderate (161002.2,0)	Ground – partial ejection
3x6 cm complex right frontal scalp laceration	Minor (110602.1,5)	Ground – partial ejection
Frontal scalp hematoma	Minor (110402.1,5)	Ground – partial ejection
Right hand extensor tendon injury	Minor (740200.1,1)	Ground – partial ejection
Right forearm abrasion	Minor (710202.1,1)	Ground – partial ejection
Right forearm contusions (numerous)	Minor (710402.1,1)	Ground – partial ejection
Left forearm abrasion	Minor (710202.1,2)	Deployed passenger air bag
Left forearm contusions (numerous)	Minor (710402.1,2)	Occupant to occupant contact

Source: Emergency room records, Discharge Summary and Operative notes

Front Right Occupant Kinematics

The 22-year-old female front right passenger was seated in a full-rear track position. The seat back angle at the time of the SCI inspection measured 25 degrees aft of vertical; however, on-scene images and the interview indicated the angle of the front right seat was closer to 45 degrees. Prior to the crash, the front right passenger was fatigued, wanted to go to sleep and had reclined the seat. The driver reported that she could not sleep with the buckled safety belt in front of her and that she placed the shoulder portion behind the front right seat. The webbing was held in place by the crease between the top of the seat and the head restraint. **Figure 9** was an on-scene image that depicts the belt still behind the front right seat and the reclined front right seat. The passenger was also turned to the left within the front right seating position and was facing the driver. She was asleep at the time of the crash and was not able to brace for the impact. Immediately prior to the initial impact, the driver extended his right arm in front of the passenger in an attempt to hold her in place during the crash.



Figure 9: Front right safety belt behind front right head restraint.

The initial guardrail impact actuated the front right safety belt pretensioner and deployed the frontal air bag. The passenger initiated a forward trajectory in response to the frontal crash. Her lower body was restrained by the lap belt but her upper body extended forward and loaded the deployed frontal air bag.

During the rollover, the lack of a shoulder belt allowed a partial ejection of the passenger's head and right arm through the (now disintegrated) right front window. The head and right arm contacted the ground resulting in the concussion, the scalp laceration and hematoma, the right forearm abrasions and the right hand laceration (tendon injury). The rollover forces resulted in the intrusion of the right roof area of the Chevrolet. The reduction in the occupant space resulted in contact between the passenger's head and the right roof rail and center roof during the rollover sequence. Body fluid and hair observed at the time of the SCI inspection identified these contacts. The front right passenger came to rest inverted and restrained by the lap portion of the safety belt within the front right seating position.

The front right passenger was unconscious upon the arrival of EMS. They cut her safety belt and removed her from the vehicle while unconscious. She was transported by ground ambulance and admitted to the trauma unit of a local hospital for treatment of her head and soft tissue injuries.

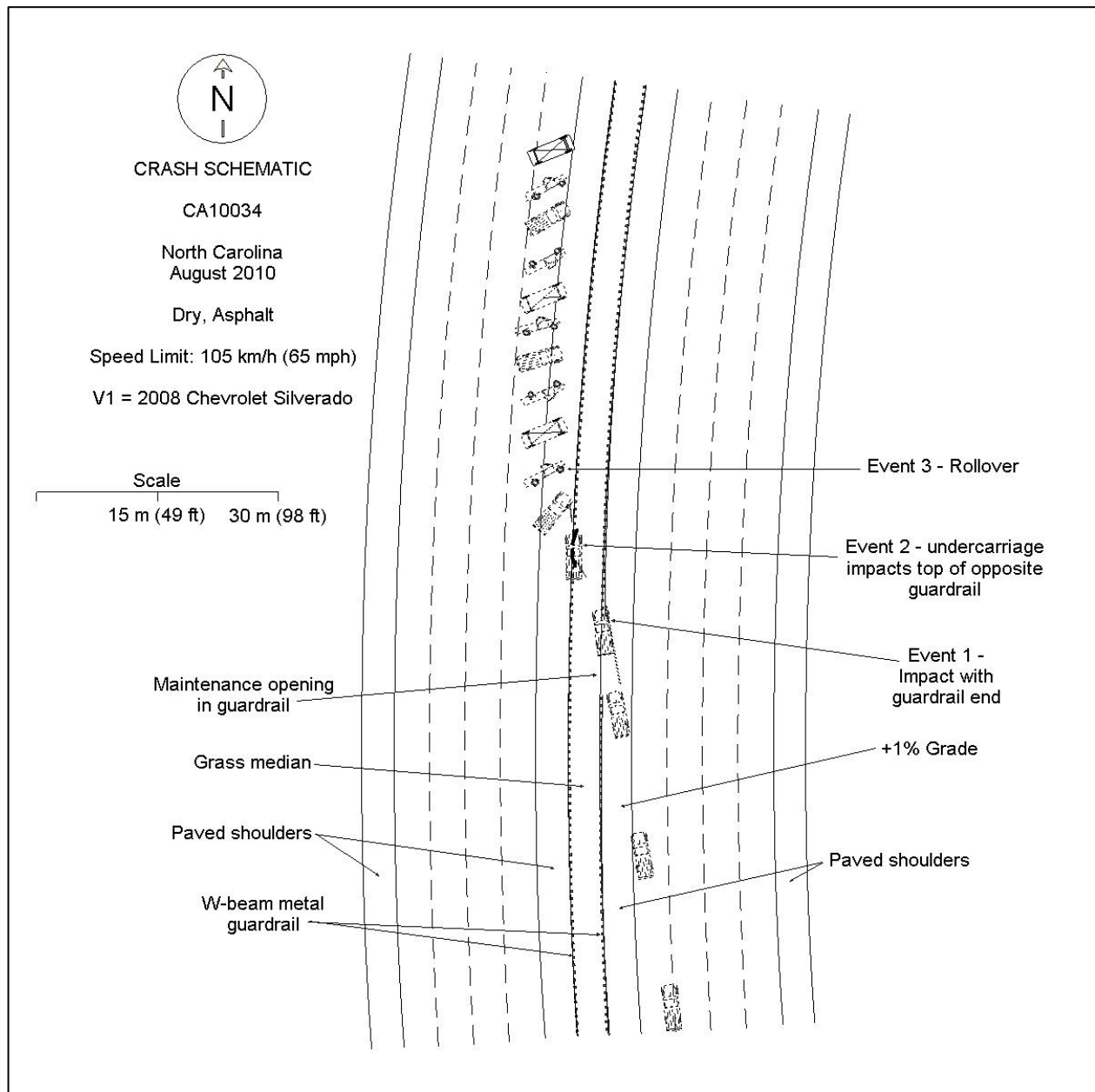


Figure 10: Crash Schematic

ATTACHMENT A

2008 Chevrolet Silverado EDR Data

IMPORTANT NOTICE: Robert Bosch LLC and the manufacturers whose vehicles are accessible using the CDR System urge end users to use the latest production release of the Crash Data Retrieval system software when viewing, printing or exporting any retrieved data from within the CDR program. Using the latest version of the CDR software is the best way to ensure that retrieved data has been translated using the most current information provided by the manufacturers of the vehicles supported by this product.

CDR File Information

User Entered VIN	2GCEC13J281*****
User	B.L. Blankenship
Case Number	2010-0801-198
EDR Data Imaging Date	Monday, August 2 2010
Crash Date	Sunday, August 1 2010
Filename	CA10034 CDR.CDR
Saved on	Monday, August 2 2010 at 03:46:08 PM
Collected with CDR version	Crash Data Retrieval Tool 3.3
Reported with CDR version	Crash Data Retrieval Tool 3.7
EDR Device Type	airbag control module
Event(s) recovered	Deployment Non-Deployment

Comments

No comments entered.

Data Limitations

Recorded Crash Events:

There are two types of recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event records data but does not deploy the air bag(s). The minimum SDM Recorded Vehicle Velocity Change, that is needed to record a Non-Deployment Event, is five MPH. A Non-Deployment Event may contain 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 velocity change. This event will be cleared by the SDM, after approximately 250 ignition cycles. This event can be overwritten by a second Deployment Event, referred to as Deployment Event #2, if the Non-Deployment Event is not locked. The data in the Non-Deployment Event file will be locked, if the Non-Deployment Event occurred within five seconds of a Deployment Event. A locked Non Deployment Event cannot be overwritten or cleared by the SDM. The second type of SDM recorded crash event is the Deployment Event. It also may contain Pre-Crash and Crash data. The SDM can store up to two different Deployment Events. If a second Deployment Event occurs any time after the Deployment Event, the Deployment Event #2 will overwrite any non-locked Non-Deployment Event. Deployment Events cannot be overwritten or cleared by the SDM. Once the SDM has deployed an air bag, the SDM must be replaced.

Data:

- SDM Recorded Vehicle Velocity Change reflects the change in velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle 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. For Deployment Events, the SDM will record 220 milliseconds of data after deployment criteria is met and up to 70 milliseconds before deployment criteria is met. For Non-Deployment Events, the SDM can record up to the first 300 milliseconds of data after algorithm enable. Velocity Change data is displayed in SAE sign convention.
- The CDR tool displays time from Algorithm Enable (AE) to time of deployment command in a deployment event and AE to time of maximum SDM recorded vehicle velocity change in a non-deployment event. Time from AE begins when the first air bag system enable threshold is met and ends when deployment command criteria is met or at maximum SDM recorded vehicle velocity change. Air bag systems such as frontal, side, or rollover, may be a source of an enable. The time represented in a CDR report can be that of the enable of one air bag system to the deployment time of another air bag system.
- Maximum Recorded Vehicle Velocity Change is the maximum square root value of the sum of the squares for the vehicle's combined "X" and "Y" axis change in velocity.
- 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 by various factors, including but not limited to the following:
 - significant changes in the tire's rolling radius
 - final drive axle ratio changes
 - wheel lockup and wheel slip
- Brake Switch Circuit Status indicates the open/closed state of the brake switch circuit.

- Pre-Crash data is recorded asynchronously.
- Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if:
 - the SDM receives a message with an "invalid" flag from the module sending the pre-crash data
 - no data is received from the module sending the pre-crash data
 - no module is present to send the pre-crash data
- Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit.
- The Time Between Non-Deployment to Deployment Events is displayed in seconds. If the time between the two events is greater than five seconds, "N/A" is displayed in place of the time. If the value is negative, then the Deployment Event occurred first. If the value is positive, then the Non-Deployment Event occurred first.
- If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
- The ignition cycle counter relies upon the transitions through OFF->RUN->CRANK power-moding messages, on the GMLAN communication bus, to increment the counter. Applying and removing of battery power to the module will not increment the ignition cycle counter.
- All data should be examined in conjunction with other available physical evidence from the vehicle and scene

Data Source:

All SDM recorded data is measured, calculated, and stored internally, except for the following:

- Vehicle Status Data (Pre-Crash) is transmitted to the SDM, by various vehicle control modules, via the vehicle's communication network.
- The Belt Switch Circuit is wired directly to the SDM.

01005_SDMC-delphi_r001

Multiple Event Data

Associated Events Not Recorded	1
Event(s) was an Extended Concatenated Event	No
An Event(s) was in Between the Recorded Event(s)	No
An Event(s) Followed the Recorded Event(s)	Yes
The Event(s) Not Recorded was a Deployment Event(s)	No
The Event(s) Not Recorded was a Non-Deployment Event(s)	Yes

System Status At AE

Low Tire Pressure Warning Lamp (If Equipped)	OFF
Vehicle Power Mode Status	Run
Remote Start Status (If Equipped)	Inactive
Run/Crank Ignition Switch Logic Level	Active

Pre-crash data

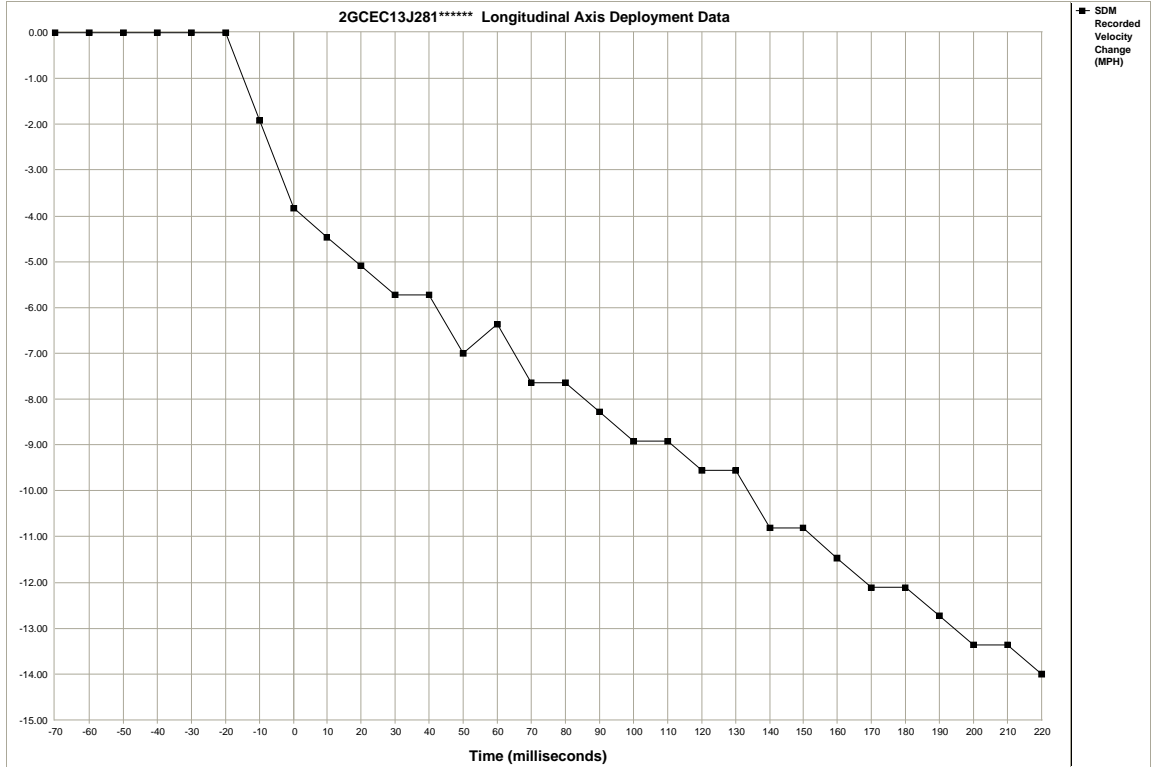
Parameter	-1.0 sec	-0.5 sec
Reduced Engine Power Mode	OFF	OFF
Cruise Control Active (If Equipped)	No	No
Cruise Control Resume Switch Active (If Equipped)	No	No
Cruise Control Set Switch Active (If Equipped)	No	No
Engine Torque (foot pounds)	218.7	213.9

Pre-Crash Data

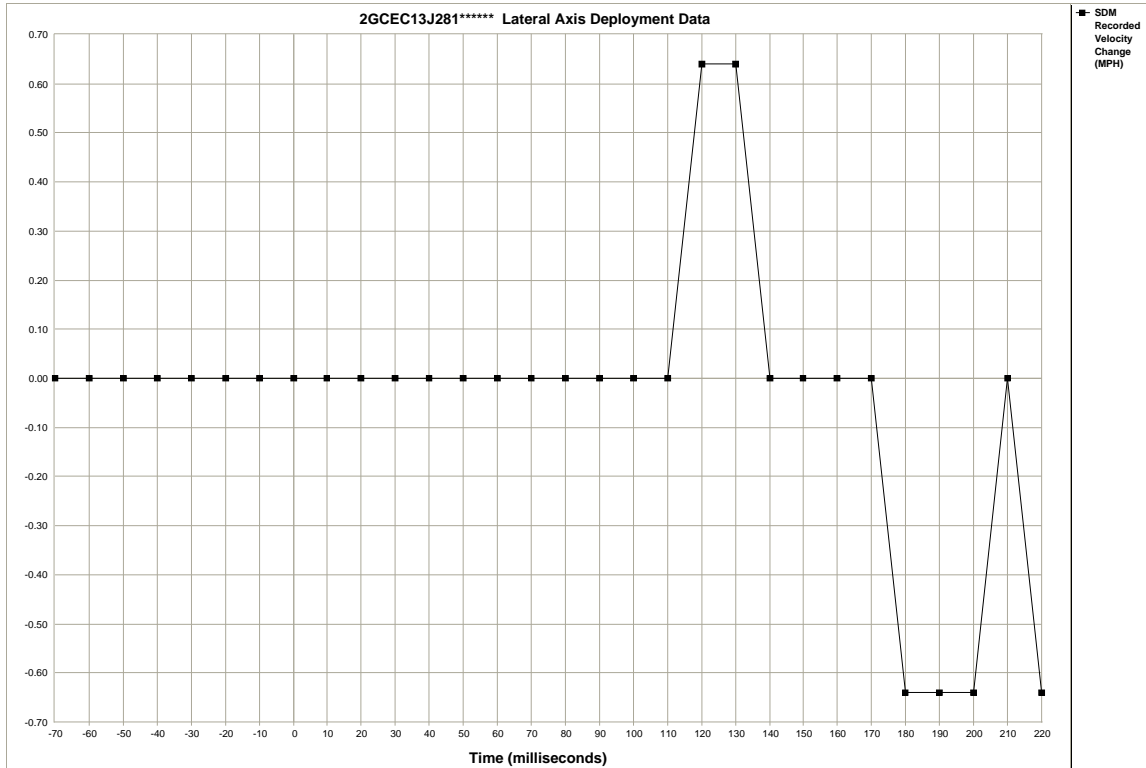
Parameter	-2.5 sec	-2.0 sec	-1.5 sec	-1.0 sec	-0.5 sec
Accelerator Pedal Position (percent)	23	23	23	23	23
Vehicle Speed (MPH)	80	80	80	80	80
Engine Speed (RPM)	2048	2048	2048	2048	2048
Percent Throttle	39	39	39	40	39
Brake Switch Circuit State	OFF	OFF	OFF	OFF	OFF

System Status At Deployment

Ignition Cycles At Investigation	4889
SIR Warning Lamp Status this Ignition Cycle	OFF
SIR Warning Lamp ON/OFF Time Continuously (seconds) this Ignition Cycle	655350
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously this Ignition Cycle	3893
Ignition Cycles At Event	4883
Ignition Cycles Since DTCs Were Last Cleared	255
Driver's Belt Switch Circuit Status	BUCKLED
Passenger's Belt Switch Circuit Status	BUCKLED
Driver Seat Position Switch Circuit Status	Rearward
Passenger Classification Status at Event Enable	Large Occupant Classification Type #1
Current Passenger Position Status at Event Enable	Unknown
Previous Passenger Position Status at Event Enable	Unknown
Passenger Air Bag Indicator Status at Event Enable	ON
Diagnostic Trouble Codes at Event, fault number: 1	N/A
Diagnostic Trouble Codes at Event, fault number: 2	N/A
Diagnostic Trouble Codes at Event, fault number: 3	N/A
Diagnostic Trouble Codes at Event, fault number: 4	N/A
Diagnostic Trouble Codes at Event, fault number: 5	N/A
Diagnostic Trouble Codes at Event, fault number: 6	N/A
Diagnostic Trouble Codes at Event, fault number: 7	N/A
Diagnostic Trouble Codes at Event, fault number: 8	N/A
Diagnostic Trouble Codes at Event, fault number: 9	N/A
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	2.5
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	5
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	2.5
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	5
Driver Side or Roof Rail/Head Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger Side or Roof Rail/Head Curtain Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Crash Record Locked	Yes
Multiple Event Data/Vehicle Event Data (Pre-Crash) Associated With This Event	Yes
SDM Synchronization Counter	4883
Time Between Events (sec)	N/A
Event Recording Complete	Yes
Driver First Stage Deployment Loop Commanded	Yes
Passenger First Stage Deployment Loop Commanded	Yes
Driver Second Stage Deployment Loop Commanded	Yes
Driver 2nd Stage Deployment Loop Commanded for Disposal	No
Passenger Second Stage Deployment Loop Commanded	Yes
Passenger 2nd Stage Deployment Loop Commanded for Disposal	No
Driver Pretensioner Deployment Loop Commanded	Yes
Passenger Pretensioner Deployment Loop Commanded	Yes
Driver Side Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Second Row Left Side Deployment Loop Commanded	No
Second Row Right Side Deployment Loop Commanded	No
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 3) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 3) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No



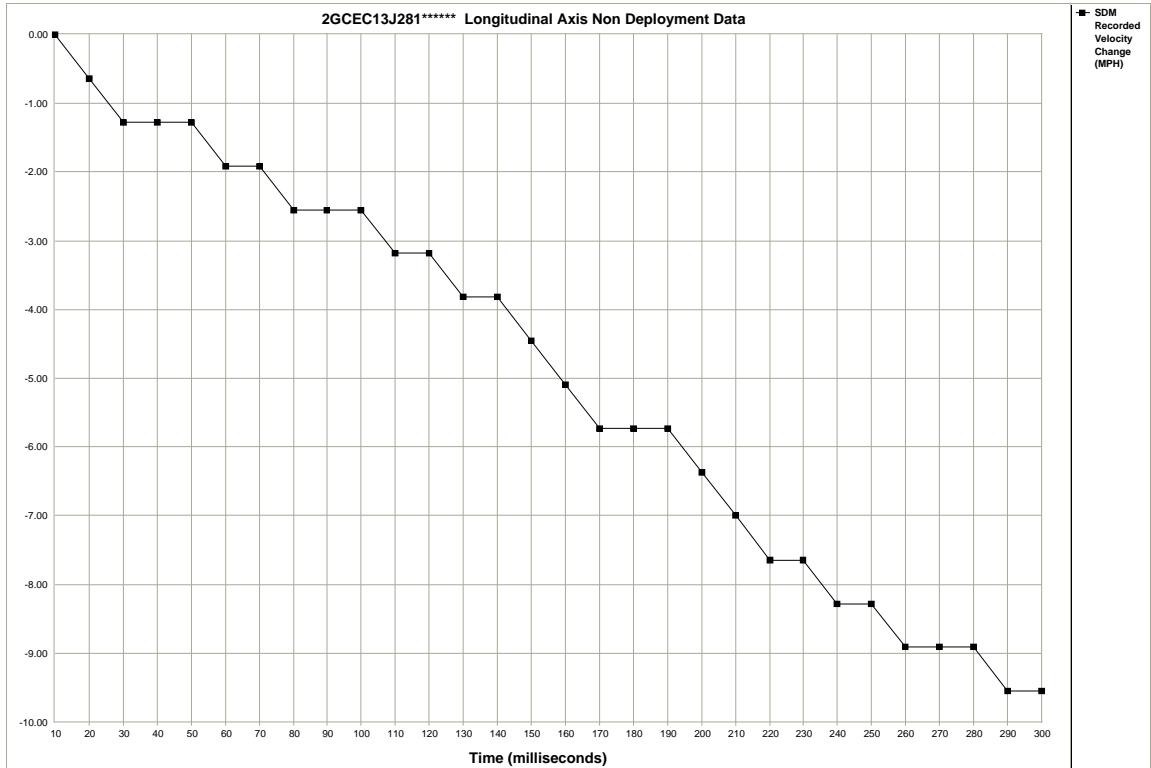
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	-1.91	-3.82	-4.46	-5.09	-5.73	-5.73	-7.00	-6.37	-7.64
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-7.64	-8.28	-8.91	-8.91	-9.55	-9.55	-10.82	-10.82	-11.46	-12.10	-12.10	-12.73	-13.37	-13.37	-14.01



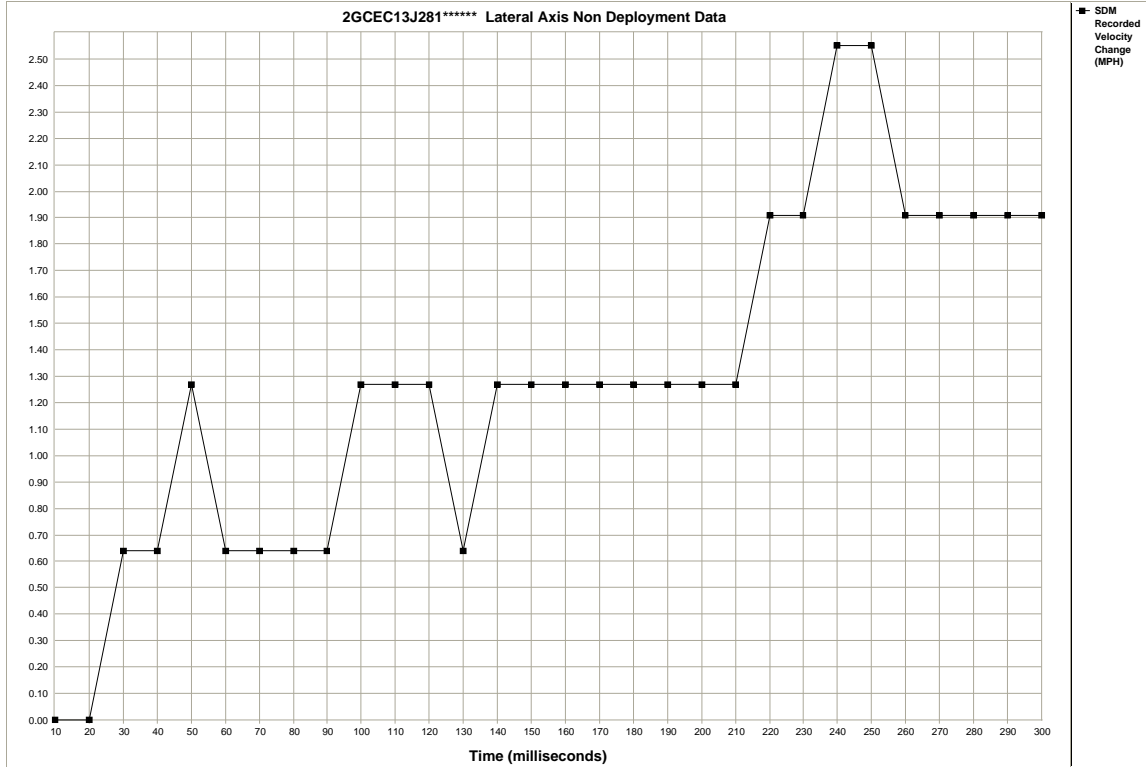
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.64	0.64	0.00	0.00	0.00	0.00	-0.64	-0.64	-0.64	0.00	-0.64

System Status At Non-Deployment

Ignition Cycles At Investigation	4889
SIR Warning Lamp Status this Ignition Cycle	ON
SIR Warning Lamp ON/OFF Time Continuously (seconds) this Ignition Cycle	0
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously this Ignition Cycle	0
Ignition Cycles At Event	4883
Ignition Cycles Since DTCs Were Last Cleared	255
Driver's Belt Switch Circuit Status	BUCKLED
Passenger's Belt Switch Circuit Status	BUCKLED
Driver Seat Position Switch Circuit Status	Rearward
Diagnostic Trouble Codes at Event, fault number: 1	B0052
Diagnostic Trouble Codes at Event, fault number: 2	N/A
Diagnostic Trouble Codes at Event, fault number: 3	N/A
Diagnostic Trouble Codes at Event, fault number: 4	N/A
Diagnostic Trouble Codes at Event, fault number: 5	N/A
Diagnostic Trouble Codes at Event, fault number: 6	N/A
Diagnostic Trouble Codes at Event, fault number: 7	N/A
Diagnostic Trouble Codes at Event, fault number: 8	N/A
Diagnostic Trouble Codes at Event, fault number: 9	N/A
Maximum SDM Recorded Velocity Change (MPH)	10.30
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	310
Crash Record Locked	No
Deployment Event Recorded in the Non-Deployment Record	No
Multiple Event Data/Vehicle Event Data (Pre-Crash) Associated With This Event	No
SDM Synchronization Counter	4883
Event Recording Complete	Yes
Driver First Stage Deployment Loop Commanded	No
Passenger First Stage Deployment Loop Commanded	No
Driver Second Stage Deployment Loop Commanded	No
Driver 2nd Stage Deployment Loop Commanded for Disposal	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger 2nd Stage Deployment Loop Commanded for Disposal	No
Driver Pretensioner Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	No
Driver Side Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Second Row Left Side Deployment Loop Commanded	No
Second Row Right Side Deployment Loop Commanded	No
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 3) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 3) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	-0.64	-1.27	-1.27	-1.27	-1.91	-1.91	-2.55	-2.55	-2.55	-3.18	-3.18	-3.82	-3.82	-4.46
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-5.09	-5.73	-5.73	-5.73	-6.37	-7.00	-7.64	-7.64	-8.28	-8.28	-8.91	-8.91	-8.91	-9.55	-9.55



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.64	0.64	1.27	0.64	0.64	0.64	0.64	1.27	1.27	1.27	0.64	1.27	1.27
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Lateral Axis Recorded Velocity Change (MPH)	1.27	1.27	1.27	1.27	1.27	1.27	1.91	1.91	2.55	2.55	1.91	1.91	1.91	1.91	1.91

Hexadecimal Data

Data that the vehicle manufacturer has specified for data retrieval is shown in the hexadecimal data section of the CDR report. The hexadecimal data section of the CDR report may contain data that is not translated by the CDR program. The control module contains additional data that is not retrievable by the CDR system.

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Disclaimer of Liability

The users of the CDR product and reviewers of the CDR reports and exported data shall ensure that data and information supplied is applicable to the vehicle, vehicle's system(s) and the vehicle ECU. Robert Bosch LLC and all its directors, officers, employees and members shall not be liable for damages arising out of or related to incorrect, incomplete or misinterpreted software and/or data. Robert Bosch LLC expressly excludes all liability for incidental, consequential, special or punitive damages arising from or related to the CDR data, CDR software or use thereof.