CRASH DATA RESEARCH CENTER
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CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
SCI CASE NO.:CA09013

VEHICLE: 2008 CHEVROLET SILVERADO

LOCATION: NORTH CAROLINA

CRASH DATE: JANUARY 2009

Contract No. DTNH22-07-C-00043

Prepared for:

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

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An investigation of the road side departure rollover crash of a 2008 Chevrolet Silverado pickup truck.

16. Abstract

This on-site investigation focused on the run-off-road rollover crash of a 2008 Chevrolet Silverado Crew Cab 4x4 pickup truck and the source of injury for the vehicle's three unrestrained occupants. The Chevrolet was equipped with 4-wheel antilock brakes, Electronic Stability Control (ESC) and Certified Advanced-208 Compliant (CAC) frontal air bags for the driver and front right passenger positions. The manufacturer of this vehicle has certified that the Chevrolet is compliant with the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The Chevrolet was not equipped with side impact or Inflatable Curtain air bags. The vehicle departed the right side of the road, entered a counterclockwise (CCW) yaw, tripped and rolled ten-quarter turns coming to rest on its roof. The driver's frontal air bag deployed during the crash sequence. The 18-year-old unrestrained male driver and the 18-year-old unrestrained male second row left passenger were ejected from the vehicle, transported to a regional trauma center and hospitalized. The 17-year-old unrestrained male front right passenger remained in the vehicle and was treated and released from a local hospital.

The damaged vehicle was identified through a visit to a regional salvage facility on March 5, 2009 and an image of the Chevrolet was forwarded to SCI 1 for review on the same day. Based on the information in the Police Accident Report (PAR) regarding the rollover and occupant injury, this case was assigned for on-site investigation on March 6, 2009. The on-site portion of this investigation was conducted on March 11, 2009. This investigation involved the inspection and documentation of the Chevrolet and the crash site, and interviews with the driver and a representative of the company that completed the aftermarket modifications on the case vehicle. The vehicle's Event Data Recorder (EDR) was imaged during the investigation and the output is included as **Attachment A** of this report.

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SCI CASE NO.:CA09013

VEHICLE: 2008 CHEVROLET SILVERADO
LOCATION: NORTH CAROLINA
CRASH DATE: JANUARY 2009

BACKGROUND

This on-site investigation focused on the run-off-road rollover crash of a 2008 Chevrolet Silverado K1500 pickup truck and the source of injury for the vehicle's three unrestrained occupants. The Chevrolet (**Figure 1**) was equipped with 4-wheel antilock brakes, Electronic Stability Control (ESC) and Certified Advanced-208 Compliant (CAC) frontal air bags for the driver and front right passenger positions. The manufacturer of this vehicle has certified that the Chevrolet is compliant with the advanced air bag requirements of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The Chevrolet was not equipped with side impact or Inflatable Curtain air bags. The vehicle departed the right side of the road, entered a counterclockwise (CCW) yaw, tripped and rolled ten-quarter turns, coming to rest on its roof. The driver's frontal air bag deployed during the crash sequence. The 18-year-old unrestrained male driver and the 18-year-old unrestrained male second row left passenger were ejected from the vehicle, transported to a regional trauma center and hospitalized. The 17-year-old unrestrained male front right passenger remained in the vehicle and was treated and released from a local hospital.

Figure 1: Chevrolet Silverado case vehicle.

The damaged vehicle was identified through a visit to a regional salvage facility on March 5, 2009. Based on the information in the Police Accident Report (PAR) regarding the rollover and occupant injury, this case was assigned for on-site investigation on March 6, 2009. The on-site portion of this investigation was conducted on March 11, 2009. This investigation involved the inspection and documentation of the Chevrolet and the crash site, interviews with the driver and a representative of the company that completed the aftermarket modifications on the case vehicle and the acquisition of the medical records. The vehicle's Event Data Recorder (EDR) was imaged during the investigation and the output is included as **Attachment A** of this report.

SUMMARY

VEHICLE DATA

2008 Chevrolet Silverado

The case vehicle was a 2008 Chevrolet Silverado 4x4 Crew Cab pickup truck. The Chevrolet was manufactured in December 2007 and was identified by the Vehicle Identification Number (VIN): 3GCEK13348G (production number deleted). The vehicle was modified and certified-altered by American Luxury Coach in South Carolina. There was no date of completion for the post-manufacturer modifications which included: a certification for larger tires on the OEM size 46 cm (18 in) rims, a spray-in bed liner, dual stainless steel exhaust, aftermarket window tint and interior carbon fiber accents to the instrument panel. The vehicle was purchased new in 2008 by the father of the driver involved in this crash.

The 4-wheel drive vehicle was powered by a 5.3-liter, V-8 engine linked to a 4-speed automatic transmission and an electronic transfer case. The braking system consisted of power-assisted front disc and rear drum brakes with four-wheel antilock. The Chevrolet was equipped with ESC and an indirect Tire Pressure Monitoring System (TPMS). The driver reported that he was aware that the vehicle was equipped with ESC, and that there was a switch on the center instrument panel under the air conditioning controls to activate and deactivate the feature. The driver indicated that he had not deactivated the ESC prior to the crash. The driver also reported that the TPMS warning light was not illuminated prior to the crash. All four side windows and the sliding backlight window were closed at the time of the crash. The Chevrolet was equipped with Mickey Thompson Baja ATZ Radial tires on aftermarket six-spoke alloy wheels. The tire size was LT325/60R18. The vehicle manufacturer recommended tire size was P265/65R18 as OEM tires; however, the aftermarket certification from the alteration company specified size was LT325/60R18. The left front, left rear and right rear wheels fractured and separated from the center spokes. The separated wheels were located in the bed of the truck. It was possible to determine the original locations of each wheel/tire by comparing the wheel rim damage to the center spokes that were still attached to the vehicle. 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	Flat	10 mm (13/32 in)	Wheel fractured and separated from vehicle
Left Rear	Flat	11 mm (14/32 in)	Wheel fractured, tire de-beaded and separated from rim
Right Rear	Flat	11 mm (14/32 in)	Center spokes fractured from outer rim, Outer rim and tire separated
Right front	Flat	10 mm (13/32 in)	None

The interior of the Chevrolet was configured with six-passenger seating. The cloth surfaced, front split bench was configured with a center seat with a folding-back that also served as a center console/armrest. The lower cushion of the center seat folded up to reveal a storage box with a plastic latch at the front. The front outboard seats were equipped with adjustable head restraints. The front left head restraint was adjusted 5.0 cm (2.1 in) above the seat back. The front right head restraint was in the full-down position. The second row was equipped with a

60/40 split-bench with seat cushions that folded vertically upward and a fixed seat back. Both cushions were folded down at the time of the crash. The rear outboard seats were equipped with adjustable head restraints; both were in the full-down position. The rear outboard seats were equipped with Lower Anchors and Tethers for Children (LATCH).

The interior occupant safety systems consisted of a CAC frontal air bag system for the driver and front right passenger positions. The vehicle was also equipped with 3-point lap and shoulder belts for the front outboard and three rear seating positions. The front outboard safety belts were equipped with a retractor pretensioner. A lap belt was available for the front center seating position.

CRASH SITE

This crash occurred during nighttime hours of January 2009 on the north road side of a four-lane east/west state highway. Lighting conditions were dark, as the rural area was not lighted. The highway consisted of two lanes in each direction. There was a shallow left curve for westbound traffic. The traffic lanes measured 3.7 meters (12.1 feet) in width and were surfaced with asphalt. The east/westbound lanes were separated by a grass median that measured 8.2 meters (26.9 feet) in width. In the westbound direction of travel, the roadway had a positive grade of 1.6 percent and transitioned to a level grade at the mid-point of the curve. The outboard (north) shoulder of the roadway measured 0.7 meters (2.3 feet) in width. The width of the inboard (south) shoulder measured 0.5 meters (1.6 feet). Both shoulders were surfaced with asphalt. The roadside outboard the north shoulder measured approximately 4.5 m (14.8 ft) in width and was sloped away from the pavement for drainage. The slope of the roadside then transitioned into a ditch that was located 7 m (23 ft) north of the road edge. A two-lane road and several private driveways intersected the highway from the north, along the pre-crash trajectory of the Chevrolet. Mailboxes for the respective properties were located 3.1 m (10.2 ft) north of the road edge. The posted speed limit was 89 km/h (55mph). Schematics of the crash site are included at end of this report as **Figures 13 and 14**.

CRASH SEQUENCE

Pre-Crash

The Chevrolet was westbound in a shallow left curve on the outboard lane of the highway driven by the 18-year-old male. The vehicle was traveling at an EDR recorded speed of 146 km/h (91 mph) 2.5 seconds prior to the initial roadside departure. The driver allowed the Chevrolet to drift to the right and depart the right shoulder. The driver responded to the vehicle's errant trajectory by steering counterclockwise (CCW) to the left. During this initial roadway departure, the Chevrolet traveled 1.3 m (4.3 ft) north of the road edge on an arcing trajectory that measured 30 m (98.4 ft) in length parallel to the road. The trajectory of the vehicle was evidenced by a rotating tire impression on the roadside.

The Chevrolet reentered the westbound travel lanes and traveled 41 m (134 ft) across both travel lanes to the left shoulder. The driver counter-steered clockwise (CW) back to the right as the vehicle traveled 66 m (216.5 ft) along the left shoulder. The Chevrolet crossed over the roadway again traveling 61 m (200.1 ft) to the right shoulder. As the Chevrolet approached the right shoulder a second time; the driver applied a CCW counter-steer to the left and the Chevrolet began to yaw CCW. Diverging right side tire impressions on the roadside evidenced the yawing

trajectory of the Chevrolet. The tire marks indicated the vehicle travelled 54 m (177.1 ft) along the roadside and had rotated approximately 50 degrees CCW at the time of the initial impact.

Crash

The right plane of the Chevrolet impacted a wheeled trash can and a wood mailbox post with the right door area (Events 1 and 2). The directions of force for both impacts were within the 2 o'clock sector. **Figure 2** is a trajectory view at the points of impact for the events. The wood mailbox post had been replaced prior to the scene inspection. The Chevrolet's right side tire impressions are visible in the image. Due to the overlapping damage from the subsequent rollover event, it was not possible to obtain a crush profile for these two impacts. These impacts did not alter the trajectory of the vehicle.

Figure 2: POI events 1 and 2 (Trash can removed).

After the impact with the mailbox, the Chevrolet continued an additional 17.6 m (57.7 ft) and yawed an additional 30 degrees CCW along the road side. The right side tire impressions indicated that the vehicle was on an arcing trajectory heading back toward the road. As the vehicle encountered the pavement edge, the right front wheel rim tripped on an 11 cm (4.3 in) drop off between the asphalt and the dirt/grass roadside. The interaction at the road/rim interface caused the Chevrolet to initiate a right side leading tripped rollover. The location of the edge drop and the start of the rollover are depicted in **Figure 3**.

Figure 3: Location of start of rollover.

The Chevrolet rolled 10-quarter turns along the roadside and came to rest on its roof in the north roadside ditch facing southward. The vehicle was located 8 m (26.2 feet) north of the roadway and 52.9 m (173.6 ft) west of the trip point. The rollover was not interrupted. The driver's and front right passenger's safety belt pretensioners actuated and the driver's frontal air bag deployed during the rollover sequence. There was a small amount of slack in the front right passenger's safety belt, indicating that the pretensioner actuated prior to the roof intrusion. The unrestrained driver and the unrestrained second row left passenger were fully ejected through the left front and left rear windows, respectively. The final rest positions of the ejected occupants were not documented by the investigating police officer. The unrestrained front right passenger remained in the vehicle.

Post-Crash

It is unknown who notified emergency personnel of the crash. The front right occupant exited the vehicle and attempted to attend to the ejected occupants. Police, emergency medical and tow personnel responded to the scene. The driver sustained multiple soft tissue abrasions and contusions, brain hemorrhages, a fractured lumbar vertebra, and a rib fracture. He was transported via helicopter and admitted to a trauma center for treatment. He was released six days post-crash. The second row left passenger sustained facial fractures, a fractured lumbar vertebra and multiple soft tissue abrasions and contusions. He was transported via helicopter to a trauma center and admitted for three days. The front right passenger was transported by ambulance to a local hospital for treatment of a fractured left ankle and soft tissue injuries to the chest. The front right passenger was treated and released from the emergency department on the day of the crash.

VEHICLE DAMAGE

Exterior Damage

The exterior of the Chevrolet sustained moderate severity damage to the side, top and front planes as a result of the multiple impact crash. The right plane sustained two impacts from the plastic trash can (Event 1) and the mailbox (Event 2). The contact damage from these events was overlapped by the damage from the rollover (Event 3). **Figure 4** depicts the right side damage to the Chevrolet. The first impact occurred to the right front door. The direct damage measured 46 cm (18.1 in) in length and began 67 cm (26.4 in) rearward of the right front axle, extending rearward to 113 cm (44.5 in) rear of the RF axle. The Collision Deformation Classification (CDC) for this impact was 02RPEW01. The second impact to the right plane occurred to the forward aspect of the right rear door. The direct damage measured 5 cm (2 in) in length and began 179 cm (70.5 in) rear of the right front axle, extending rearward to 184 cm (72.4 in) rear of the front right axle. The CDC for this impact was 02RPEN01

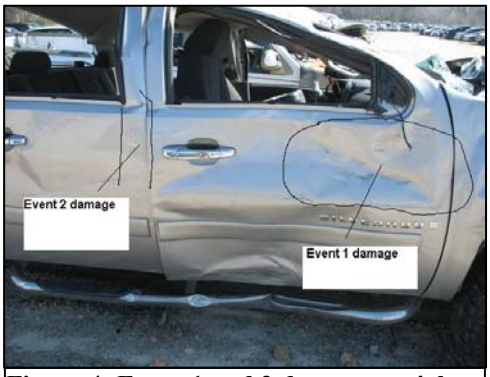


Figure 4: Event 1 and 2 damage to right side.

The rollover resulted in body panel abrasions and deformation to the left and right sides, roof and hood of the vehicle. The abrasions overlapped in multiple directions, indicating that the Chevrolet rolled over multiple times. The left front wheel separated from the suspension during the impact sequence. The left rear and right rear wheel rims fractured and the rims separated from the vehicle during the impact. The right rear rim was found to be embedded with grass of the same type found at the crash scene. The right front tire was de-beaded but the tire and rim were still attached to the Chevrolet. The location of the maximum crush, both vertically and laterally, was located at the junction of the right roof side rail and the right A-pillar. The maximum vertical and lateral crush was 17 cm (6.7 in) and 8 cm (3.2 in), respectively. (The left C-pillar area was also measured for the extent of rollover damage, but it did not exceed the crush to the right A-pillar area.) The left front, left rear and right front doors were jammed shut. The right rear door remained closed during the crash and was operational. The windshield was fractured and all the side glazing disintegrated. The CDC assigned for the rollover was 00TYDO3. **Figures 5 and 6** depict the rollover damage to the Chevrolet.

Figure 5: Maximum crush location.

Figure 6: Rollover damage to roof.

Interior Damage

The Chevrolet Silverado sustained moderate severity interior damage that was attributed to intrusion that resulted from the rollover and to the deployment of the driver air bag. The intrusion of the Chevrolet is listed on the following table:

Position	Component	Direction	Magnitude
Row 1 Left	Windshield header	Vertical	8 cm (3.2 in)
Row 1 Middle	Windshield header	Vertical	13 cm (5.1 in)
Row 1 Right	Windshield header	Vertical	15 cm (5.9 in)
Row 1 Middle	Roof	Vertical	8 cm (3.2 in)
Row 1 Right	Roof	Vertical	7 cm (2.8 in)
Row 1 Right	Roof side rail	Vertical	14 cm (5.5 in)
Row 2 Right	Roof side rail	Vertical	6 cm (2.4 in)
Row 2 Left	Roof side rail	Vertical	9 cm (3.5 in)
Row 2 Left	Roof	Vertical	16 cm (6.3 in)
Row 2 Middle	Roof	Vertical	10 cm (3.9 in)
Row 2 Right	Roof	Vertical	7 cm (2.8 in)
Row 2 Left	Backlight header	Vertical	15 cm (5.9in)
Row 2 Middle	Backlight header	Vertical	11 cm (4.3 in)
Row 2 Right	Backlight header	Vertical	5 cm (2 in)
Row 1 Right	A-pillar	Lateral	14 cm (5.5 in)
Row 1 Right	B-pillar	Lateral	9 cm (3.5 in)
Row 1 Right	Roof side rail	Lateral	16 cm (6.3 in)
Row 2 Right	Roof side rail	Lateral	9 cm (3.5 in)
Row 2 Left	Roof side rail	Lateral	12 cm (4.7 in)
Row 2 Left	B-pillar	Lateral	11 cm (4.3 in)
Row 2 Left	C-pillar	Lateral	8 cm (3.2 in)
Row 2 Left	Front seat back	Longitudinal	17 cm (6.7 in)

Position	Component	Direction	Magnitude
Row 1 Right	Front seat back	Longitudinal	15 cm (5.9 in)
Row 1 Left	Left instrument panel	Longitudinal	2 cm (0.8 in)
Row 1 Middle	Center instrument panel	Longitudinal	2 cm (0.8 in)

The driver seat was adjusted to the full-rear position. The seat back angle measured 22 degrees aft of vertical. The recline adjustment mechanism was jammed. The steering column was completely separated from the shear capsules and the rim was resting on the driver seat cushion (**Figure 7**). The front right seat was adjusted to a mid-track position. The front right seat back angle measured 8 degrees forward of vertical. The recline adjustment mechanism of this seat was also jammed. The second row of the Chevrolet was relatively undamaged. The split-rear bench seats maintained their pre-crash position.

Figure 7: View of the steering assembly.

The interior of the Chevrolet sustained minor damage from occupant contacts. In the front row, the left roof side rail and window sill were both scuffed over a 12 cm (4.7 in) length as a result of contact from the driver as he was ejected through the disintegrated window. The steering wheel rim was deformed 5 cm (2 in) at the 10 to 12 o'clock position by contact with the driver's right lower extremity. The front right passenger contacted the front right sun visor, overhead console and roof. The sun visor was scuffed over a 27 cm x 15 cm (10.6 in x 5.9 in) area. The scuff to the overhead console measured 4 cm x 4 cm (1.6 in x 1.6 in). The roof contact measured 36 cm x 28 cm (14.2 in x 11.0 in).

In the second row, the roof was scuffed in two locations by contact from the second row left passenger. The areas measured 6 cm x 25 cm (2.4 in x 9.8 in) and 26 cm x 24 cm (10.2 in x 9.5 in). The inboard upper aspect of the front left seat back was scuffed over a 4 cm x 6 cm (1.6 in x 2.4 in) are by contact with the second row left passenger as he was ejected through the disintegrated left rear window. The interior of the vehicle was coated with a layer of dust from the vehicle being uncovered in a dirt salvage yard for several weeks. This may have concealed additional faint contacts.

Manual Restraint Systems

The manual restraint systems in the Chevrolet consisted of 3-point lap and shoulder belts in the front left, front right, rear left, rear center and rear right seating positions, and a lap-only belt in the front center seat position. The driver's manual restraint consisted of a continuous loop webbing, an Emergency Locking Retractor (ELR), a sliding latch plate and height adjustable D-ring. The retractor was equipped with a pretensioner that actuated during the crash. The retractor was locked and the webbing was pulled taut against the B-pillar. The driver was not restrained during the crash based on the observations of the SCI inspection and the driver interview.

The front right passenger's manual restraint consisted of a continuous loop webbing, a switchable ELR/Automatic Locking Retractor (ALR), a sliding latch plate and a height adjustable D-ring. The retractor was equipped with a pretensioner that actuated during the crash. The retractor was locked and the webbing was pulled against the B-pillar but had approximately 2.5 cm (1 in) of slack from the intrusion of the right roof side rail and B-pillar after the actuation of the pretensioner. The front right passenger was not restrained during the crash based on the observations of the SCI inspection and the driver interview.

The manual restraint in the second row left position consisted of a continuous loop webbing, a switchable ELR/ALR retractor, a sliding latch plate and a fixed D-ring. The examination of the belt system was unremarkable for crash related evidence. The rear left passenger was not restrained during the crash based on the observations of the SCI inspection and the driver interview. The front center, second row center and second row right seating positions were not occupied at the time of the crash.

Air Bag System

The Chevrolet was equipped with a Certified Advanced 208-Complaint (CAC) frontal air bag system for the driver and front right passenger positions. The manufacturer of this vehicle has certified that the Chevrolet is compliant to the advanced air bag requirements of Federal Motor Vehicle Safety Standard No. 208. The CAC system consisted of dual-stage driver and front right passenger air bags, a front right occupant presence sensor, front seat track positioning sensors, buckle switch sensors and front retractor pretensioners.

Figure 8: Deployed driver's frontal air bag.

The driver air bag (**Figure 8**) deployed from an I-configuration module located in the hub of the four-spoke steering wheel rim. The air bag measured 62 cm (24.4 in) in its deflated state. It was tethered by two straps sewn to the face of the bag that were located at the 3 and 9 o'clock positions. There was a small 4 cm (1.6 in) tear along the tether seam on the face of the bag in the 5 o'clock sector. The air bag was vented by two ports located at the 11 and 1 o'clock positions on the back side of the bag. The 1 o'clock vent port was surrounded by melted fabric from the driver's seat cushion. A 5 cm (2 in) diameter burn pattern was observed on the driver's seat. A similar burn pattern was observed on the cushion of the front center seat. This burn pattern was related to the 11 o'clock vent port. The orientation of the burned/melted seat cushions indicated that the steering wheel rim was rotated approximately 180 degrees at the time of the air bag deployment. The driver air bag must have deployed during the later stages of the rollover sequence, after the driver had loaded and compressed the steering column separating the shear capsules, and after he was ejected. **Figures 9 and 10** depict the residual evidence and burn from the driver air bag deployment to the cushions of the center and driver seat.

Figure 9: Residual evidence to the center seat cushion from the 11 o'clock vent port.

Figure 10: Burn to the driver seat cushion from the 1 o'clock vent port of the diver air bag.

The front right air bag did not deploy during the crash. The imaged EDR data indicated that the air bag was suppressed at the time of the crash. The Passenger Classification Status at Event Enable was recorded as "Invalid". It was probable that due to the length of time between the Algorithm Enable (AE) of the CAC air bag system and meeting deployment criteria, the front right passenger was out of position. Therefore, and the CAC system suppressed the deployment of the front passenger air bag as designed.

Event Data Recorder

The Event Data Recorder (EDR) of the Chevrolet was imaged at the time of the inspection by applying 12-volt power to the vehicle and imaging the data through the OBD port under the left instrument panel. The recovered data indicated that a Non-Deployment and a Deployment event had been stored in the module. Additionally, there were three associated Non-Deployment events that had not been recorded. These unrecorded Non-Deployment events preceded, were in-between, and followed the two recorded events. The recorded Non-Deployment event occurred 1.4 seconds prior to the recorded Deployment event. All five events were recorded on Ignition Cycle 2,045. The EDR data was imaged on Ignition Cycle 2,051.

The Chevrolet's EDR recorded 2.5 seconds of Pre-Crash data. Data flags within both the recorded Non-Deployment file and the recorded Deployment file indicated that the Pre-crash data was not associated to that file. The pre-crash data was most likely related to the first unrecorded Non-Deployment event. The imaged pre-crash data is listed on the following table:

Parameter	-2.5 sec	-2.0 sec	-1.5 sec	-1.0 sec	-0.5 sec
Vehicle speed	146 km/h (91 mph)	142 km/h (88 mph)	134 km/h (83 mph)	129 km/h (80 mph)	116 km/h (72 mph)
Engine speed (RPM)	3648	2752	2176	2176	1920
Percent Throttle	42	25	17	13	9
Brake Switch	Off	Off	Off	Off	Off

The recorded Non-Deployment data reported that the SIR warning lamp was "Off". The safety belts for the driver and front right passenger were "Unbuckled". The maximum recorded (total) delta-V was 41.95 km/h (26.07 mph) at 230 milliseconds. The longitudinal and lateral delta-V components were -5.12 km/h (-3.18 mph) and 40.97 km/h (25.46 mph), respectively. The event record was completely written. The source of this Non-Deployment event was possibly related to ground contact during the initial stage of the rollover. The velocity change was oriented primarily in the lateral direction.

The recorded Deployment data indicated that both front safety belts were "Unbuckled" and that both pretensioners were actuated. A Stage 2 driver air bag deployment was commanded 185 milliseconds after AE. There were no diagnostic trouble codes stored at the time of the deployment. The event record was completely written. The maximum recorded longitudinal and lateral delta-V components were -17.41 km/h (-10.82 mph) and 34.83 km/h (21.64 mph), respectively. The pretensioner actuation and driver air bag deployment was most likely related to ground contact during the rollover sequence. The imaged EDR is attached to the end of this report as **Attachment A**.

OCCUPANT DEMOGRAPHICS

	Driver	**Front Right Passenger**
Age/Sex:	18-year-old/Male	17-year-old/Male
Height:	196 cm (77 in)	168 cm (66 in)
Weight:	89 kg (195 lb)	50 kg (110 lb)
Eyewear:	None	None
Seat Track Position:	Full-rear position	Mid-track position
Restraint Use:	Not used	Not used
Restraint Usage Source:	SCI inspection/driver interview	SCI inspection/driver interview
Mode of Transport From Scene:	Transported via helicopter to a regional trauma center	Transported via ambulance to a local hospital
Type of Medical Treatment	Admitted to trauma center for six days	Treated and released from hospital ER

	Second Row Left Passenger	**Second Row Center**	**Second Row Right**
Age/Sex:	18-year-old/Male	Not Occupied	Not Occupied
Height:	183 cm (72 in)		
Weight:	150 kg (330 lb)		
Eyewear	Contact lenses		
Seat Track Position:	Not adjustable		
Restraint Use:	Not used		
Restraint Usage Source:	SCI inspection/driver interview		
Mode of Transport From Scene:	Transported via helicopter to a regional trauma center		
Type of Medical Treatment	Admitted to trauma center for three days		

DRIVER INJURY

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Subdural hematoma (right frontal lobe along the high posterior inter-hemispheric fissure)	Severe (140650.4,1)	Ground contact
Right frontal subarachnoid hemorrhage	Serious (140684.3,1)	Ground contact
Left lateral 6th rib fracture with small left pneumothorax	Serious (450214.3,2)	Door panel - forward upper quadrant
L5 vertebral body fracture (with minimal displacement)	Moderate (650630.2,8)	Ground contact
Scalp abrasions	Minor (190202.1,9)	Ground contact
Scalp contusions (right frontal scalp)	Minor (190402.1,5)	Ground contact
Right eye ecchymosis	Minor (297402.1,1)	Ground contact
Right eye, lateral subconjuntival hemorrhage (with debris in eye)	Minor (240416.1,1)	Ground contact
Left lateral chest wall abrasion (6 cm diameter in size)	Minor (490202.1,2)	Door panel - forward upper quadrant
Right shoulder and arm abrasions	Minor (790202.1,1)	Occupant to occupant contact
Back abrasions (entire back)	Minor (690202.1,0)	Ground contact
Left flank abrasions	Minor (590202.1,2)	Door panel - forward upper quadrant
Right flank abrasions	Minor (590202.1,1)	Left roof side rail
Left knee 4 cm abrasion	Minor (890202.1,2)	Steering wheel rim
Left knee ecchymosis (over proximal tibia)	Minor (890402.1,2)	Steering wheel rim
Right knee ecchymosis	Minor (890402.1,1)	Steering wheel rim
Left calf abrasion	Minor (890202.1,2)	Steering wheel rim

Source: Emergency Room records and Discharge Summary

DRIVER KINEMATICS

The 18-year-old male driver was seated in a full-rear track position in an upright posture. He was not restrained by the manual safety belt. The driver reported that he was wearing a Carhartt

jacket, a tee-shirt, denim jeans and tennis shoes at the time of the crash. The police investigation determined his post-crash Blood Alcohol Content (BAC) was 0.12.

The Chevrolet departed the roadway to the right and the driver applied an evasive left steering maneuver to regain the road. The rapid steering maneuver initiated a CCW yaw. As the vehicle rotated and decelerated during the yaw, the driver was displaced to the right. The vehicle tripped as it came back to the edge of the asphalt shoulder and initiated a right side leading rollover. As the rollover began, the driver continued the right trajectory across the front center seating position and loaded the front right occupant. This contact resulted in the soft tissue injuries to the driver's right shoulder and arm. As the vehicle rolled over, the driver initiated a left and forward trajectory. The driver loaded the steering wheel and separated the column from the shear capsules. The force of the rollover caused the driver to be ejected through the front left window opening. During the ejection sequence, the driver contacted the door panel with the left side of his chest and flank. This contact was evidenced by the scuffed panel and resulted in the rib fracture and soft tissue flank abrasions. His right flank contacted and was abraded by the left roof side rail. The driver's lower extremities contacted the steering wheel rim evidenced by the rim deformation and soft tissue injuries to his lower extremities. **Figure 11** depicts the trajectory of the driver as he was ejected.

Figure 11: Driver contacts along path of ejection.

The ejected driver contacted the ground with his head and back. This contact resulted in the identified brain hemorrhages, the lumbar vertebrae fracture and multiple soft tissue injuries. The abrasions were described as being embedded with dirt and gritty material. The driver did not know his position of final rest in relation the final rest of the vehicle.

FRONT RIGHT PASSENGER INJURY

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Left ankle small avulsion fractures, NFS	Moderate (840402.2,2)	Floor pan
Left lateral chest wall lacerations (2 cm each x 2)	Minor (490602.1, 2)	Occupant to occupant contact
Left chest wall abrasions	Minor (490202.1,2)	Occupant to occupant contact
Cervical strain	Minor (640278.1,6)	Roof (indirect)
Lumbar Strain	Minor (640678.1,8)	Front right seat back

Source: Emergency Room records

FRONT RIGHT PASSENGER KINEMATICS

The 17-year-old male front right passenger was seated in a mid-track position and was not restrained at the time of the crash. The driver reported that the passenger was wearing a sweatshirt, denim jeans and tennis shoes at the time of the crash. Additionally, the driver reported that the front passenger braced for the crash by holding the right side grab-handle, pushing his feet to the floor, and pushing his back into the front right seat back. At the initiation of the rollover, the front right passenger began a right trajectory and loaded the right front door panel. He was then loaded by the driver as the driver passed across the front bench. This contact resulted in the soft tissue injuries to the left lateral chest. As the Chevrolet rolled inverted, the front right passenger began a vertical trajectory and contacted the right sun visor and center roof console with his head. As the rollover continued, the vehicle returned to its wheels and impacted the ground. The front right passenger responded with a downward trajectory back into the seat. The passenger loaded the floor with his foot resulting in the small avulsion fractures. His loading of the seat back resulted in the lumbar and cervical strain. **Figure 12** depicts the contacts left by the front right passenger. The vehicle came to rest on its roof with the passenger was still inside. He self-extricated through an unknown portal and attempted to assist the other occupants before EMS and police arrived.

Figure 12: Contacts to the roof over the front right seating position.

REAR LEFT PASSENGER INJURY

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Left mildly displaced orbital floor and medial orbital wall fractures	Serious (251204.3,2)	Ground contact
Right L3 transverse process fracture (minimally displaced)	Moderate (650620.2,8)	Ground contact
Concussion with loss of consciousness, unknown length of time	Moderate (160406.2,0)	Ground contact
Right chest abrasion	Minor (490202.1,1)	Ground contact
Right chest contusion	Minor (490402.1,1)	Ground contact
Left periorbital eccymosis (with grass/foreign body in left eye)	Minor (297402.1,2)	Ground contact
Left side face contusions	Minor (290402.1,2)	Ground contact
Left side face abrasions	Minor (290202.1,2)	Ground contact
Right flank abrasions	Minor	Ground contact

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
	(590202.1,1)	
Left lower back abrasions	Minor (690202.1,2)	Ground contact
Right hip abrasions	Minor (890202.1,1)	Ground contact

Source: Emergency Room records and Discharge Summary

REAR LEFT PASSENGER KINEMATICS

The 18-year-old male rear left passenger was seated in an unknown posture and was unrestrained at the time of the crash. The driver reported that the rear left passenger was wearing denim jeans, a tee-shirt, boots and a jacket at the time of the crash. As the Chevrolet began to roll to the right, the rear left passenger initiated a right trajectory into the rear right seating position. As the vehicle rolled inverted, he initiated a vertical trajectory and contacted the roof evidenced by the scuffed headliner. As the roll sequence continued, the passenger was ejected through the disintegrated left rear window. The passenger impacted the ground facing downward, resulting in the fractures of the left orbital floor and wall, the periorbital eccymosis with grass in the left eye, and the soft tissue facial injuries. As the ejected passenger tumbled to final rest, he sustained the lumbar fracture and additional soft tissue injuries. The interviewed driver did not know the location of the final rest of the rear left passenger in relation to the final rest of the vehicle.

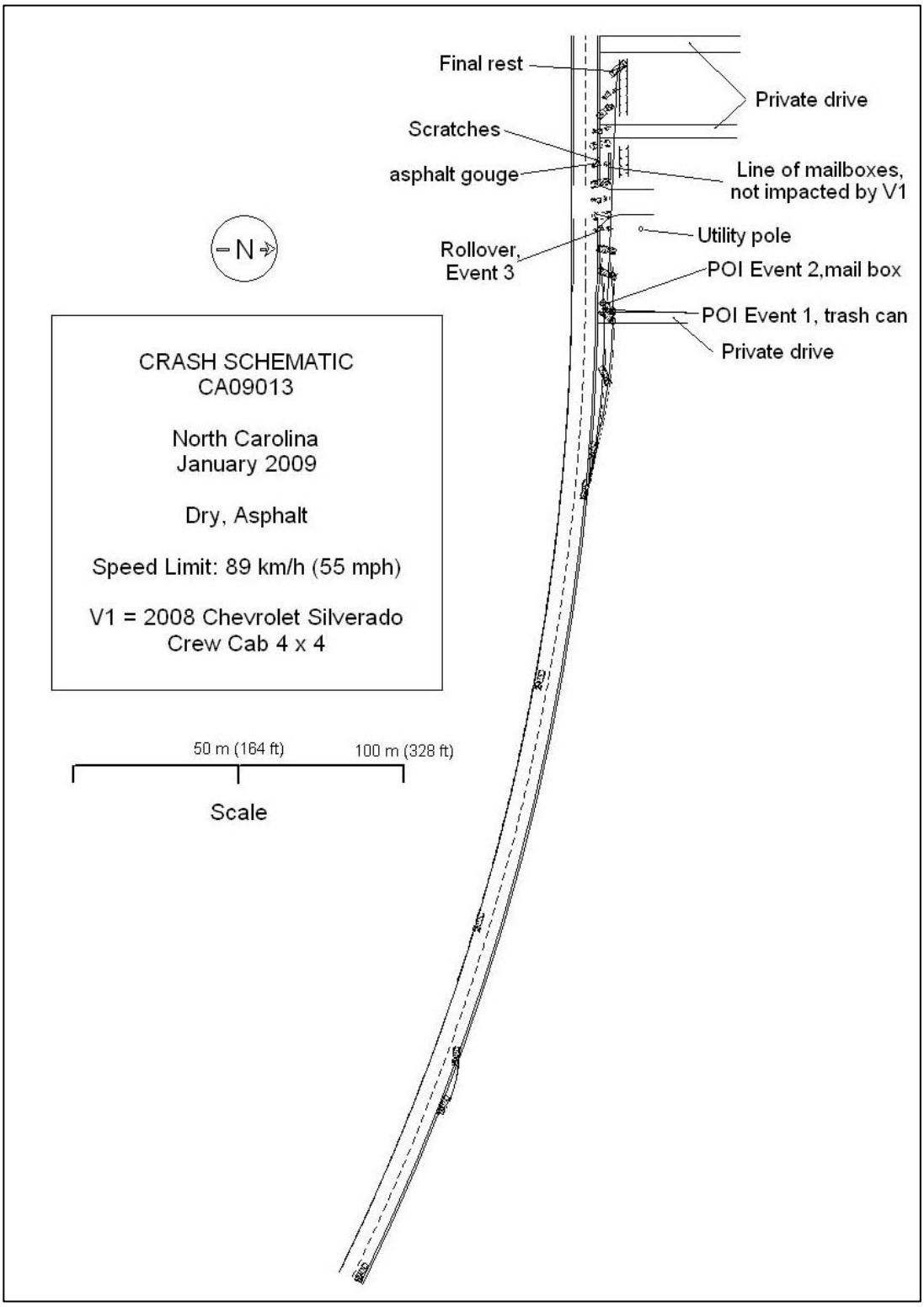


Figure 13: Crash Schematic.

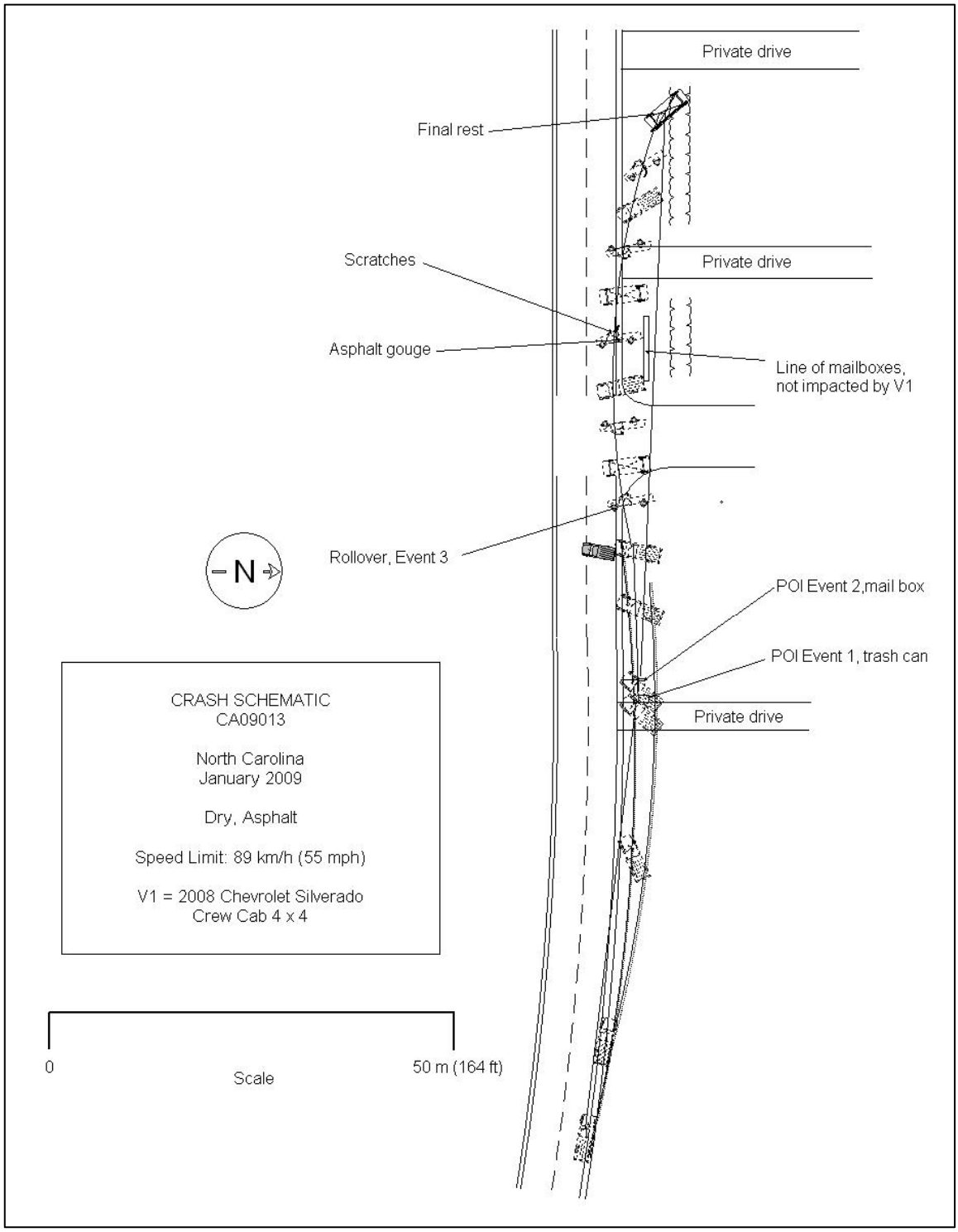


Figure 14: Close-up of rollover sequence.

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	3GCEK13348G******
User	
Case Number	
EDR Data Imaging Date	Tuesday, March 10 2009
Crash Date	Sunday, January 25 2009
Filename	
Saved on	Tuesday, March 10 2009 at 11:28:02 AM
Collected with CDR version	Crash Data Retrieval Tool 3.00
Reported with CDR version	Crash Data Retrieval Tool 3.4
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	3
An Event(s) Preceded the Recorded Event(s)	Yes
An Event(s) was in Between the Recorded Event(s)	Yes
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

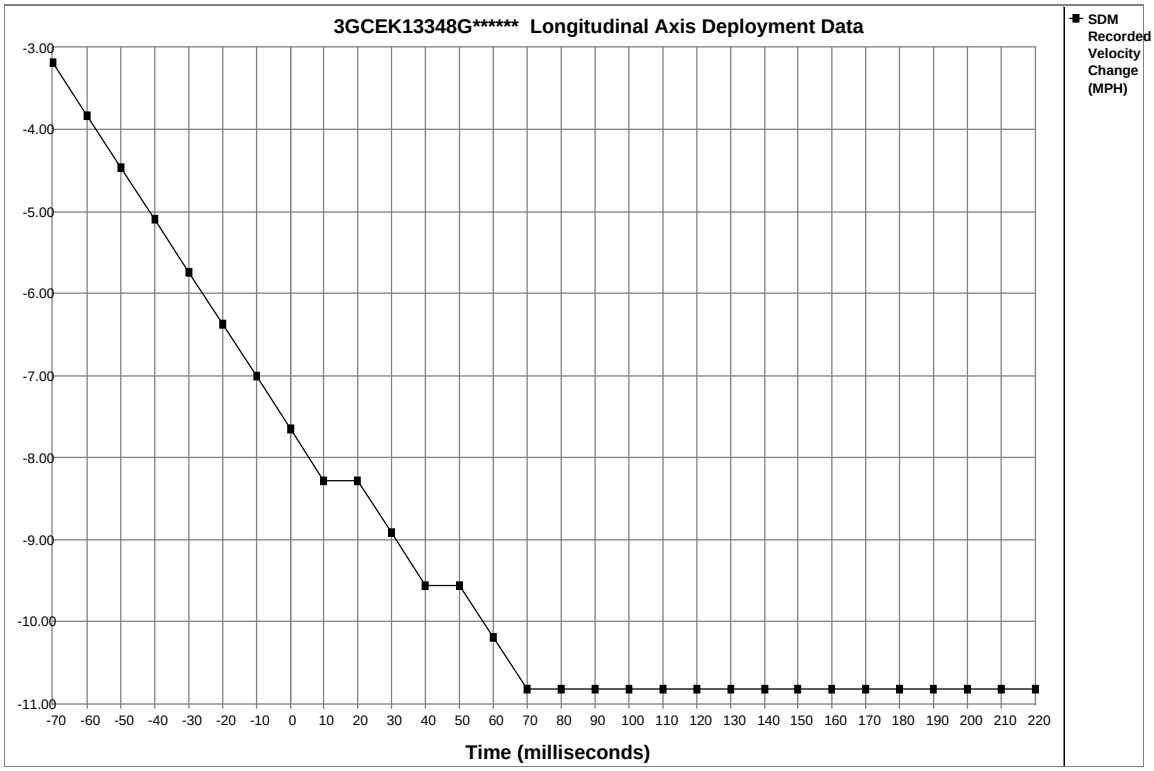
Parameter	-1.0 sec	-0.5 sec
Reduced Engine Power Mode	OFF	OFF
Cruise Control Active (If Equipped)	No	No
Cruise Control Resume Switch Active (If Equipped)	No	No
Cruise Control Set Switch Active (If Equipped)	No	No
Engine Torque (foot pounds)	-3.69	-4.06

Pre-Crash Data

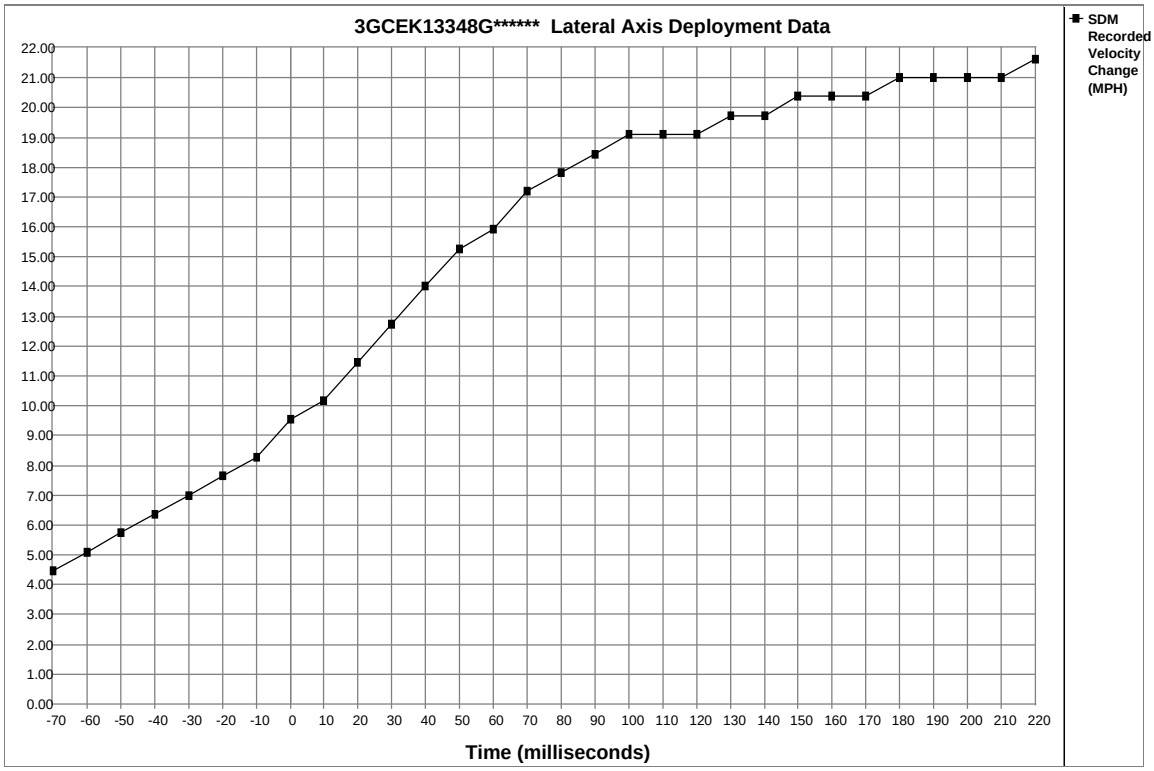
Parameter	-2.5 sec	-2.0 sec	-1.5 sec	-1.0 sec	-0.5 sec
Accelerator Pedal Position (percent)	0	0	0	0	0
Vehicle Speed (MPH)	91	88	83	80	72
Engine Speed (RPM)	3648	2752	2176	2176	1920
Percent Throttle	42	25	17	13	9
Brake Switch Circuit Status	OFF	OFF	OFF	OFF	OFF

System Status At Deployment

Ignition Cycles At Investigation	2051
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time Continuously (seconds)	655350
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	2039
Ignition Cycles At Event	2045
Ignition Cycles Since DTCs Were Last Cleared	255
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Driver Seat Position Switch Circuit Status	Rearward
Passenger Classification Status at Event Enable	Invalid
Current Passenger Position Status at Event Enable	Unknown
Previous Passenger Position Status at Event Enable	Unknown
Passenger Air Bag Indicator Status at Event Enable	OFF
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)	185
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	185
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	Suppressed
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	Suppressed
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
Vehicle Event Data (Pre-Crash) Associated With This Event	No
SDM Synchronization Counter	2045
Time Between Events (sec)	1.4
Event Recording Complete	Yes
Driver First Stage Deployment Loop Commanded	Yes
Passenger First Stage Deployment Loop Commanded	No
Driver Second Stage Deployment Loop Commanded	Yes
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	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



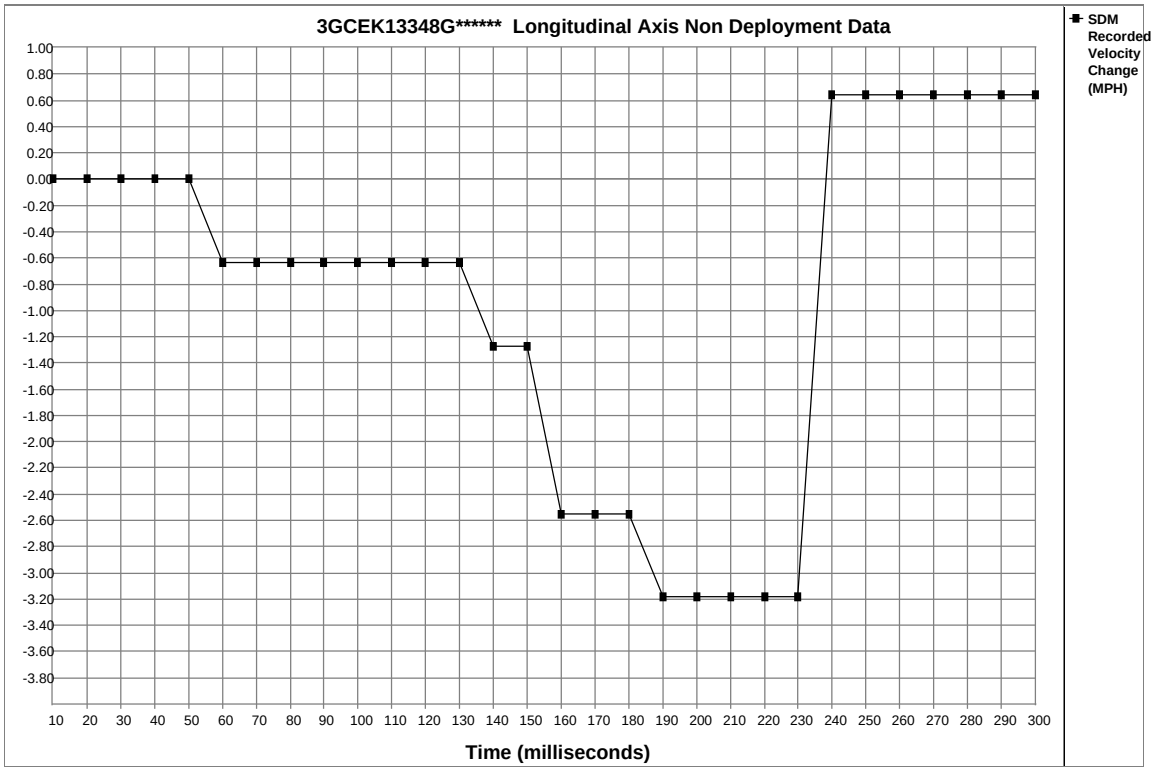
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-3.18	-3.82	-4.46	-5.09	-5.73	-6.37	-7.00	-7.64	-8.28	-8.28	-8.91	-9.55	-9.55	-10.19	-10.82
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82	-10.82



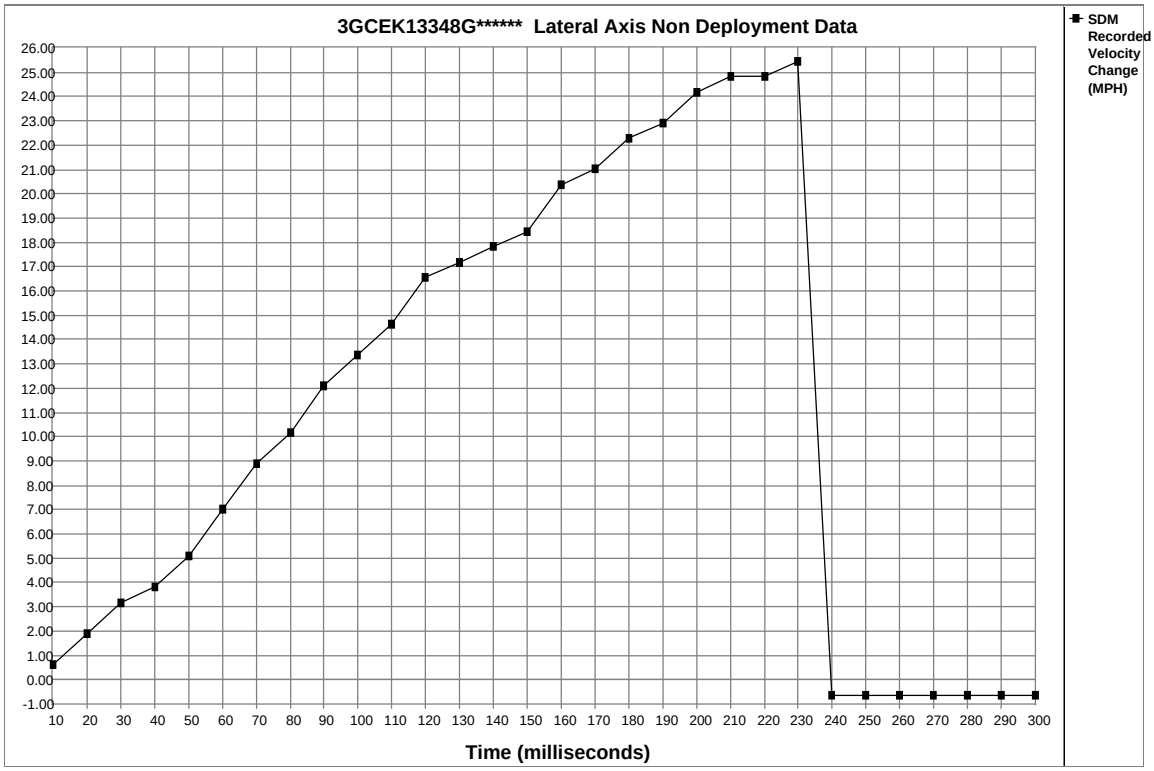
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Lateral Axis Recorded Velocity Change (MPH)	4.46	5.09	5.73	6.37	7.00	7.64	8.28	9.55	10.19	11.46	12.73	14.01	15.28	15.91	17.19
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Lateral Axis Recorded Velocity Change (MPH)	17.82	18.46	19.10	19.10	19.10	19.73	19.73	20.37	20.37	20.37	21.01	21.01	21.01	21.01	21.64

System Status At Non-Deployment

Ignition Cycles At Investigation	2051
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time Continuously (seconds)	655350
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	2039
Ignition Cycles At Event	2045
Ignition Cycles Since DTCs Were Last Cleared	255
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Driver Seat Position Switch Circuit Status	Rearward
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
Maximum SDM Recorded Velocity Change (MPH)	26.07
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	230
Crash Record Locked	Yes
Deployment Event Recorded in the Non-Deployment Record	No
Vehicle Event Data (Pre-Crash) Associated With This Event	No
SDM Synchronization Counter	2045
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	0.00	0.00	0.00	0.00	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64	-1.27	-1.27
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-2.55	-2.55	-2.55	-3.18	-3.18	-3.18	-3.18	-3.18	0.64	0.64	0.64	0.64	0.64	0.64	0.64



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Lateral Axis Recorded Velocity Change (MPH)	0.64	1.91	3.18	3.82	5.09	7.00	8.91	10.19	12.10	13.37	14.64	16.55	17.19	17.82	18.46
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Lateral Axis Recorded Velocity Change (MPH)	20.37	21.01	22.28	22.92	24.19	24.83	24.83	25.46	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64	-0.64