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Each crash represents a unique sequence of events and generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems. This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was published.

16. Abstract

This report documents the on-site investigation of a four-vehicle crash involving the rollover of a 2016 Nissan Frontier, which resulted in partial ejection of the belted 56-year-old male driver. He sustained police-reported incapacitating (A-level) injuries and was transported by ambulance to a regional trauma center, where he was hospitalized for 18 days. The Nissan had front seat belt pretensioners, certified 208-compliant frontal air bags, side impact air bags, and inflatable curtain air bags. The crash occurred on a divided, multi-lane roadway near a four-leg intersection. Also involved were a 2012 Chevrolet Malibu, a 2011 Toyota Highlander, and a 2013 Kia Sorento. The Nissan was traveling the wrong way at a speed over 100 mph.

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Special Crash Investigations
On-Site Rollover Crash Investigation
Case No: CR18009
Vehicle: 2016 Nissan Frontier
Location: Georgia
Crash Date: February 2018

Background

This report documents the on-site investigation of a four-vehicle crash involving the rollover of a 2016 Nissan Frontier (Figure 1) that resulted in partial ejection of the belted 56-year-old male driver. He sustained police-reported incapacitating (A-level) injuries and was transported by ambulance to a regional trauma center, where he was hospitalized for 18 days. The Nissan had front seat belt pretensioners, Federal Motor Vehicle Safety Standard (FMVSS) No. 208-compliant (CAC) frontal air bags, FMVSS No. 214-compliant side impact air bags, and FMVSS No. 226-compliant inflatable curtain (IC) air bags. The crash occurred on a divided, multi-lane roadway near a four-leg intersection and involved the Nissan, a 2012 Chevrolet Malibu, a 2011 Toyota Highlander, and a 2013 Kia Sorento.

Figure 1. Law enforcement image of the overturned 2016 Nissan Frontier at final rest

Notification of the crash was received by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration in March 2018. It was forwarded to the Special Crash Investigations (SCI) group and assigned to the team at Crash Research & Analysis, Inc., for on-site investigation. The SCI team located the vehicle at a regional salvage facility and established cooperation to inspect the vehicle. The on-site portion of this investigation took place in May 2018, and consisted of inspections of the Nissan, Toyota, Kia, and crash site. The inspection of the Nissan documented its exterior and interior damage, identified points of occupant contact, and assessed the manual and supplemental restraint systems. Inspections of the Toyota and Kia documented their exterior damage. During the vehicle inspection process, data was imaged from the event data recorder (EDR) component of the Toyota's air bag electronic control unit (ECU) using the Bosch Crash Data Retrieval tool/software. The inspection of the crash site included documentation of the environment using a total station mapping system and photographs. In addition to the on-site activities, on-scene images, images of all involved vehicles, and electronic files of EDR data from the Nissan and Chevrolet were obtained from the investigating law enforcement agency. Medical records documenting the Nissan driver's injuries were obtained from the treating facility.

Summary

Crash Site

The crash occurred in the afternoon on a divided multi-lane roadway near its intersection with a local roadway. At the intersection, the multi-lane roadway was oriented east/west, while the local roadway was oriented north/south. At the time of the crash, conditions in the locale included overcast/cloudy skies with a temperature of 21 ºC (70 ºF), 49-percent relative humidity, and variable winds at 9 km/h (5.6 mph). The roadway surfaces were wet.

The eastbound approach to the intersection consisted of two through lanes bordered by designated left and right turn lanes. The eastbound lane widths from right (south right turn) to left (north left turn) were 3.6 m (11.8 ft), 3.5 m (11.5 ft), 3.5 m (11.5 ft), and 3.6 m (11.8 ft), respectively. The through lanes were delineated by a broken white lane line, with solid white lines to delineate the left turn and right turn lanes. A solid white edge line marked the right turn lane, while a solid yellow edge line terminated the left turn lane along the median. In the vicinity of the intersection, a 2.2 m (7.2 ft) wide raised concrete curb median divided the eastbound and westbound portions of the roadway. Concrete curbing bordered the north and south roadway edges. All travel lanes were asphalt-surfaced (bituminous). Figure 2 depicts an east-facing view of the divided roadway looking toward the intersection. In the vicinity of the crash site, the roadway was essentially level and curved slightly to the left with respect to eastbound traffic flow, with a radius of curvature of 410 m (1,345 ft). Speed was regulated by a posted limit of 72 km/h (45 mph).

Figure 2. East-facing view of the divided roadway on approach to the intersection

Figure 3. East-facing view of the divided roadway at the intersection

The east/west divided roadway was intersected by a four-lane local roadway from the south and a two-lane local roadway from the north. The south leg was a single southbound travel lane and three northbound lanes that included designated left and right turn lanes with a single through lane. Painted pedestrian crosswalks and stop bars were present at the four legs of the intersection. Traffic flow through the intersection was controlled by overhead traffic signals with designated left turn signals (Figure 3). Pedestrian signals were present at all four quadrants of the intersection. A crash diagram is included at the end of this report.

Pre-Crash

Prior to the crash, the local emergency response system received multiple reports of a wrong-way driver traveling eastbound at a high speed in the westbound lanes of the divided roadway. The reports described a vehicle similar to the Nissan in this SCI investigation. Witnesses to the crash at the scene reported to the investigating law enforcement agency that they observed the Nissan traveling east at a high speed in the westbound lanes approaching the intersection where the crash occurred.

For unknown reasons, the Nissan was traveling eastbound in the westbound lanes. The belted 56-year-old male driver, whose medical record indicated he had a history of seizures, operated the Nissan against traffic for an extended distance of at least 1.6 km (1.0 mi), which was the distance from the prior intersection to the location of the crash. According to data from the recorded EDR data, the Nissan was traveling 160 km/h (99 mph) at the beginning of its 5-second pre-crash recording. The accelerator pedal was depressed 80 percent or greater over the entire pre-crash data buffer, and the vehicle's speed was increasing.

The Chevrolet was traveling in the eastbound left through lane on approach to the intersection. It was driven by a belted 35-year-old female at a speed of 79 km/h (49 mph) immediately prior to its first impact involvement in the crash, according to its EDR.

The Toyota was traveling in the eastbound right through lane on approach to the intersection, immediately to the right and ahead of the Chevrolet. It was driven by a belted 66-year-old female with a belted 79-year-old male front right passenger. According to the Toyota's EDR, it was traveling at a speed of 74 km/h (46 mph) immediately prior to its impact involvement in the crash.

The Kia was stopped in the westbound left turn lane as it waited behind other vehicles at the intersection. It was driven by a belted 21-year-old male.

Approximately 75 m (246 ft) west of the intersection, the eastbound Nissan drifted right in the westbound travel lanes toward the raised concrete center median. Its right side tires/wheels, then its left side tires/wheels, overrode the center median as the Nissan crossed over and into the eastbound portion of the roadway toward the Chevrolet. The jolt of the vehicle created by the raised concrete median was of sufficient magnitude to be detected as a crash event by the Nissan's ACU. At that time, the Nissan's speed was 165 km/h (103 mph).

Crash

The first impact (Event 1) occurred as the front plane, right aspect of the Nissan struck the back plane, left aspect of the Chevrolet. This impact occurred in the left through lane of the eastbound travel lanes, and began approximately 43 m (141 ft) from the center of the intersection. Directions of force were within the 12 o'clock sector for the Nissan and 6 o'clock sector for the Chevrolet.

Due to the speed of the vehicles at impact and close alignment of their heading angles, the Chevrolet was pushed forward as the vehicles engaged. Impact forces induced a slight clockwise rotation to the Nissan and a counterclockwise rotation to the Chevrolet as the two vehicles remained engaged and maintained their eastbound trajectory as a combined unit. The second impact (Event 2) occurred as the Chevrolet's right plane, rear aspect struck the left plane of the Toyota. This impact occurred in the through lanes of the eastbound portion at the intersection.

Directions of force were within the 3 o'clock sector for the Chevrolet and the 8 o'clock sector for the Toyota. The Nissan and Chevrolet remained engaged on an easterly trajectory, while the Toyota was directed toward the southeast. The right rear corner of the Chevrolet sideswiped the forward aspect of the Toyota (Event 3) as the vehicles maintained their eastbound trajectories.

As the Nissan and Chevrolet slid through the intersection and continued into the east leg, the Nissan kept rotating clockwise while the Chevrolet kept rotating counterclockwise. They separated with the Nissan in a clockwise yaw and redirected toward the south roadway edge. The combined dynamics, impact forces, and momentum induced a left roll to the Nissan as it continued east. This was captured in the Nissan's EDR data, which showed a left roll angle that began to increase from 10 degrees at 1.3 seconds after algorithm enable (AE). The Nissan rolled onto its left side (Event 4) and slid from the roadway up the curb and into the roadside. As it slid on its left plane, the front plane of the Nissan lightly impacted the face of a W-beam guardrail system (Event 5).

The Nissan's EDR data indicated that the roll angle reached 120 degrees to the left at 2.3 seconds after AE. The roll angle then achieved stability and remained constant at 110 degrees to the left for the final second of the recording interval, which was after the Nissan had slid to rest. During the rollover, the driver's left arm became partially ejected from the vehicle beneath the partially-opened deployed IC air bag, through the disintegrated left front glazing (*see Supplemental Restraint Systems section for further detail*). The driver's left arm then became entrapped beneath the Nissan once it came to rest. At final rest, the Nissan faced southeast on its left side in the south roadside.

The Chevrolet rotated counterclockwise and yawed across the center concrete median. It entered the left turn lane of the westbound lanes and struck the Kia (Event 6). The directions of force were within the 12 o'clock sector for the Chevrolet and the 11 o'clock sector for the Kia. The impact increased the Chevrolet's counterclockwise rotation and displaced the Kia rearward (northeast). The Chevrolet completed a 175-degree counterclockwise rotation and slid to final rest straddling the concrete center median, facing west. The Toyota driver regained control and brought the vehicle to a controlled stop on the right road edge, facing east. The Kia was displaced northeast by the impact forces and came to rest in the westbound lanes a short distance from its pre-crash position.

Post-Crash

All vehicles in the crash came to final rest (Figure 4). The local emergency response system received several telephone calls reporting the crash. Law enforcement, fire department, and emergency medical services personnel responded. Upon arrival, they found the Nissan driver still belted in the vehicle. His left arm extended out the opening created by the disintegration of the left front glazing. It was contorted and pinned under the vehicle. Fire department personnel used hydraulic rescue tools to cut the roof off of the Nissan and elevate the vehicle to remove the entrapped driver. He was immobilized on a long spine board and transported by ambulance to a local regional trauma center for evaluation and treatment of incapacitating (A-level) injuries. The driver ultimately was hospitalized for 18 days for treatment of his injuries.

Figure 4. West-facing lookback view of the vehicles at final rest (law enforcement image)

The 35-year-old female driver of the Chevrolet was assisted from the Chevrolet and transported by ambulance to a local hospital for evaluation and treatment of possible (C-level) injuries. The 21-year-old male driver of the Kia exited his vehicle without assistance and also was transported by ambulance to a local hospital for evaluation and treatment of possible (C-level) injuries. The 66-year-old female driver and 79-year-old male front row right passenger of the Toyota denied injury and were not medically treated or transported. A local towing service recovered the vehicles from the crash site and transferred them to a local yard. After the law enforcement investigation concluded, they were deemed total losses by their insurers and transferred to regional salvage facilities, where they were located for this SCI investigation.

2016 Nissan Frontier

Description

The 2016 Nissan Frontier (Figure 5) was a crew cab-style small pickup, manufactured in September of 2015 and identified by the VIN 1N6AD0ER3GNxxxxxx. The Nissan had the SV level trim package and was powered by a 4.0 liter, V-6, gasoline engine linked to a 5-speed automatic transmission. It was a rear-wheel drive platform with 4-wheel drive capabilities, built on a 320 cm (125.9 in) wheelbase. The cargo bed measured 185 cm (73.0 in) long.

Figure 5. Left front oblique view of the Nissan at the time of the SCI vehicle inspection

The gross vehicle weight rating (GVWR) was 2,599 kg (5,730 lb) with specific gross axle weight ratings (GAWR) of 1,495 kg (3,296 lb) front and 1,511 kg (3,331 lb) rear. The service brakes were power-assisted 4-wheel disc with ABS. Additional features included traction control, electronic stability control, and a tire pressure monitoring system. The vehicle manufacturer recommended tire size was P265/70R16 with recommended cold tire pressures of 240 kPa (35 PSI). At the time of the SCI inspection, the Nissan had BF Goodrich Radial Long Trail T/A tires of the recommended size. The right front tire and wheel had separated during the crash and were missing. The remaining three tires had at least 4 mm (0.15 in) of tread. Both rear tires remained inflated.

The Nissan had seating for five occupants (2/3). This included front row bucket seats and a split-bench second row seat, which had upward-folding seat cushions to access under seat storage. The front row bucket seats were separated by a fixed center console. Adjustable head restraints were configured to the four outboard positions. The driver's head restraint was adjusted 1 cm (0.5 in) above the seat back at the time of the SCI inspection, while the other three were in their respective full-down positions. All seat surfaces were cloth. Both front seats were manually adjustable for seat track and recline features. Safety systems included manual 3-point lap and shoulder seat belts for all five seat positions. Supplemental restraints were available, including front seat belt pretentioners, frontal air bags, front seat-mounted side impact air bags, and IC air bags. The driver's frontal, both seat-mounted, and both IC air bags deployed.

Exterior Damage

Damage was observed to the left, front, and right planes of the Nissan. There was also post-crash damage from rescue efforts to the top plane (roof) and pillars. Damage from the first impact (Event 1) with the back plane of the Chevrolet was on the front and right planes. Figures 6 and 7 depict the direct contact damage to the Nissan's right front corner area, highlighted on the hood and bumper by yellow masking tape.

Figure 6. Front view of the Nissan and the Event 1 impact damage to the right front corner

Figure 7. Right view of the front right corner damage to the Nissan from the impact with the Chevrolet

Direct contact began 25 cm (9.8 in) right of center and extended 35 cm (13.8 in) to the right front bumper corner of the bumper beam. The direct contact damage extended down the right plane to the right A-pillar/leading edge of the right front door. Direct contact on the hood began 25 cm (9.8 in) right of center and extended 35 cm (13.8 in) to the right front corner.

A residual crush profile was documented to the Nissan's front bumper beam, though it should be noted that the majority of the damage was beyond the bumper beam and consisted primarily of engagement of the right front axle position. The entire right front tire/wheel and suspension assembly were completely separated from the Nissan by the Event 1 impact with the Chevrolet. The corresponding direct and induced damage width (Field-L) measured 118 cm (46.5 in) across the front bumper beam. Resultant measurements included: C1 – C4 = 0 cm (0 in), C5 = 2 cm (0.8 in), and C6 = 5 cm (2.0 in). Maximum crush in the profile was observed at the right front bumper corner. However, the extent of damage associated with the corner impact was down the right plane to the right A-pillar. The collision deformation classification (CDC) assigned to the Nissan for the Event 1 damage profile for the impact to the Chevrolet was 12FREE5. The "missing vehicle" algorithm of the WinSMASH model was used to calculate the severity of the Event 1 crash. The Nissan's total calculated vehicle velocity change (delta V) of the crash was 11 km/h (6.8 mph). Specific longitudinal and lateral components of the calculated delta V were -11 km/h (-6.8 mph) and 0 km/h (0 mph), respectively. Based on SCI expertise and observed vehicle damage, these results were significantly underestimated.

Damage from the rollover (Event 4) was observed across the entire left plane of the Nissan. It consisted of heavy abrasions to the body surface, with minimal lateral deformation. Post-crash damage, which included damage to the pillars and roof to extricate the driver from the vehicle at

the crash scene, masked or hindered documentation of any lateral deformation or attributable rollover measurements. The corresponding CDC was 00LDAO3. No WinSMASH calculations could be computed for the rollover, which was beyond the scope of the model's capabilities due to the non-horizontal nature of the impact forces and lack of residual deformation measurements. Figures 8 and 9 show the direct contact/rollover damage to the Nissan's left plane.

Figure 8. Left view of the Nissan and the Event 4 rollover damage to the forward aspect

Figure 9. Rollover damage to the rear aspect of the Nissan's left plane

There was no discernable damage to the Nissan's front plane in association to the minor severity impact (Event 5) with the W-beam guardrail system. This impact overlapped prior damage, without associated deformation. There also was no significant deformation to the W-beam from the impact. Figure 10 depicts the W-beam guardrail system and slight redirection of the Nissan's sliding trajectory. The CDC assigned to the Nissan was 00FLEN1. No WinSMASH calculations could be performed for this impact due to the lack of residual deformation and non-horizontal nature of the forces, which were beyond the scope of the model's capabilties.

Figure 10. Sliding trajectory of the Nissan evidentiary of the guardrail impact (on-scene law enforcement image)

Event Data Recorder

The 2016 Nissan Frontier had an ACU beneath the center tunnel between the front row seats that monitored the diagnostic functions of the vehicle's restraint systems (air bags and seat belt pretensioners) and controlled the deployment/actuation of those devices dependent upon crash event severity. The ACU had EDR capabilities to record crash event data for longitudinal and lateral crash events.

The ACU was removed from the Nissan and retained as evidence by the investigating law enforcement agency, which imaged data from the ACU using the CDR tool and software version 17.6.1. An electronic file of the imaged data was given to the SCI team, and later reported using software version 21.0.1. The reported data is included at the end of this report as Appendix A.

The EDR could store a combination of up to two crash event records for either of the two event types, termed "non-deployment event" or "deployment event." By definition, a non-deployment event was any event that enabled the algorithm, but did not meet the threshold for deployment/actuation of a safety device. A deployment event actuated pretensioners and/or deployed inflatable restraints. Non-deployment events were subject to overwrite by subsequent events of greater severity or typing, whereas air bag deployment event types could not be overwritten. If power supply to the ACU was lost following a crash event, all or part of the data may not have been recorded to the EDR's memory. The EDR had the capacity to record up to 250 milliseconds of data once the minimum threshold was achieved in longitudinal or lateral event types. Associated to the recording of each respective event was a 5-second pre-crash buffer that recorded multiple pre-crash data points in 0.5-second intervals. Data recorded included vehicle speed (mph), accelerator pedal (% full), engine speed (rpm), motor speed (rpm), service brake (on/off) status, and steering input (degrees) data. Additional data samples, including seat belt status of the front row occupants and system status data, were recorded at the time of an event.

The imaged data contained two events, termed event record 1 and event record 2. Event record 1 was a non-deployment event that occurred on ignition cycle number 1,798, while event record 2 was a deployment event that occurred on ignition cycle number 3,109. Both were completely recorded. Based on the ignition cycle counter at download of 3,111, only event record 2 was related to the crash under investigation. Due to the limitations of the ACU, the Nissan's EDR was only able to record the first recognized event in the crash under investigation.

At the time of event record 2, the seat belt status of the driver was reported as "on (fastened)." In relation to the event, the driver's frontal air bag (first and second stages), driver's side air bag, right front side air bag, both IC air bags, and both front seat belt pretensioners were reported as commanded to actuate/deploy at 253 milliseconds. Associated with event record 2 was the following recorded pre-crash buffer data:

Time	Vehicle Speed	Accelerator Pedal (% Full)	Engine rpm	Service Brake	Steering Wheel Angle (degrees)
-5.0	160 km/h (99 mph)	83.5	3,800	OFF	22
-4.5	160 km/h (99 mph)	79	3,800	OFF	-18
-4.0	160 km/h (99 mph)	87	3,800	OFF	-4
-3.5	160 km/h (99 mph)	88	3,850	OFF	4
-3.0	161 km/h (100 mph)	81.5	3,850	OFF	-4
-2.5	161 km/h (100 mph)	86	3,850	OFF	-8
-2.0	162 km/h (101 mph)	88	3,850	OFF	2
-1.5	163 km/h (101 mph)	88	3,900	OFF	6
-1.0	164 km/h (102 mph)	98	3,900	OFF	12
-0.5	165 km/h (103 mph)	100	3,900	OFF	10
0.0	165 km/h (103 mph)	100	3,900	OFF	12

The maximum longitudinal delta V for event record 2 was 0 km/h (0 mph). The maximum lateral delta V was -1 km/h (-1 mph) at 130 milliseconds after AE. This was associated with a right to left acceleration, and was believed to be related to the vehicle mounting and crossing over the center concrete median prior to the initial impact event with the Chevrolet.

Interior Damage

Loss of integrity to the Nissan included the disintegration of the closed AS2 left front glazing by the rollover impact forces. The AS1 windshield was fractured by the crash forces, then removed post-crash by emergency services personnel. In addition, the Nissan's pillars were cut by hydraulic rescue tools to fold the roof open and extricate the driver. All the doors remained closed and were operational post-crash. There were no discernable intrusions into the Nissan's interior associated with the crash. Exposure of the interior to the environment between the date of the crash and the time of the SCI inspection hindered the identification of areas of occupant contact.

Blood transfer was observed on the driver's frontal, left seat-mounted, and left IC air bags. These are described in the *Supplemental Restraint Systems* section of this report. There was also blood transfer on the webbing of the driver's seat belt system, discussed in the *Manual Restraint Systems* section of this report. Although no discernable evidence to the support contact could be found, the driver's left flank certainly contacted and engaged the four quadrants of the left front door. Figure 11 depicts an on-scene law enforcement image of the overturned Nissan and its interior following removal of the driver.

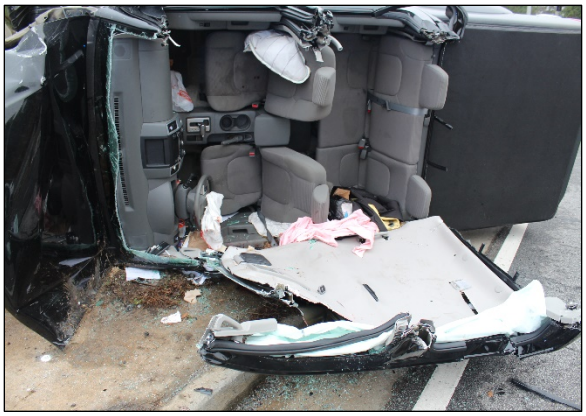


Figure 11. View of the overturned Nissan and its interior (law enforcement image)

Manual Restraint Systems

The Nissan had manual 3-point lap and shoulder seat belts for the five designated seat positions, all with continuous loop webbing and sliding latch plates. The driver's seat belt retracted onto an emergency locking retractor (ELR) while the others retracted onto switchable ELR/automatic locking retractors. Both front row retractors were equipped with retractor pretensioners. The front row seat belt systems also utilized adjustable D-rings. The driver was the sole occupant of the Nissan; therefore, the front row right and all second row seat belt systems were fully retracted and stowed when the crash occurred. The SCI investigator observed during the vehicle inspection that the front row right seat belt was taut against the B-pillar due to pretensioner actuation.

At the time of the SCI inspection, the driver's D-ring was adjusted to a middle height position. His use of the seat belt system was evidenced by subtle frictional abrasions on the polymer surface of the latch plate from loading during the multiple event crash. The latch plate was still engaged in the buckle, and the lap belt webbing was gathered in the latch plate (Figure 12). During the post-crash extrication activities, rescue personnel cut the webbing of the driver's seat belt system at two locations to facilitate removal of the driver. The shoulder belt webbing was cut 61 cm (24.0 in) below the D-ring and the lap belt webbing was cut 93 cm (36.6 in) above the lower anchor point. The webbing remained routed through the D-ring and the retractor was locked in position, presumably as a result of pretensioner actuation.

Figure 12. Webbing gathered in the Nissan driver's latch plate as a result of occupant loading during the crash

Supplemental Restraint Systems

The Nissan had frontal, side, and rollover protection air bags. The frontal system consisted of FMVSS No. 208-compliant (CAC) dual stage frontal air bags for the driver and front row right occupant positions. In addition to the air bags, the system used seat track positioning sensors, seat belt buckle switches, front row retractor pretensioners, and an occupant presence (weight) sensor in the front row right seat cushion. FMVSS No. 214-compliant side impact protection was provided by front seat-mounted air bags and dual sensing (side impact and rollover) roof side rail-mounted IC air bags. The IC air bags were also certified by the manufacturer to be FMVSS No. 226-compliant ejection mitigation systems, designed to reduce the likelihood of the complete ejection of vehicle occupants through side windows during rollovers or side impact events. In this multiple event crash, the front seat belt pretensioners actuated and the driver's frontal, both seat-mounted, and both IC air bags deployed. SCI reconstruction of the crash determined that the front seat belt retractors and driver's frontal air bag most likely deployed as a result of the initial impact with the Chevrolet (Event 1).

The Nissan driver's frontal air bag deployed from the steering wheel-mounted module in the three-spoke steering wheel through tri-configuration cover flaps. Deflated, the air bag measured 48 cm (18.9 in) in overall diameter. Venting was achieved by two 4 cm (1.6 in) ports located on the back side of the air bag at the 11 and 1 o'clock sectors. The air bag was internally tethered, which were stitched to the face of the air bag via a 24 cm (9.4 in) diameter pattern at the midpoint of the air bag. There was no discernable evidence of driver contact to the air bag at the time of the SCI inspection, which occurred more than two months after the crash. At that time, the air bag was stained by dirt from exposure to the outside elements (Figure 13). However, on-scene law enforcement images showed the deployed driver's frontal air bag with an area of blood on the left edge and top.

Figure 13. View of the deployed driver's frontal air bag in the Nissan at the time of the SCI vehicle inspection

The front-seat-mounted side impact air bags deployed through a 45 cm (17.7 in) section of the vertical stitching of the outer side surface of the seat backs. Deflated, the air bags measured 70 cm (27.6 in) in overall height and protruded approximately 20 cm (7.9 in) forward. A 2 cm (0. 8 in) diameter vent port was located on the leading edge of the middle aspect on the outboard side. Similar to the driver's frontal air bag, there was no discernable contact evidence to the left seat-mounted air bag. Dirt staining was noted to the left seat-mounted air bag, with a possibility of washed-out blood staining. This was confirmed by on-scene law enforcement images that showed significant blood from post-crash contact on the deployed front left seat-mounted side air bag. There was no occupant contact or damage to the deployed right seat-mounted side air bag.

The IC air bags deployed through the separation of the headliner from the side rails and provided outboard protection for both seating rows. The air bags were symmetrical in size and shape. The overall rectangular dimensions included a length of 160 cm (63.0 in) and height of 48 cm (18.9 in). The forward aspects of each IC air bag was tethered to its respective A-pillar by a 33 cm (13.0 in) long woven strap. At the time of the SCI inspection, the SCI Investigator found the left IC air bag captured between the left B-pillar trim, B-pillar, and headliner (Figure 14). Initially, the SCI Investigator believed that the air bag had been tucked upward by some individual involved in the post-crash movement of the vehicle, as is commonly done by towing, emergency services, and insurance professionals. However, after exposing the entire air bag and observing pronounced folds still creased into the fabric at the left B-pillar area and a distinct clean area and void in contact (Figure 15), it became apparent to the SCI investigator that the left IC air bag had not fully opened during its deployment.

Figure 14. View of the left IC air bag captured at the top of the B-pillar as observed by the SCI Investigator

Figure 15. Interior aspect of the deployed left IC air bag. Note the clean folds and contact void at the B-pillar area

The evidence showed that the left IC air bag snagged the top of the B-pillar trim panel during deployment, which partially restricted its opening and caused the air bag to became captured between the left B-pillar trim, B-pillar, and headliner. The snagging of the IC air bag prevented its complete opening during deployment, which created a void in the vertical/beltline coverage of the air bag. It was through this void that the left arm of the driver became partially ejected during the crash sequence. Figure 16 depicts an on-scene view of the driver's area and left glazing opening, with the partially opened IC air bag covered in blood. The image was taken while the vehicle was still lying on its left side, with the roof cut open.

Figure 16. View of the deployed driver's frontal air bag in the Nissan at the time of the SCI vehicle inspection

2016 Nissan Frontier Occupant Data

Driver Demographics

Age/sex:	56 years/male
Height:	175 cm (69 in)
Weight:	95 kg (209 lb)
Eyewear:	Prescription eyeglasses
Seat type:	Forward-facing bucket seat with adjustable head restraint
Seat track position:	Between middle and rearmost track position
Manual restraint usage:	3-point lap and shoulder seat belt
Usage source:	Vehicle inspection
Air bags:	Driver's frontal, seat-mounted, and IC air bags available; all deployed
Alcohol/drug involvement:	BAC = 0
Egress from vehicle:	Removed from vehicle due to perceived severity of injuries
Transport from scene:	Ambulance to local trauma center
Type of medical treatment:	Hospitalized for 18 days, then transferred to rehabilitation

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Degloving injury of left forearm from elbow to wrist, with ulnar artery transection and destruction of distal segment; radial artery near-transection; carpal and metacarpal bones destroyed and crushed, resulting in surgical amputation of the distal 1/3 of the forearm	713003.3	Critical IPC 2-point; Critical 1: Exterior of Occupant's Vehicle - Left front door; Critical 2: Other Vehicle or Object - Ground	Certain Certain
2	Bilateral pulmonary contusions	441411.3	Tandem IPC; Initial: Interior – Shoulder portion of belt restraint; Secondary: Left Air Bag – Steering wheel hub	Certain Possible
3	Small apical right pneumothorax	442202.2	Tandem IPC; Initial: Interior – Shoulder portion of belt restraint; Secondary: Left Air Bag – Steering wheel hub	Certain Possible
4	Abrasions to right hand	710202.1	Isolated IPC: Front – Left instrument panel	Possible
5	Abrasions to right lower leg	810202.1	Isolated IPC: Floor – Foot controls including parking brake	Possible

Source – Hospital records

Driver Kinematics

The Nissan's 56-year-old male driver was seated in the bucket seat. He had adjusted the seat to a track position between middle and rearmost, with the seat back slightly reclined and the adjustable head restraint 1 cm (0.4 in) above the seat back. Based on the post-crash condition of the manual seat belt system, it was apparent that the driver was belted at the time of the crash. His specific posture remains unknown.

At impact with the back plane, left aspect of the Chevrolet (Event 1), the driver initiated a forward trajectory in response to the 12 o'clock direction of the impact forces. The actuation of the seat belt pretensioner removed excess slack from the seat belt system, and the deployment of the driver's fontal air bag prevented the driver's interaction with the steering wheel/hub/column. The dynamic forces associated with the Nissan's impact and engagement with the Chevrolet, coupled with the severity of the crash, likely resulted in the deployment of the seat-mounted side impact and IC air bags as well. During the deployment of the left IC air bag, the fabric snagged on the B-pillar trim and the air bag became captured between the trim and left B-pillar. It did not completely open. In response to the frontal forces, the driver's torso and lap loaded the seat belt system. This restricted his movement and prevented his displacement about the interior of the Nissan. Loading forces were transmitted through his chest wall, which ultimately resulted in bilateral pulmonary contusions and a small right pneumothorax. The driver's right hand separated from the steering wheel rim and was displaced forward. He sustained an abrasion of the right hand from possible contact with the instrument panel, though no corresponding contact evidence was discernable.

Due to the pre-crash speed of the Nissan, it accelerated the Chevrolet forward as the vehicles remained engaged and the Chevrolet struck the Toyota. Forces associated with the Chevrolet's impact to the Toyota were insufficient to alter or otherwise affect the trajectory of the Nissan, and did not elicit further kinematic response from the driver.

The Nissan rotated clockwise as it yawed through the intersection and then rolled onto its left side as it departed the right (south) road edge. The left front glazing disintegrated on contact. The driver initiated a left lateral trajectory in response to the centrifugal and lateral forces associated with the left rollover. His left flank contacted and engaged the deployed left seat-mounted air bag and left door panel (rear quadrants), while the driver's left arm passed through the void below the partially-opened IC air bag and contacted the ground. His arm then was dragged beneath the overturned Nissan as it slid, and became entrapped between the left front door and ground at final rest.

The Nissan's driver sustained a degloving injury to his lower left arm, which required surgical amputation.

The driver remained belted in the Nissan at final rest. Emergency response personnel used hydraulic rescue tools to cut open the pillars/roof of the Nissan and elevate/stabilize the vehicle to remove the driver. He was then immobilized on a long spine board and transported by ambulance to a regional trauma center. According to his medical records, his left lower arm injury was evaluated and the initial treatment resulted in surgical amputation of a finger and the thumb. Further evaluation and progression of the injury ultimately required amputation at the left forearm, distal to the elbow. The Nissan's driver was hospitalized for 18 days, then transferred to a rehabilitation facility for physical therapy.

2012 Chevrolet Malibu

Description

The 2012 Chevrolet Malibu LS was identified by the VIN 1G1ZA5E01CFxxxxxx. It was sold at auction prior to SCI case assignment; therefore, it was not available for SCI inspection. Insurance salvage facility (Figure 17) and law enforcement images of the damaged vehicle were obtained to support this investigation. According to its placard, the Chevrolet was manufactured in March 2012. It was a 4-door sedan equipped with a 2.4 liter, inline, 4-cylinder gasoline engine that was linked to a 6-speed automatic transmission with a console-mounted shifter. The service brakes were 4-wheel power-assisted disc with ABS, electronic brakeforce distribution, and emergency brake assist. Additional features included traction control, electronic stability control, and a tire pressure monitoring system.

Figure 17. Left front oblique view of the Chevrolet (insurance salvage facility image)

The Chevrolet was built on a 285 cm (112.2 in) wheelbase. It had a GVWR of 1,991 kg (4,388 lb), with specific GAWR of 1,040 kg (2,292 lb) front and 951 kg (2,096 lb) rear. The manufacturer's recommended tire size and pressure were P215/55R17 at 210 kPa (30 PSI) for all four axle positions. Based on the obtained images, the Chevrolet had all-season tires of the vehicle manufacturer's recommended size. The tires were mounted on OEM steel wheels with plastic hub caps.

The interior of the Chevrolet was configured for seating of five occupants with front row bucket seats and a second row three-passenger bench seat. All four outboard seat positions had adjustable head restraints. Safety systems included manual 3-point lap and shoulder seat belts for the five seat positions. Supplemental restraint was provided by front seat belt pretensioners and CAC frontal, front seat-mounted side impact, and dual-sensing IC air bags. The driver's frontal air bag deployed. A child restraint system of unknown make/model was located in the second row of the Chevrolet.

Exterior Damage

Damage was observed to the back, left, right, and front planes of the Chevrolet. Damage from the inital impact (Event 1) with the front plane of the Nissan was located on the back and left planes of the Chevrolet. Based on the available images, the direct contact began approximately 45 cm (18 in) left of center and extended 35 cm (14 in) to the left rear corner. Direct contact

damage extended down the left plane on the left rear quarter panel to the center aspect of the left rear door. The left rear tire was missing from the vehicle and the axle position was displaced forward. The left rear door was separated from the striker and deformed forward. Figures 18 and 19 depict the direct contact damage to the Chevrolet's left rear corner area from the impact by the Nissan. The estimated CDC was 06BLEE8.

Figure 18. Back left oblique view of the Chevrolet (law enforcement inspection image)

Figure 19. Left plane view of the Chevrolet (on-scene law enforcement image)

The "missing vehicle" algorithm of the WinSMASH model was used to calculate the severity of the Event 1 crash. The total calculated vehicle velocity change (delta V) of the crash for the Chevrolet was 15 km/h (9.3 mph). Specific longitudinal and lateral components of the calculated delta-V were 14 km/h (8.7 mph) and 3 km/h (1.9 mph), respectively. Based on SCI expertise and observed vehicle damage, these results were significantly underestimated.

Damage from the side impact (Event 2) with the left plane of the Toyota was located on the right plane of the Chevrolet (Figure 20). Based on the available images, the direct contact began at the right rear corner and extended along the right rear quarter panel to the right rear tire/wheel. In the damage pattern was minor lateral crush to the body, with black rubber tire transfer from the Toyota's left rear tire to the left rear corner. The estimated CDC for the Event 2 impact to the Chevrolet was 03RBEW2.

Figure 20. Back right oblique view of the Chevrolet (on-scene law enforcement image)

The "missing vehicle" algorithm of the WinSMASH model was used to calculate the severity of the Event 2 crash. The total calculated vehicle delta V of the crash for the Chevrolet was 12 km/h (7.5 mph). Specific longitudinal and lateral components of the calculated delta-V were 0 km/h (0 mph) and -12 km/h (-7.5 mph), respectively. Based on SCI expertise and observed vehicle damage, these results were underestimated.

The subsequent sideslap (Event 3) with the Toyota also involved the right rear corner aspect of the Chevrolet. Although this impact overlapped the Event 2 impact damage pattern, the severity of the Event 3 sideslap was minimal. There likely was no corresponding deformation to the Chevrolet, and the event was of insufficient magnitude to affect the Chevrolet's dynamics or induce occupant injury. Therefore, no corresponding crush profile or damage measurements exist. The CDC assigned to the Chevrolet for the Event 3 sideswipe was 01RBES1. No WinSMASH calculations could be calculated for this event due to the minimal severity and lack of corresponding deformation mesurements for an event type that was beyond the scope of the model's capabilities.

Damage from the frontal impact (Event 6) with the left plane of the Kia was located on the left aspect of the Chevrolet's front plane. Based on the available images, the direct contact began at the left front corner and extended approximately 80 cm (32 in) to the vehicle's centerline. In the damage pattern was minor longitudinal crush to the bumper beam and surrounding components (Figure 21), and the left front headlight assembly was disintegrated. The estimated CDC for the Event 6 impact to the Chevrolet was 12FYEW2.

Figure 21. Front left oblique view of the Chevrolet (on-scene law enforcement image)

The "missing vehicle" algorithm of the WinSMASH model was used to calculate the severity of the Event 6 crash. The total calculated vehicle delta V of the crash for the Chevrolet was 20 km/h (12.4 mph). Specific longitudinal and lateral components of the calculated delta V were -19 km/h (-11.8 mph) and -3 km/h (-1.9 mph), respectively. Based on SCI expertise and observed vehicle damage, these results were slightly underestimated.

Event Data Recorder

The 2012 Chevrolet Malibu had an air bag sensing and diagnostic control module (SDM) that performed the diagnostic, sensing, and actuation/deployment command functions for the vehicle's supplemental restraint systems. The SDM also had EDR capabilities. It was fastened to the center tunnel beneath the center console, and was removed from the vehicle by the

investigating law enforcement agency. The law enforcement agency had used the CDR software version 17.6.1 to image EDR data from the Chevrolet's SDM.

An electronic file of the imaged data was provided to the SCI team. The data was reported using software version 21.0.1, and is included at the end of this report as Appendix B. Data limitations reported that the EDR was capable of recording two event types, designated as non-deployment or deployment. It could store up to one non-deployment and two deployment events, for a maximum of three recorded events. A non-deployment event required a delta V of 8 km/h (5 mph) for qualification and recording, but did not deploy air bags.

Pretensioner-only actuation, battery cut-off, and head restraint actuation were all considered non-deployment event types. Although the oldest unlocked non-deployment event could be cleared after 250 ignition cycles or overwritten by a subsequent event of greater severity, locked non-deployment events could not be overwritten. A locked non-deployment event was one that occurred within 5 seconds of a deployment event. By definition, deployment events deployed air bags. Data from a deployment event became locked to memory and could not be overwritten. Recorded events were accompanied by a 5-second pre-crash data buffer, which described various asynchronously-recorded vehicle performance parameters such as vehicle speed, accelerator pedal position, brake status, and engine performance.

The data had been imaged from the SDM on ignition cycle 14,745, which was the same ignition cycle that the data were recorded on. The imaged data indicated that the Chevrolet's EDR had recognized and recorded one non-deployment event and one deployment event. Event counter data fields in the recording indicated that these were the only events recorded during the SDM's active lifetime. All available data for each event had been completely recorded to memory. Sequentially, the non-deployment event occurred prior to the deployment event. Because they were within 5 seconds of one another, the non-deployment event was locked to memory. The maximum recorded vehicle velocity change (delta V) was 44.6 km/h (27.69 mph), which had occurred at 170 milliseconds after AE. Components of the maximum delta V included a longitudinal maximum of 41.4 km/h (25.75 mph) and lateral maximum of 16.3 km/h (10.17 mph). These data were related to the left rear impact by the Nissan. The deployment event occurred 3.24 seconds after the recorded non-deployment event. It resulted in commands for the actuation/deployment of the front seat belt pretensioners and the driver's frontal air bag (first and second stages). The maximum recorded longitudinal delta V was -22.9 km/h (-14.23 mph) at 80 milliseconds after AE, while the maximum recorded lateral delta V was -3.2 km/h (-2.03 mph) at 70 milliseconds after AE. These data were related to the front plane impact with the Kia. The reported pre-crash vehicle parameters associated with the recorded events were as follows:

Time (seconds)	Vehicle Speed	Accelerator Pedal	Engine Throttle	Steering Angle	Engine rpm	Brake Status
-5	79 km/h (49 mph)	0%	9%	-16 deg	1,408	Off
-4	77 km/h (48 mph)	0%	9%	-16 deg	1,280	Off
-3	77 km/h (48 mph)	0%	9%	-16 deg	1,152	Off
-2	77 km/h (48 mph)	18%	40%	-16 deg	2,176	Off
-1	79 km/h (49 mph)	17%	40%	-16 deg	2,368	Off

The right plane impact of the Chevrolet with the left plane of the Toyota was not recognized or recorded as a separate event. It is possible that the occurrance in time relative to the impact by the Nissan likely masked the associated forces of the Toyota impact due to the severe forces associated with the Nissan's impact.

Occupant Data

The Chevrolet was driven by a 35-year-old female. Law enforcement documentation of the crash indicated she was belted. Following the crash, the driver was assisted from the Chevrolet and transported by ambulance to a local hospital for evaluation and treatment of reported "possible" (C-level) injuries. No further information concerning the Chevrolet's driver or her injury outcome was available.

2011 Toyota Highlander

Description

The 2011 Toyota Highlander was manufactured in October 2010 and identified by the VIN 5TDYK3EH1BSxxxxxx. It was an SUV (Figure 22) manufactured on a 279 cm (109.8 in) wheelbase and equipped with the Limited trim package. The Toyota was powered by a 3.5 liter, gasoline engine linked to a 5-speed automatic transmission, with front-wheel drive. The GVWR was 2,630 kg (5,800 lb), with GAWR of 1,340 kg (2,955 lb) front and 1,530 kg (3,375 lb) rear. Service brakes were power-assisted 4-wheel disc with ABS, emergency brake assist, and electronic brakeforce distribution. Additional safety features included a tire pressure monitoring system, traction control, electronic stability control, and a post-collision safety system. The vehicle manufacturer's recommended tire size was P245/55R19, with recommended cold tire pressures of 210 kPa (30 PSI). At the time of the crash, the Toyota had Nitto Crosstek all-season radial tires of the recommended size, mounted on OEM alloy wheels. They had matching TINs of 73HH 224 2713. All had at least 4mm (5/32 in) of tread. None were damaged or restricted as a result of the crash.

Figure 22. Left front oblique view of the Toyota at the time of the SCI vehicle inspection

The Toyota had seating for seven occupants (2/3/2) with front row bucket seats, and split bench second and third row seats. All seat positions were equipped with adjustable head restraints. Manual safety systems included 3-point lap and shoulder seat belts for all seven positions. Supplemental restraints consisted of front seat belt pretensioners and CAC frontal, front seat-mounted side impact, and dual-sensing IC air bags. None of the supplemental restraint systems were commanded to actuate/deploy in this crash.

Exterior Damage

Damage was observed to the left plane of the Toyota from impact with the Chevrolet (Event 2). Direct contact damage began at the left rear corner and extended 205 cm (80.7 in) forward to the left B-pillar area, 124 cm (48.8 in) forward of the left rear axle position. In the damage pattern was lateral crush to the left rear quarter panel, left rear door, and left aspect of the rear bumper wrap-around. Induced damage included the disintegration of the rearmost left glazing (third seating row). A residual crush profile was documented using a direct and induced damage width (Field-L) that matched the direct contact width (Figure 23). Resultant measurements included:

C1= 7 cm (2.8 in), C2 = 5 cm (2.0 in), C3 = 1 cm (0.4 in), C4 = 3 cm (1.2 in), C5 = 4 cm (1.6 in), and C6 = 0 cm (0 in). Maximum crush in the profile was observed at the left rear corner. The CDC assigned to the Toyota's damage profile for the first impact with the Chevrolet (Event 2) was 08LZEW2. The "missing vehicle" algorithm of the WinSMASH model was used to calculate the severity of the Event 2 crash. The total calculated delta V of the crash for the Toyota was 10 km/h (6.2 mph). Specific longitudinal and lateral components of the calculated delta V were 5 km/h (3.1 mph) and 8 km/h (5.0 mph), respectively. Based on SCI expertise and observed vehicle damage, these results were slightly underestimated.

Figure 23. Direct contact damage to the rear aspect of the Toyota's left plane

A second area of direct contact damage was observed from 305 cm (120.0 in) to 383 cm (150.8 in) on the baseline. This damage (Figure 24) was centered at the left A-pillar, and was the result of a secondary sideswipe (Event 3) that occurred as the Chevrolet was displaced past the Toyota by the Nissan during their prolonged engagement associated with Event 1. A residual crush profile was documented using a direct and induced damage width (Field-L) that matched the 78 cm (30.7 in) direct contact width. Resultant measurements included: C1= 0 cm (0 in), C2 = 1 cm (0.4 in), C3 = 1 cm (0.4 in), C4 = 8 cm (3.2 in), C5 = 3 cm (1.2 in), and C6 = 0 cm (0 in). Maximum crush in the profile was observed to the fender flare at the left A-pillar. The CDC assigned to the Toyota for the Event 3 damage profile for the sideswipe by the Chevrolet was 06LYES1. No WinSMASH calculations could be conducted for the Event 3 impact due to the minimal severity of the event type which was beyond the scope of the model's capabilities.

Figure 24. Secondary damage to the left plane of the Toyota from the sideswipe by the Chevrolet

Event Data Recorder

The 2011 Toyota Highlander ECUwas mounted in the bottom of the center instrument stack. The ECU monitored the diagnostic functions of the vehicle's restraint systems (air bags and seat belt pretensioners) and controlled the deployment/actuation of those devices dependent upon crash event severity. The ECU also had EDR capabilities to record crash event data for longitudinal (front/rear), lateral (side), and non-horizontal (rollover) crash events. At the time of the SCI vehicle inspection, the Toyota's ECU had been removed by the investigating law enforcement agency following the crash for evidence data collection. It had then been left loose in the vehicle. The SCI Investigator imaged its EDR data using the CDR software and tool, version 17.7.1, via a direct to module connection. The data was later read using software version 21.0.1, and is included at the end of this technical report as Appendix C.

The Toyota's EDR could store up to two recording pages of pre-crash data, and up to two recording pages of post-crash data for each of the three crash event types. Data was recorded in chronological order based on event recognition (termed *trigger* or TRG). The reported data were referenced based on the TRG counter, and the recording of each event was based on a judgement threshold (specific value unknown) dependent upon the type. In crash impacts where forces were recognized in multiple directions, data correlating to that event may be recorded in additional pages (i.e., an angular horizontal impact may be recorded in both front/rear and side event type pages). For a recorded event, if the "Freeze Signal" was indicated ON, subsequent events would not be recorded in the recording page. The freeze signal typically was associated with air bag deployment commands. If power supply to the ECU was lost during or following a crash event, all or part of the data may not have been recorded to the EDR's memory.

The imaged data contained two events, which included a rear (first prior, TRG 2) and rollover (most recent, TRG 2). There were no DTCs present and the air bag warning lamp was off when the events occurred. The TRG 1 and TRG 2 events were separated by only 11 milliseconds, indicative that they were related to the same overall crash event (left plane impact from the Chevrolet, Event 2). The data reported that both the driver's and front right passenger's seat belt systems were buckled. The following recorded pre-crash buffer data was reported with TRG 2:

Time (sec)	Speed (km/h [mph])	Engine rpm	Service Brake
-4	76 km/h [47.2 mph]	1,200	OFF
-3	76 km/h [47.2 mph]	1,200	OFF
-2	76 km/h [47.2 mph]	1,200	OFF
-1	74 km/h [46 mph]	1,200	OFF
0	74 km/h [46 mph]	1,200	OFF
0 (TRG)	74 km/h [46 mph]	1,200	OFF

There were no supplemental restraint device actuations/deployments associated with either of the recorded event triggers. The maximum recorded longitudinal delta V related to TRG 1 was 1.4 km/h (0.9 mph). The maximum recorded roll angle peak related to TRG 2 was 4.6 degrees.

Occupant Data

The Toyota was driven by a 66-year-old female with a 79-year-old male front row right occupant. According to the law enforcement documentation of the crash, and corroborated by the data imaged from the Toyota's EDR during the SCI vehicle inspection, both were belted at the time of the crash. They denied injury and were not medically treated or transported.

2013 Kia Sorento

Description

The 2013 Kia Sorento (Figure 25) was manufactured in July 2012 and identified by the VIN 5XYKU4A28DGxxxxxx. It was a front-wheel drive SUV powered by a 3.5 liter, V-6, gasoline engine linked to a 6-speed automatic transmission. A manufacturer placard declared that the Kia's GVWR was 2,360 kg (5,203 lb), with GAWRs of 1,350 kg (2,977 lb) front and 1,450 kg (3,197 lb) rear. The vehicle manufacturer's recommended tire size was P235/60R18, with recommended cold tire pressures of 228 kPa (33 PSI). At the time of the SCI inspection, the Kia had Yokohama YK 740 GTX all-season tires of the manufacturer's recommended size, mounted on OEM alloy wheels. All tires had at least 5 mm (6/32 in) of tread, with matching TINs of "4UDC 6ES." The Kia had seating of up to five occupants (2/3), with front row bucket seats and a split-bench second row seat with forward folding and reclining seat backs. The four outboard seat positions were equipped with head restraints. Manual safety systems included 3-point lap and shoulder seat belts for the five seat positions. Supplemental restraint was provided by seat belt pretensioners and CAC frontal, front-seat-mounted side impact, and roof side-rail-mounted IC air bags. Both front-seat-mounted side air bags and both IC air bags deployed in the crash.

Figure 25. Left front oblique view of the Kia at the time of the SCI vehicle inspection

Exterior Damage

Damage was observed to the left plane of the Kia from impact by the front plane of the Chevrolet (Event 6). Direct contact damage began near the left front corner of the vehicle, 67 cm (26.4 in) forward of the center of the left front axle position. It extended 215 cm (84.6 in) rearward to 148 cm (58.3 in) rearward of the left front axle position, at the left B-pillar. In the damage pattern was lateral crush to the left front fender and left front door, and the left sill step was missing forward of the B-pillar. The left front axle position was also canted from the impact.

A residual crush profile was documented to the left plane of the Kia using a direct and induced damage length (Field-L) that matched the direct contact measurements. The resultant crush profile included: C1= 2 cm (0.8 in), C2 = 6 cm (2.4 in), C3 = 8 cm (3.2 in), C4 = 13 cm (5.1 in), C5 = 14 cm (5.5 in), and C6 = 6 cm (2.4 in). Maximum crush in the profile was observed to the fender surrounding the left front axle position. The CDC assigned to the Kia for the Event 6 damage profile for the impact with the Chevrolet was 11LYEW2. Figure 26 depicts the canted

left front axle position of the Kia following the crash, while Figure 27 depicts the documented residual crush profile.

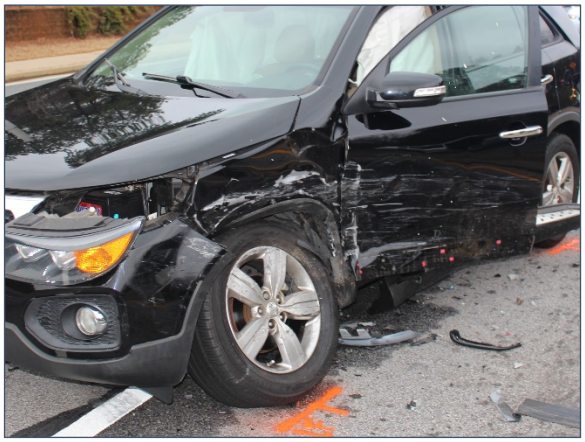


Figure 26. Left front oblique view of the damage pattern to the Kia (on-scene law enforcement image)

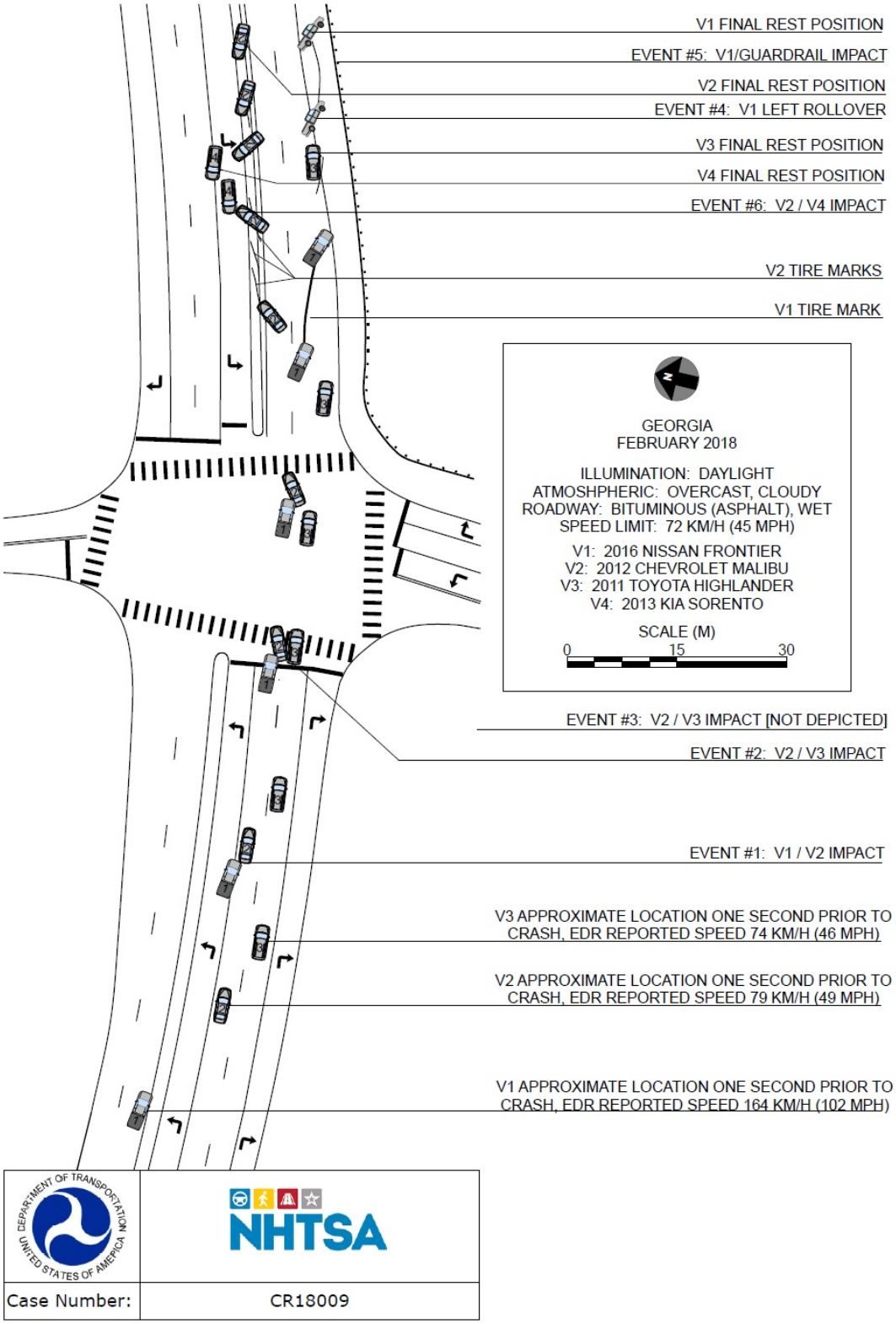
Figure 27. Overhead view of the Kia's damage profile at the time of the SCI inspection

The "missing vehicle" algorithm of the WinSMASH program calculated the severity of the Event 6 crash. The total calculated delta V of the crash for the Kia was 17 km/h (10.6 mph). Specific longitudinal and lateral components of the calculated delta V were -13 km/h (-8.1 mph) and 11 km/h (6.8 mph), respectively. Based on SCI expertise and observed vehicle damage, these results were underestimated.

Occupant Data

The Kia was driven by a belted 21-year-old male at the time of the crash. According to law enforcement documentation of the crash, he was belted. Following the crash, he exited the vehicle without assistance. He was then transported by ambulance to a local hospital for evaluation and treatment of reported "possible" (C-level) injuries. No further information concerning the Kia's driver or his injury outcome was available.

Crash Diagram



APPENDIX A: 2016 Nissan Frontier Event Data Recorder Report

The EDR report contained in this technical report was imaged by the law enforcement agency investigating this crash, using their licensed version of the Bosch CDR software. An electronic file of the imaged data was provided to the SCI team and re-read using the current version of the Bosh CDR software at the time that this report was published. The CDR report contained in the associated Crash Viewer application may differ relative to this report.

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	1N6AD0ER3GN******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	CR18009_V1_ACU.CDRX
Saved on	
Imaged with CDR version	Crash Data Retrieval Tool 17.6.1
Imaged with Software Licensed to (Company Name)	Company Name information was removed when this file was saved without VIN sequence number
Reported with CDR version	Crash Data Retrieval Tool 21.0.1
Reported with Software Licensed to (Company Name)	NHTSA
EDR Device Type	Airbag Control Module
Event(s) recovered	Event Record 1, Event Record 2

Comments

No comments entered.

Data Limitations

General Information:

Data limitations are intended to assist in reading event data that has been imaged from the vehicle's Air bag Control Unit (ACU). Event data should be considered in conjunction with other available physical evidence from the vehicle and scene.

Airbag Control Unit (ACU)

- The Air bag Control Unit (ACU) can store two types of events: Non-Deployment Events and Deployment.
  - A Non-Deployment Event is a crash or other physical occurrence which causes the ACU algorithm to be activated, but in which deployment thresholds are not reached.
  - A Deployment Event is a crash or other physical occurrence which causes ACU deployment thresholds to be reached or exceeded. Depending on the vehicle model, one or more of the following may be activated during a Deployment Event: front air bags, seat-mounted side airbags, roof-mounted or door-mounted curtain air bags, pretensioners, or pop-up roll bars.

- The ACU can record up to two events. If additional events occur subsequently, the older of the two events already recorded (i.e. the one which occurred first) is overwritten.
  - A Non-Deployment Event can be overwritten by another Non-Deployment event, or by a Deployment Event.
  - A Deployment Event has higher priority than a Non-Deployment Event, and cannot be interrupted or overwritten by another event.
  - The data pertaining to a Deployment Event is locked after being recorded. However, a second event can still be recorded subsequently in the portion of the event memory which is not locked.

- Event data includes both pre-crash data and crash data.
  - If the power supply to the ACU is lost during an event, all or part of the event data may not be recorded.
  - In addition to the recording of event data, the ACU has the ability to perform diagnostics and record Diagnostic Trouble Codes (DTCs).

Data Element Sign Convention:

The following table provides an explanation of the sign convention for data elements in the CDR report.

Data Element Name	Positive Sign Notation Indicates
Longitudinal Acceleration	Forward
Delta-V, Longitudinal	Forward
Maximum Delta-V, Longitudinal	Forward
Lateral Acceleration	Left to Right
Delta-V, Lateral	Left to Right
Maximum Delta-V, Lateral	Left to Right
Vehicle Roll Angle	Left to Right Rotation
Steering Input	Left Turn

- “Life Time Counter (sec)” indicates the elapsed time, in seconds, from the vehicle’s first ignition activation until the start of the first recorded event. The counter is incremented whenever the vehicle’s ignition is on. The counter is reset to 0 if the ACU is replaced.
- "Complete File Recorded" indicates whether a complete EDR data set has been stored after the event. "Yes" indicates that a complete data set has been recorded. "No" indicates that only a portion of the data set has been recorded, for example due to the power to the ACU being lost during the event.
- "Multi-Event, Number of Events (1, 2)" indicates the number of events which are stored during a given ignition cycle. A Multi-Event occurs whenever the time between Event 2 trigger threshold and Event 1 trigger threshold is less than or equal to 5 seconds during the same ignition cycle, and "2" will be recorded in this case. Otherwise, "1" will be recorded.
- "Air Bag Warning Lamp (On, Off)" indicates whether the ACU was in trouble mode or in normal operation mode at the time of the event. "On" indicates that the air bag warning lamp was illuminated at the time of the event, and the ACU was in trouble mode. "Off" indicates that the air bag warning lamp was not illuminated at the time of the event, and the ACU was in normal operation mode.
- "Frontal Air Bag Suppression Switch Status" indicates whether front passenger air bag deployment was suppressed at the time of the event. "On" indicates that the front passenger air bag was suppressed at the time of the event (deployment inhibited). "Off" indicates that the front passenger air bag was not suppressed at the time of the event (deployment enabled). This data will not be available for all vehicles.
- "Delta-V, Longitudinal" indicates the cumulative change in velocity along the longitudinal direction.
- "Acceleration, Longitudinal" indicates the rate of change of velocity with time along the longitudinal direction.
- "Delta-V, Lateral" indicates the cumulative change in velocity along the lateral direction.
- "Acceleration, Lateral" indicates the rate of change of velocity with time along the lateral direction.
- "Engine Throttle, % full" indicates the position of the accelerator pedal as a percentage of the fully depressed position.
- "Service Brake (On, Off)" indicates whether the service brake is activated ("On") or not activated ("Off").
- "Steering Input (deg)" indicates the angular displacement of the steering wheel measured in degrees. -250 deg indicates a 250 degree turn to the right of the steering wheel, 0 deg indicates the straight-ahead steering wheel position, and 250 deg indicates a 250 degree turn to the left of the steering wheel.
- The notation "CLP" indicates that the measurement captured by a sensor exceeded the design range of the sensor.
- “Seat Track Position Switch, Foremost, Status, Driver (Yes/No)” indicates whether the driver’s seat is positioned within a designated threshold value of the most forward adjustment position. “Yes” indicates that the driver’s seat is positioned within a designated threshold value of the most forward adjustment position. For all other adjustment positions, “No” is displayed. This data will not be available if the seat track position switch is not installed in the vehicle.
- “Occupant Size Classification, Right Front Passenger, Child (Yes/No)” indicates whether or not the right front passenger is classified as a child (as defined in 49 CFR part 572, subpart N or smaller). This data will not be available for all vehicles.
- “e-pedal ON/OFF Status” indicates whether “e-pedal” is activated (ON), or not activated (OFF). This data will not be available for all vehicles.
- “ABS Warning lamp, on/off” indicates whether “Anti-lock Brake System” was in trouble mode or in normal operation mode at the time of the event. This data will not be available for all vehicles.
- “AEB/FCW switch status ON/OFF (from ADAS)” indicates whether the switch of “Automatic Emergency Braking or Forward Collision Warning controlled by ADAS unit” was ON, or OFF at the time of the event. This data will not be available for all vehicles.
- “AEB Warning lamp (from ADAS)” indicates whether “Automatic Emergency Braking controlled by ADAS unit” was in trouble mode or in normal operation mode at the time of the event. This data will not be available for all vehicles.
- “ABS regulation status” indicates whether “Anti-lock Brake System” was activated (ABS in regulation), or not activated (no ABS regulation). This data will not be available for all vehicles.
- “VDC switch status ON/OFF” indicates whether the switch of “Vehicle Dynamic Control” in ON, or OFF. This data will not be available for all vehicles.
- “VDC status/warning” indicates whether “Vehicle Dynamic Control” was in normal operation mode and not activated (No failure and no control), in trouble mode and not activated (Failure), or in normal mode and activated (In active control). This data will not be available for all vehicles.
- “Adaptive Cruise Control status” indicates whether “Intelligent Cruise Control status” was activated (ACC activated), waiting (ACC waiting), suspended (ACC suspended), or not activated (No display request). This data will not be available for all vehicles.
- “AEB operating capability” indicates whether “Automatic Emergency Braking” was in trouble mode (Impossible to execute request) or in normal operation mode (Braking fully operational). This data will not be available for all vehicles.
- “AEB Brake request (from ADAS)” indicates whether “Automatic Emergency Braking controlled by ADAS unit” was activated (Brake Torque AEB Maximum), or not activated (No Brake Request). This data will not be available for all vehicles.

Hexadecimal Data:
All data that has been specified for retrieval is shown in the Hexadecimal Data section of this report. However, the Hexadecimal Data section may contain data that is not translated by the CDR tool.

Data Sources:
- Crash data is measured internally in the ACU.
- Pre-crash data is not measured internally in the ACU, but is transmitted from other control units through the Controller Area Network (CAN).
- Pre-crash data and crash data are asynchronous.

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DTCs at Time of Retrieval

DTC	Status	Description
B1421	Current	FRONTAL COLLISION DETECTION
B1422	Current	SIDE COLLISION DETECTION
B1423	Current	ROLLOVER DETECTION
B0001	Current	DRIVER AIRBAG MODULE CIRCUIT [OPEN]
B0002	Current	DRIVER AIRBAG MODULE 2ND CIRCUIT [OPEN]
B1431	Current	FRONT PRE-TEN RH CIRCUIT [OPEN]
B1430	Current	FRONT PRE-TEN LH CIRCUIT [OPEN]
B0021	Current	CURTAIN AIRBAG MODULE LH CIRCUIT [OPEN]
B00D5	Current	PASSENGER AIRBAG INDICATOR CIRCUIT [VB-SHORT], [OPEN]
B0029	Current	CURTAIN AIRBAG MODULE RH CIRCUIT [OPEN]
B0094	Current	CRASH ZONE SENSOR [DISCONNECT]
B0091	Current	B-PILLAR SATELLITE SENSOR LH [DISCONNECT]
B0096	Current	B-PILLAR SATELLITE SENSOR RH [DISCONNECT]
B0093	Current	DOOR SATELLITE SENSOR LH [DISCONNECT]
B0098	Current	DOOR SATELLITE SENSOR RH [DISCONNECT]
U1000	Current	(CAN COMMUNICATION FAILER)
B1421	Past	FRONTAL COLLISION DETECTION

System Status at Event (Event Record 1)

Life Time Counter (sec)	2507397
Complete File Recorded (Yes/No)	Yes (Complete)
Ignition Cycle, Crash	1798
Ignition Cycle, Download	3111
Multi-Event, Number of Events (1, 2)	1
Time from Event 1 to 2 (sec)	N/A
Safety Belt Status, Driver	Off (Unfastened)
Safety Belt Status, Right Front Passenger	Off (Unfastened)
Frontal Air Bag Warning Lamp (On, Off)	Off
Frontal Air Bag Suppression Switch Status	On (AS airbag inhibit)
Maximum Delta-V, Longitudinal (MPH [km/h])	-8 [-13]
Time, Maximum Delta-V, Longitudinal (msec)	152.5
Maximum Delta-V, Lateral (MPH [km/h])	-2 [-3]
Time, Maximum Delta-V, Lateral (msec)	135
Maximum Acceleration, Longitudinal (g)	-7
Time, Maximum Acceleration, Longitudinal (msec)	52.5
Maximum Acceleration, Lateral (g)	-8.5
Time, Maximum Acceleration, Lateral (msec)	75
Seat Track Position Switch, Foremost, Status, Driver (Yes/No)	N/A
Occupant Size Classification, Right Front Passenger, Child (Yes/No)	No

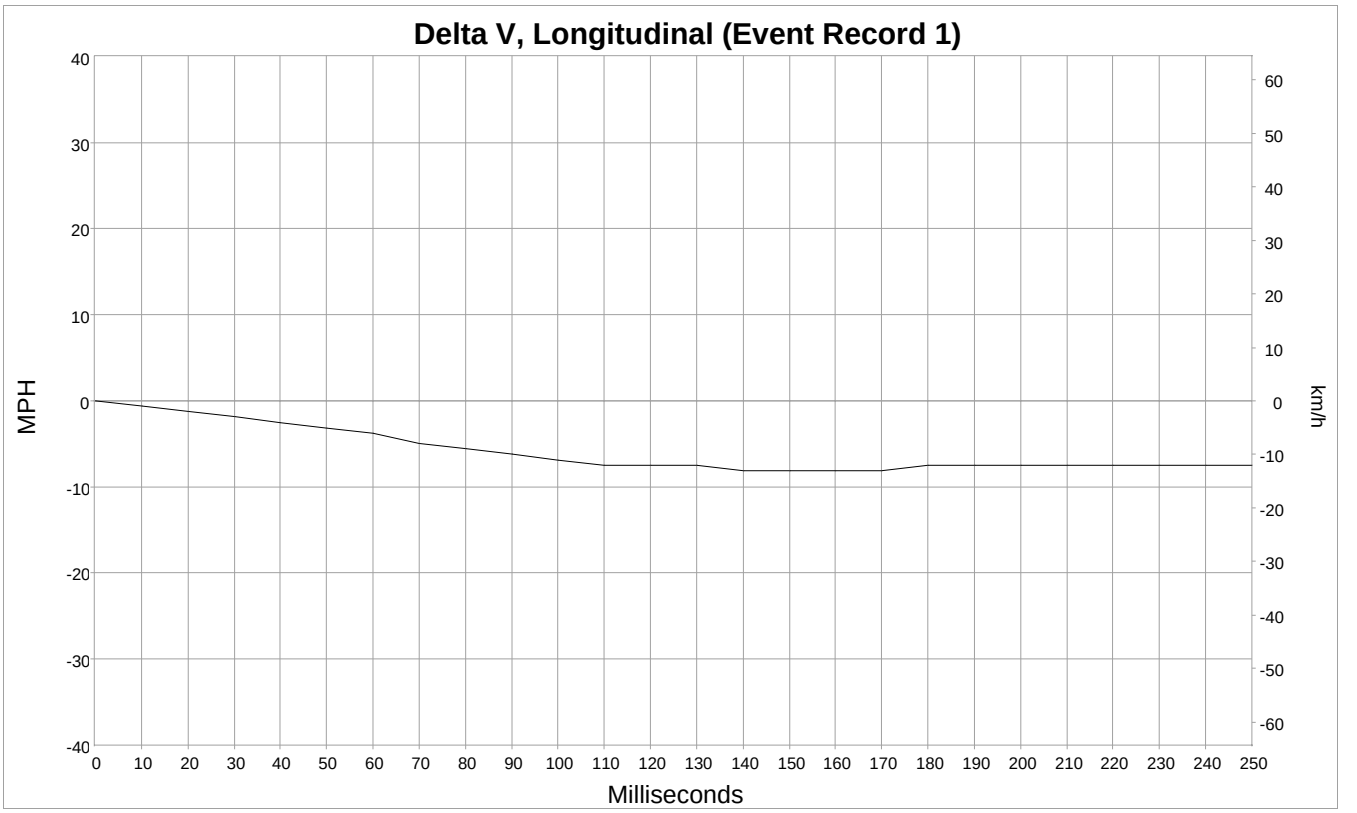
Deployment Command Data (Event Record 1)

Frontal Air Bag Deployment, Time to Deploy/First Stage, Driver (msec)	N/A
Frontal Air Bag Deployment, Time to Deploy/First Stage, Passenger (msec)	N/A
Frontal Air Bag Deployment, Time to 2nd Stage, Driver (msec)	N/A
Frontal Air Bag Deployment, Time to 2nd Stage, Right Front Passenger (msec)	N/A
Side Air Bag Deployment, Time to Deploy, Driver (msec)	N/A
Side Air Bag Deployment, Time to Deploy, Right Front Passenger (msec)	N/A
Side Curtain/Tube Air Bag Deployment, Time to Deploy, Driver Side (msec)	N/A
Side Curtain/Tube Air Bag Deployment, Time to Deploy, Right Side (msec)	N/A
Pretensioner Deployment, Time to Fire, Driver (msec)	N/A
Pretensioner Deployment, Time to Fire, Right Front Passenger (msec)	N/A

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1)

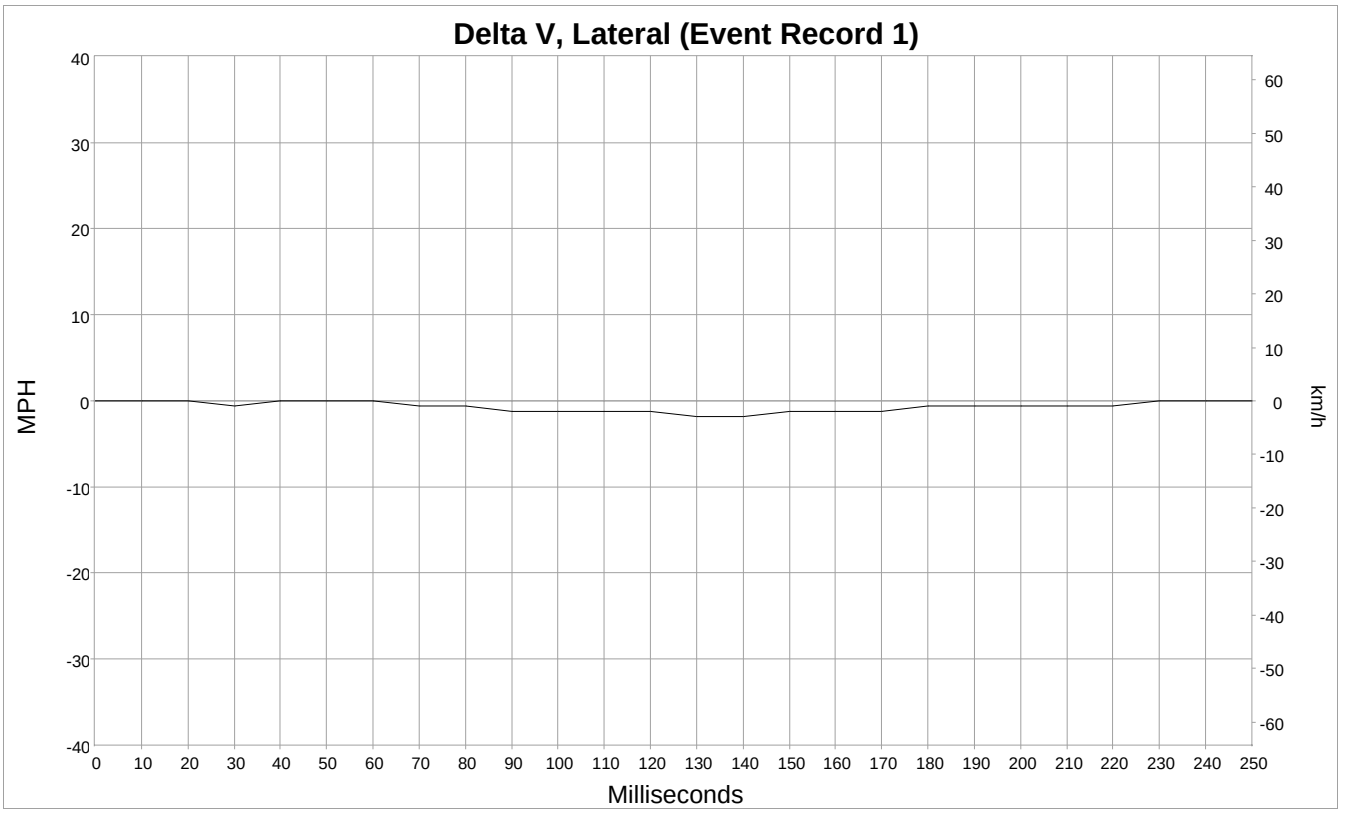
(the most recent sampled values are recorded prior to the event)

Time Stamp (sec)	Speed, Vehicle Indicated (MPH [km/h])	Accelerator Pedal, % full	Engine RPM	Motor RPM	Service Brake (On, Off)	Steering Input (deg)
-5.0	24 [38]	10.5	2100	1950	Off (Brake Not Activated)	0
-4.5	25 [40]	8.5	2150	2050	Off (Brake Not Activated)	0
-4.0	25 [41]	7.5	2200	2150	Off (Brake Not Activated)	2
-3.5	26 [42]	3.5	2200	2200	Off (Brake Not Activated)	2
-3.0	27 [43]	0	2100	2200	Off (Brake Not Activated)	2
-2.5	27 [43]	0	1900	2250	Off (Brake Not Activated)	2
-2.0	27 [43]	0	1850	2200	Off (Brake Not Activated)	2
-1.5	27 [43]	0	1850	2200	Off (Brake Not Activated)	2
-1.0	27 [43]	0	1800	2200	Off (Brake Not Activated)	2
-0.5	27 [43]	0	1800	2200	On (Brake Activated)	0
0.0	25 [40]	0	1800	2150	On (Brake Activated)	-18



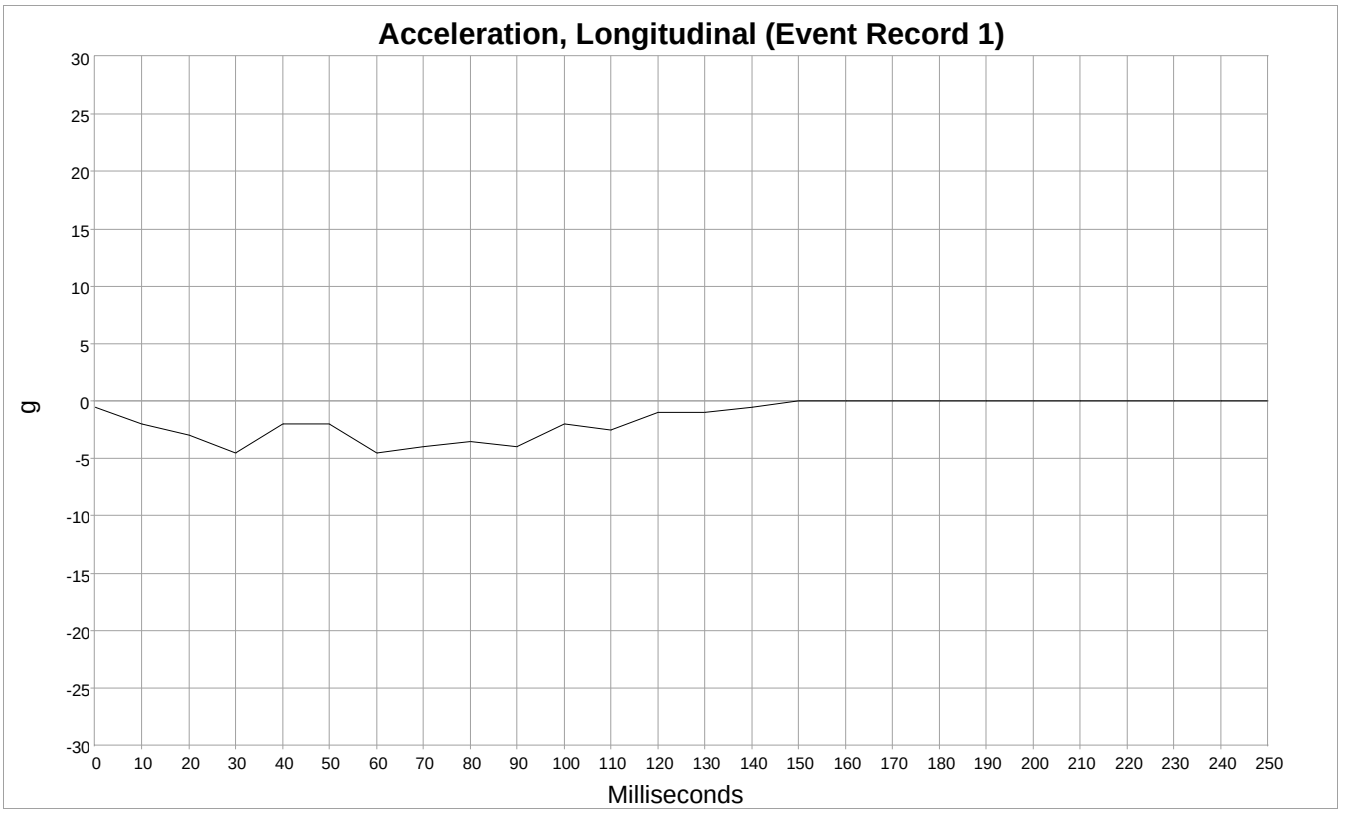
Longitudinal Delta V (Event Record 1)

Time (msec)	MPH [km/h]
0	0 [0]
10	-1 [-1]
20	-1 [-2]
30	-2 [-3]
40	-2 [-4]
50	-3 [-5]
60	-4 [-6]
70	-5 [-8]
80	-6 [-9]
90	-6 [-10]
100	-7 [-11]
110	-7 [-12]
120	-7 [-12]
130	-7 [-12]
140	-8 [-13]
150	-8 [-13]
160	-8 [-13]
170	-8 [-13]
180	-7 [-12]
190	-7 [-12]
200	-7 [-12]
210	-7 [-12]
220	-7 [-12]
230	-7 [-12]
240	-7 [-12]
250	-7 [-12]



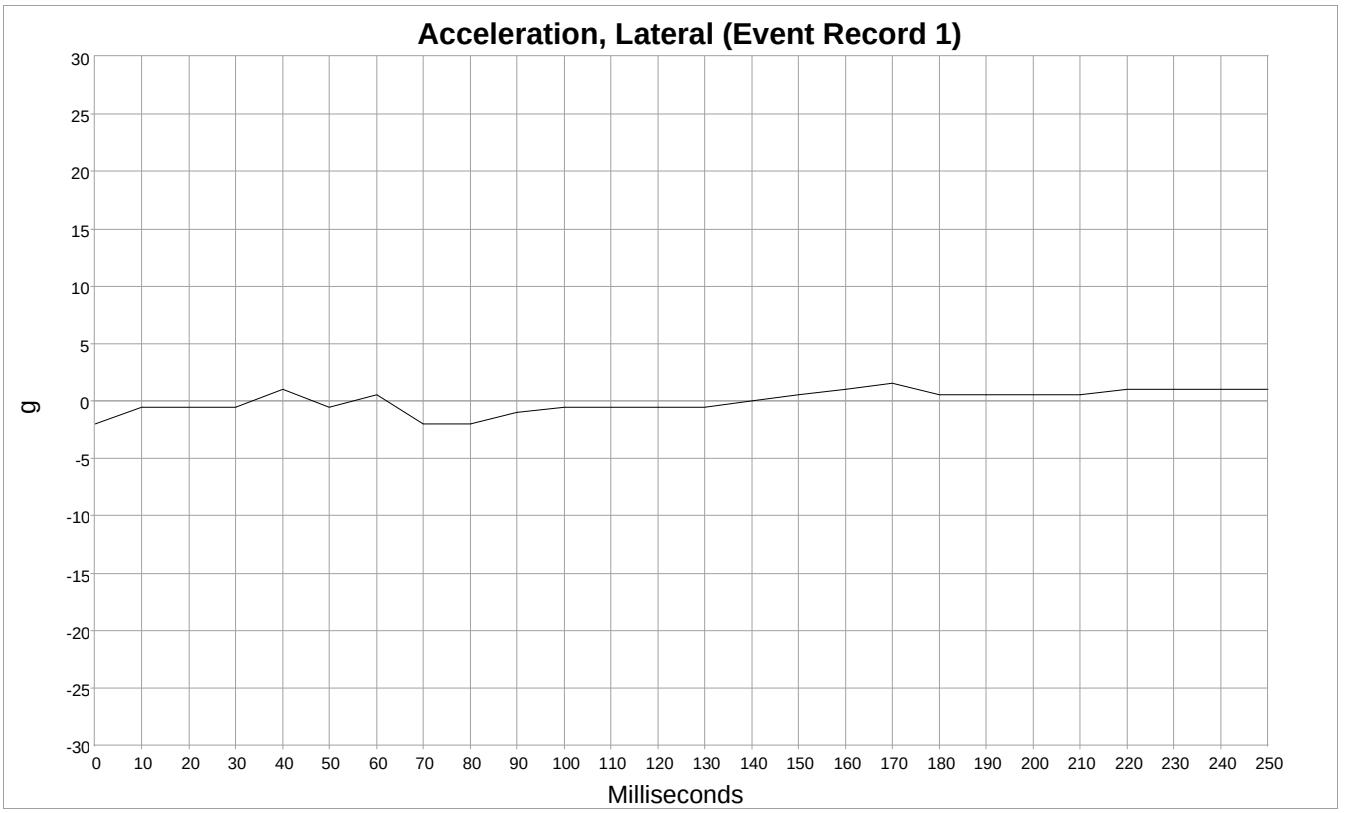
Lateral Delta V (Event Record 1)

Time (msec)	MPH [km/h]
0	0 [0]
10	0 [0]
20	0 [0]
30	-1 [-1]
40	0 [0]
50	0 [0]
60	0 [0]
70	-1 [-1]
80	-1 [-1]
90	-1 [-2]
100	-1 [-2]
110	-1 [-2]
120	-1 [-2]
130	-2 [-3]
140	-2 [-3]
150	-1 [-2]
160	-1 [-2]
170	-1 [-2]
180	-1 [-1]
190	-1 [-1]
200	-1 [-1]
210	-1 [-1]
220	-1 [-1]
230	0 [0]
240	0 [0]
250	0 [0]



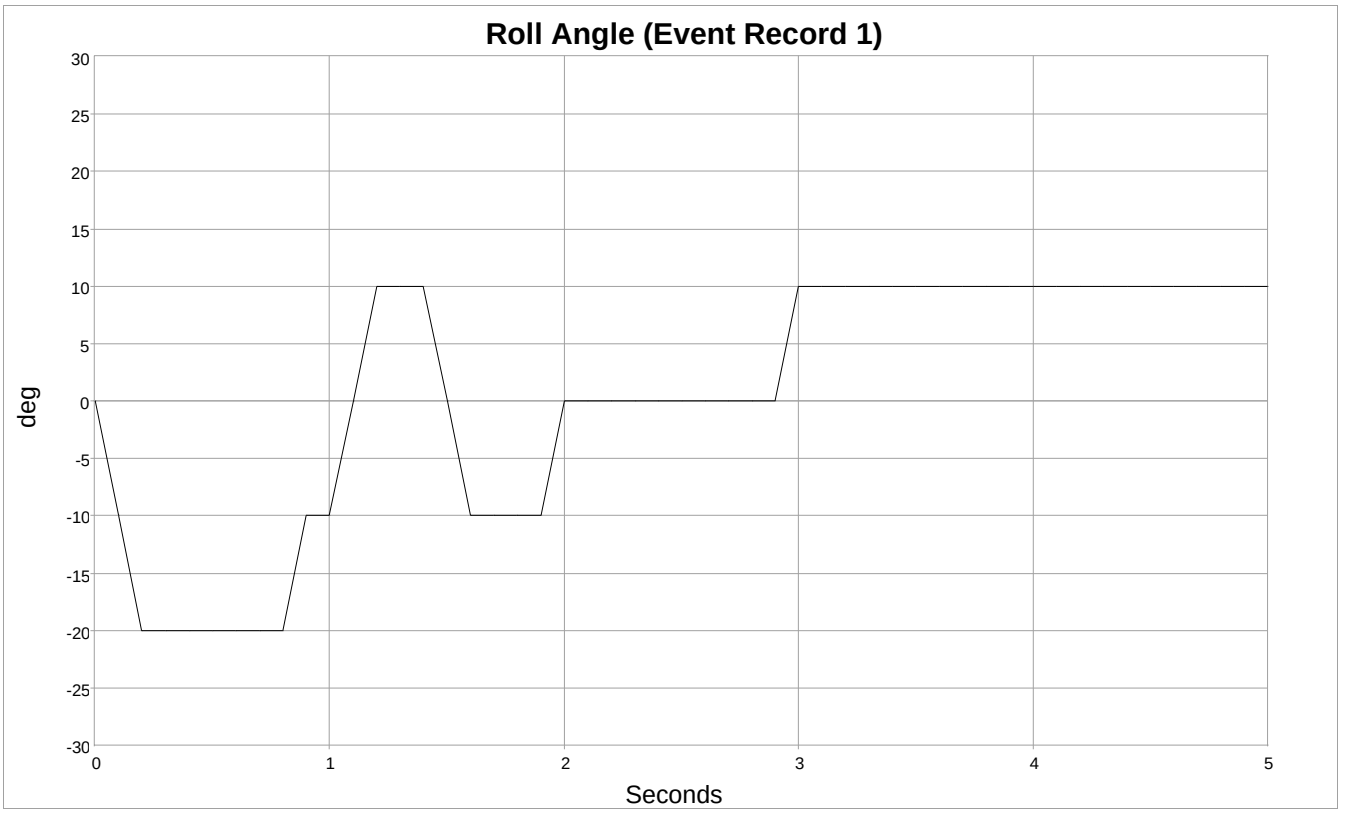
Longitudinal Acceleration (Event Record 1)

Time (msec)	g
0	-.5
10	-2
20	-3
30	-4.5
40	-2
50	-2
60	-4.5
70	-4
80	-3.5
90	-4
100	-2
110	-2.5
120	-1
130	-1
140	-.5
150	0
160	0
170	0
180	0
190	0
200	0
210	0
220	0
230	0
240	0
250	0



Lateral Acceleration (Event Record 1)

Time (msec)	g
0	-2
10	-.5
20	-.5
30	-.5
40	1
50	-.5
60	.5
70	-2
80	-2
90	-1
100	-.5
110	-.5
120	-.5
130	-.5
140	0
150	.5
160	1
170	1.5
180	.5
190	.5
200	.5
210	.5
220	1
230	1
240	1
250	1



Roll Angle (Event Record 1)

Time (sec)	deg
0.0	0
0.1	-10
0.2	-20
0.3	-20
0.4	-20
0.5	-20
0.6	-20
0.7	-20
0.8	-20
0.9	-10
1.0	-10
1.1	0
1.2	10
1.3	10
1.4	10
1.5	0
1.6	-10
1.7	-10
1.8	-10
1.9	-10
2.0	0
2.1	0
2.2	0
2.3	0
2.4	0
2.5	0
2.6	0
2.7	0

2.8	0
2.9	0
3.0	10
3.1	10
3.2	10
3.3	10
3.4	10
3.5	10
3.6	10
3.7	10
3.8	10
3.9	10
4.0	10
4.1	10
4.2	10
4.3	10
4.4	10
4.5	10
4.6	10
4.7	10
4.8	10
4.9	10
5.0	10

System Status at Event (Event Record 2)

Life Time Counter (sec)	4070668
Complete File Recorded (Yes/No)	Yes (Complete)
Ignition Cycle, Crash	3109
Ignition Cycle, Download	3111
Multi-Event, Number of Events (1, 2)	1
Time from Event 1 to 2 (sec)	N/A
Safety Belt Status, Driver	On (Fastened)
Safety Belt Status, Right Front Passenger	Off (Unfastened)
Frontal Air Bag Warning Lamp (On, Off)	Off
Frontal Air Bag Suppression Switch Status	On (AS airbag inhibit)
Maximum Delta-V, Longitudinal (MPH [km/h])	0 [0]
Time, Maximum Delta-V, Longitudinal (msec)	232.5
Maximum Delta-V, Lateral (MPH [km/h])	-1 [-1]
Time, Maximum Delta-V, Lateral (msec)	130
Maximum Acceleration, Longitudinal (g)	-1
Time, Maximum Acceleration, Longitudinal (msec)	12.5
Maximum Acceleration, Lateral (g)	-1.5
Time, Maximum Acceleration, Lateral (msec)	2.5
Seat Track Position Switch, Foremost, Status, Driver (Yes/No)	N/A
Occupant Size Classification, Right Front Passenger, Child (Yes/No)	No

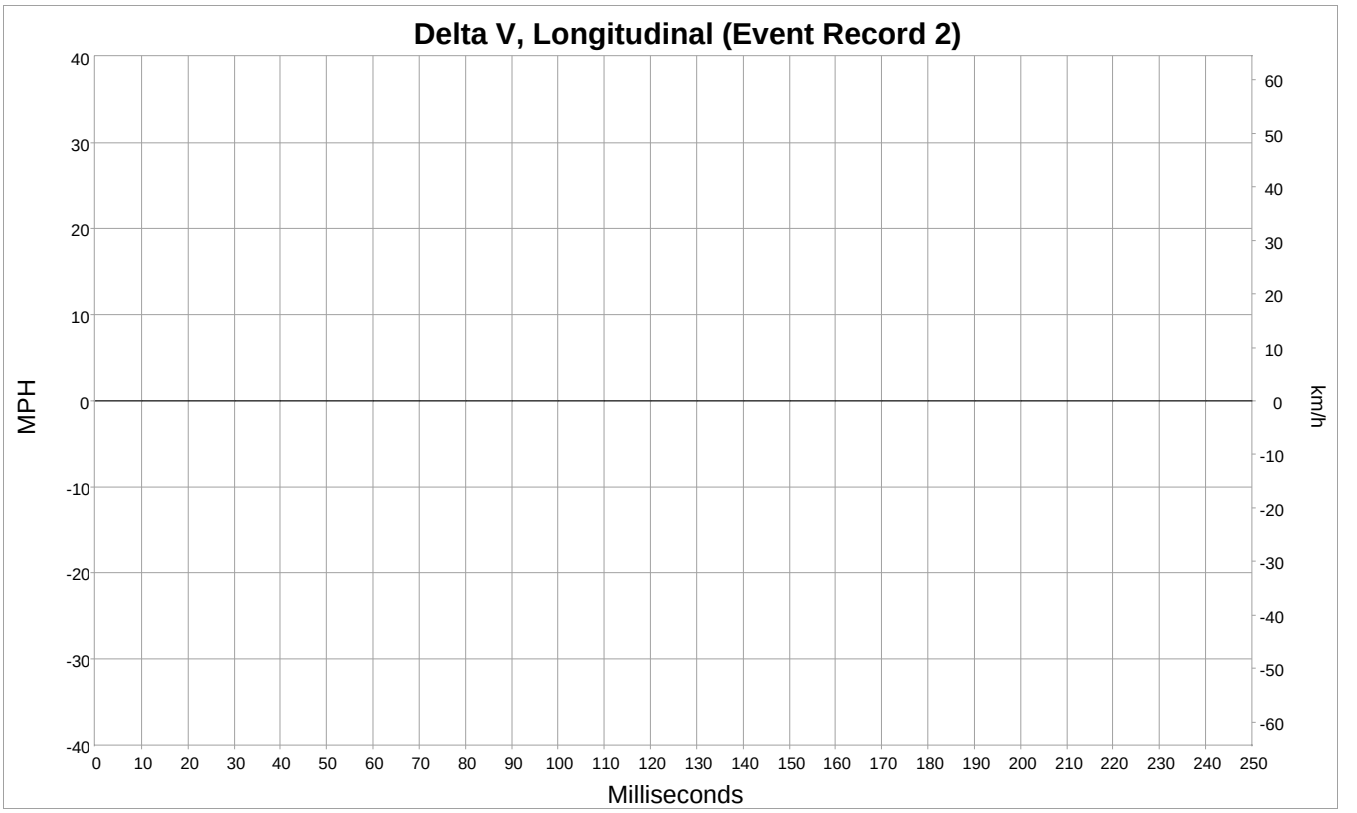
Deployment Command Data (Event Record 2)

Frontal Air Bag Deployment, Time to Deploy/First Stage, Driver (msec)	253
Frontal Air Bag Deployment, Time to Deploy/First Stage, Passenger (msec)	N/A
Frontal Air Bag Deployment, Time to 2nd Stage, Driver (msec)	253
Frontal Air Bag Deployment, Time to 2nd Stage, Right Front Passenger (msec)	N/A
Side Air Bag Deployment, Time to Deploy, Driver (msec)	253
Side Air Bag Deployment, Time to Deploy, Right Front Passenger (msec)	253
Side Curtain/Tube Air Bag Deployment, Time to Deploy, Driver Side (msec)	253
Side Curtain/Tube Air Bag Deployment, Time to Deploy, Right Side (msec)	253
Pretensioner Deployment, Time to Fire, Driver (msec)	253
Pretensioner Deployment, Time to Fire, Right Front Passenger (msec)	253

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 2)

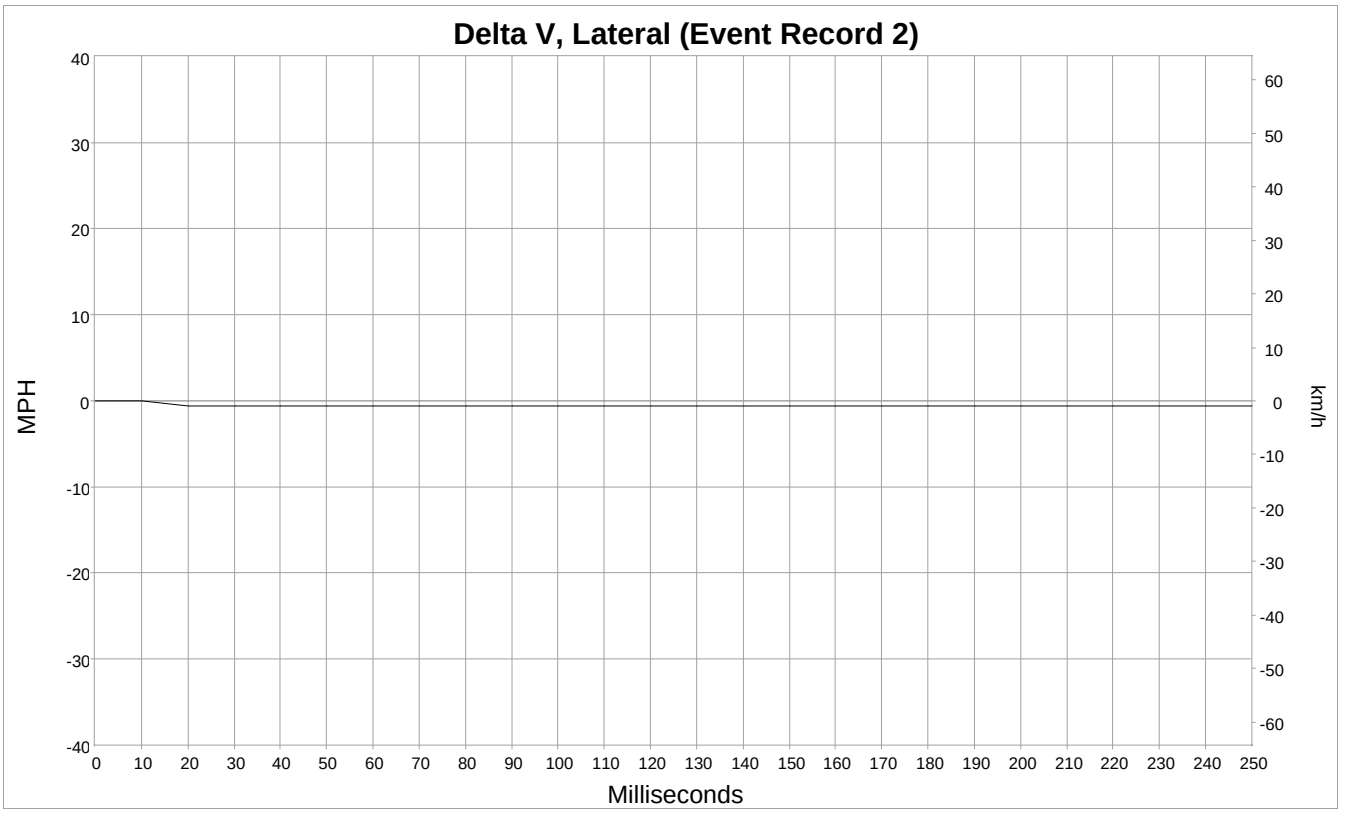
(the most recent sampled values are recorded prior to the event)

Time Stamp (sec)	Speed, Vehicle Indicated (MPH [km/h])	Accelerator Pedal, % full	Engine RPM	Motor RPM	Service Brake (On, Off)	Steering Input (deg)
-5.0	99 [160]	83.5	3800	3500	Off (Brake Not Activated)	22
-4.5	99 [160]	79	3800	3500	Off (Brake Not Activated)	-18
-4.0	99 [160]	87	3800	3500	Off (Brake Not Activated)	-4
-3.5	99 [160]	88	3850	3500	Off (Brake Not Activated)	4
-3.0	100 [161]	81.5	3850	3550	Off (Brake Not Activated)	-4
-2.5	100 [161]	86	3850	3550	Off (Brake Not Activated)	-8
-2.0	101 [162]	88	3850	3550	Off (Brake Not Activated)	2
-1.5	101 [163]	88	3900	3550	Off (Brake Not Activated)	6
-1.0	102 [164]	98	3900	3600	Off (Brake Not Activated)	12
-0.5	103 [165]	100 (clp)	3900	3600	Off (Brake Not Activated)	10
0.0	103 [165]	100 (clp)	3900	3600	Off (Brake Not Activated)	12



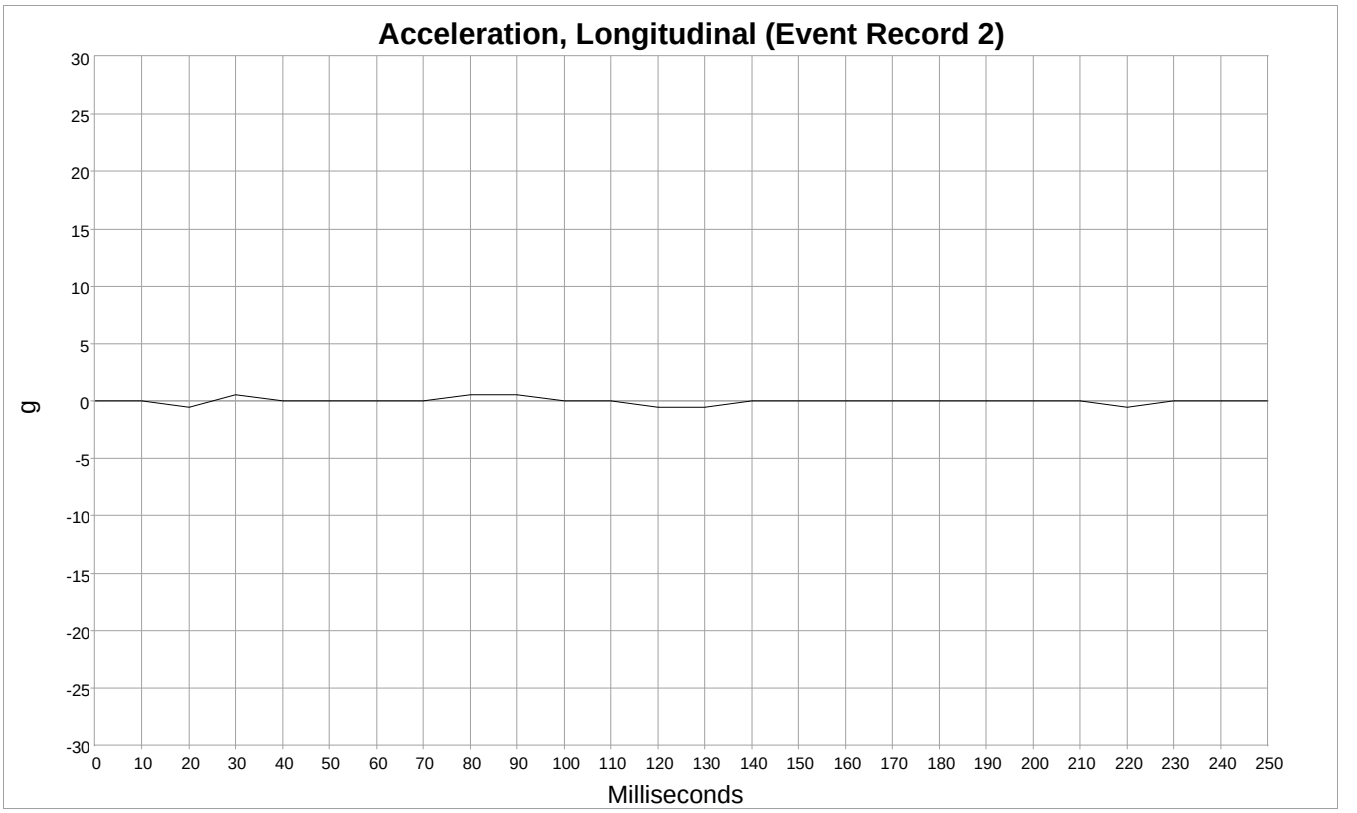
Longitudinal Delta V (Event Record 2)

Time (msec)	MPH [km/h]
0	0 [0]
10	0 [0]
20	0 [0]
30	0 [0]
40	0 [0]
50	0 [0]
60	0 [0]
70	0 [0]
80	0 [0]
90	0 [0]
100	0 [0]
110	0 [0]
120	0 [0]
130	0 [0]
140	0 [0]
150	0 [0]
160	0 [0]
170	0 [0]
180	0 [0]
190	0 [0]
200	0 [0]
210	0 [0]
220	0 [0]
230	0 [0]
240	0 [0]
250	0 [0]



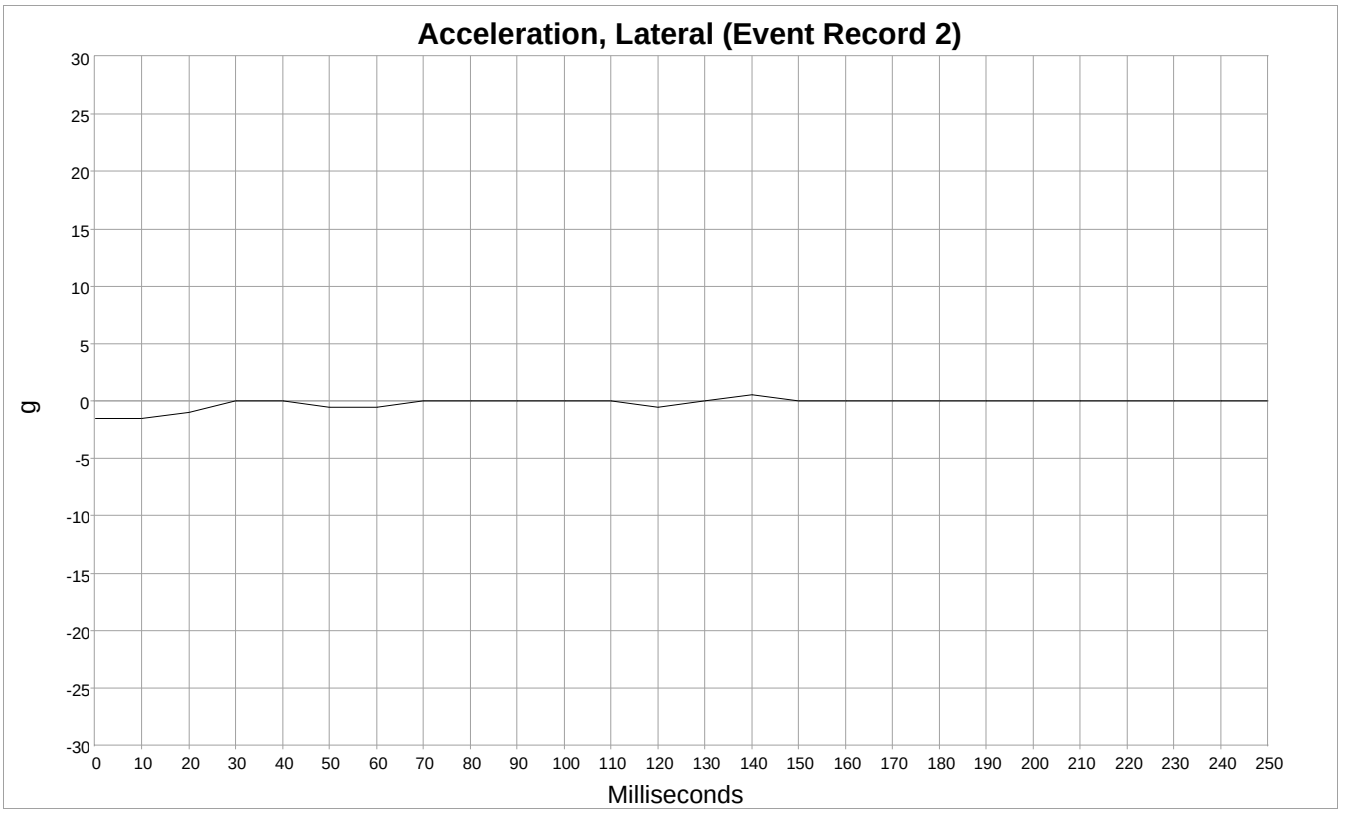
Lateral Delta V (Event Record 2)

Time (msec)	MPH [km/h]
0	0 [0]
10	0 [0]
20	-1 [-1]
30	-1 [-1]
40	-1 [-1]
50	-1 [-1]
60	-1 [-1]
70	-1 [-1]
80	-1 [-1]
90	-1 [-1]
100	-1 [-1]
110	-1 [-1]
120	-1 [-1]
130	-1 [-1]
140	-1 [-1]
150	-1 [-1]
160	-1 [-1]
170	-1 [-1]
180	-1 [-1]
190	-1 [-1]
200	-1 [-1]
210	-1 [-1]
220	-1 [-1]
230	-1 [-1]
240	-1 [-1]
250	-1 [-1]



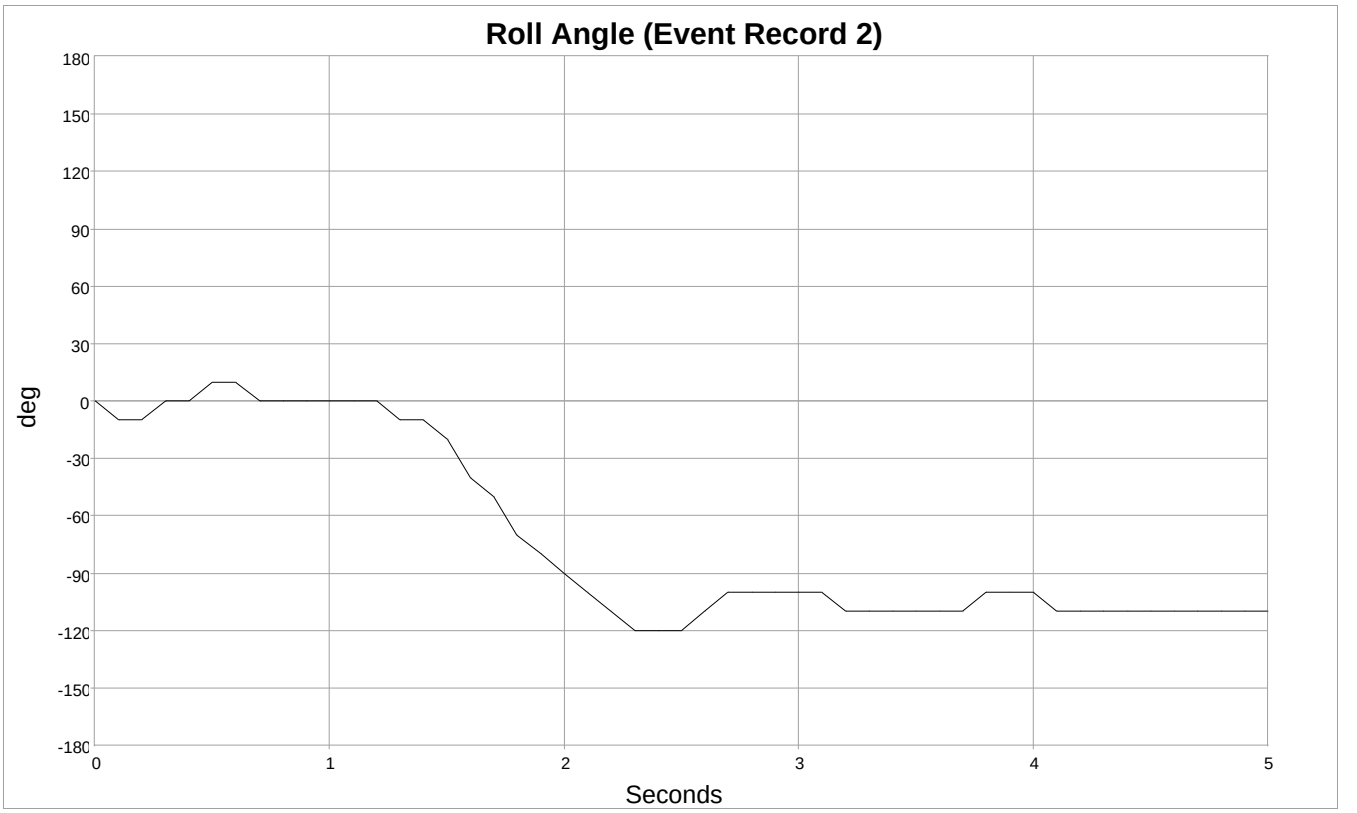
Longitudinal Acceleration (Event Record 2)

Time (msec)	g
0	0
10	0
20	-.5
30	.5
40	0
50	0
60	0
70	0
80	.5
90	.5
100	0
110	0
120	-.5
130	-.5
140	0
150	0
160	0
170	0
180	0
190	0
200	0
210	0
220	-.5
230	0
240	0
250	0



Lateral Acceleration (Event Record 2)

Time (msec)	g
0	-1.5
10	-1.5
20	-1
30	0
40	0
50	-.5
60	-.5
70	0
80	0
90	0
100	0
110	0
120	-.5
130	0
140	.5
150	0
160	0
170	0
180	0
190	0
200	0
210	0
220	0
230	0
240	0
250	0



Roll Angle (Event Record 2)

Time (sec)	deg
0.0	0
0.1	-10
0.2	-10
0.3	0
0.4	0
0.5	10
0.6	10
0.7	0
0.8	0
0.9	0
1.0	0
1.1	0
1.2	0
1.3	-10
1.4	-10
1.5	-20
1.6	-40
1.7	-50
1.8	-70
1.9	-80
2.0	-90
2.1	-100
2.2	-110
2.3	-120
2.4	-120
2.5	-120
2.6	-110
2.7	-100

2.8	-100
2.9	-100
3.0	-100
3.1	-100
3.2	-110
3.3	-110
3.4	-110
3.5	-110
3.6	-110
3.7	-110
3.8	-100
3.9	-100
4.0	-100
4.1	-110
4.2	-110
4.3	-110
4.4	-110
4.5	-110
4.6	-110
4.7	-110
4.8	-110
4.9	-110
5.0	-110

Hexadecimal Data

61 01 FF C0 00 94 21 00 94 22 00 94 23 00 80 01 13 80 02 13 94 31 13 94 30 13 80 21 13 80 D5
15 80 29 13 80 94 88 80 91 88 80 96 88 80 93 88 80 98 88 D0 00 01 14 01 03 CC 3F 03 07

61 02 94 21 00 00 00 01 3F 00 00 00 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
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61 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
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00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

61 04 00 00 00 81 00 00 14 00 00 00 00 00 00

61 06 00 04 07 0D 0D 0D 0D FF FF 16 16 16 16 FF FF 17 FF 17 FF 17 35 FF FF FF FF FF 0A 18 FF
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00 2C 00 2A 00 26 00 25 00 25 00 24 00 24 00 24

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0x04001EAC 00 00

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0x04002030 08 FF

0x04002034 00 00

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0x0400204C 0C 43

0x0400204A 08 DB

0x04002038 08 C3

0x04002036 08 C3

0x04001E3C 10 01 80 12

0x04001FC8 10 01 80 52

59 02 09 94 21 00 09 94 22 00 09 94 23 00 09 80 01 13 09 80 02 13 09 94 31 13 09 94 30 13 09 80 21 13 09 80 D5 15 09 80 29 13 09 80 94 88 09 80 91 88 09 80 96 88 09 80 93 88 09 80 98 88 09 D0 00 01 09

59 02 09 94 21 00 08

59 0F 08

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.

APPENDIX B: 2012 Chevrolet Malibu Event Data Recorder Report

The EDR report contained in this technical report was imaged by the law enforcement agency investigating this crash, using their licensed version of the Bosch CDR software. An electronic file of the imaged data was provided to the SCI team and re-read using the current version of the Bosh CDR software at the time that this report was published. The CDR report contained in the associated Crash Viewer application may differ relative to this report.

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	1G1ZA5E01CF******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	CR18009_V2_SDM.CDRX
Saved on	
Imaged with CDR version	Crash Data Retrieval Tool 17.6.1
Imaged with Software Licensed to (Company Name)	Company Name information was removed when this file was saved without VIN sequence number
Reported with CDR version	Crash Data Retrieval Tool 21.0.1
Reported with Software Licensed to (Company Name)	NHTSA
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 can record up to 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. If a CDR Printout user were to calculate resultant velocity change using X and Y axis time history data, the calculated value may be different than the Maximum SDM Recorded Velocity Change parameter value displayed in the CDR report. This is due to the rounding that occurs within the SDM while calculating the Maximum SDM Recorded Velocity Change value.
-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. The 1.0 second Pre-crash data value (most recent recorded data point) is the data point last sampled before AE. That is to say, the last data point may have been captured just before AE but no more than 1.0 second before AE. All subsequent Pre-crash data values are referenced from this data point.
-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
-Vehicle speed, Transmission Gear Select, and Transmission Actual Gear will be marked as invalid for manual transmission vehicles
-Pre-crash data associated with this event will always be for the first event even if it is not recorded.
-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit, except: The Passenger Belt Switch Circuit Status for 2005 vehicles is available only on the Cadillac STS. The Passenger Belt Switch Circuit Status for 2006 Chevrolet Cobalt Sport Coupe (AP) model vehicles, with the option package that includes Recaro brand seats (RPO ALV), always reports a default value of "Buckled," because there is no passenger belt switch with the Recaro seat option. The Passenger Belt Switch Circuit Status for 2010 Chevrolet Cobalt and 2010 Pontiac G5 vehicles, with RPO Z49, will report a default value of "Buckled". The Passenger Belt Switch Circuit Status for 2010 and 2011 Chevrolet HHR, with the LS or LT trim package and RPO Z49, will report a default value of "Buckled".
-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. Time Between events is measured from end of one event to the beginning of a next event. An event may occur within 5 seconds of another event, known as an extended event. This occurs when three or more sequential events are separated by more than 5 seconds but each event in the sequence is no more than 5 seconds apart from a subsequent event. Pre-crash data is locked to the first event in an extended event.
-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 counter.
-Steering Wheel Angle data is reported in 16 degree increments. 2005 through 2010 Chevrolet Cobalt, 2005 and 2006 Pontiac Pursuit, 2007 through 2010 Pontiac G5, and 2006 through 2011 Chevrolet HHR, do not record Steering Wheel Angle data and should not be relied upon.
-If more than one event is recorded, use the follow to determine which event the Multiple Event Data is associated with:
-If a Deployment event and not locked Non-Deployment event are recorded, the Multiple Event Data is associated with the Deployment event.
-If a Deployment event and a locked Non-Deployment event are recorded, then the Multiple Event Data is associated with both events.
-If a Deployment event and Deployment event #2 are recorded, then the Multiple Event Data is associated with both events.
-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.

Data Element Sign Convention:
The following table provides an explanation of the sign notation for data elements that may be included in this CDR report. Directional references to sign notation are all from the perspective of the driver when seated in the vehicle facing the direction of forward vehicle travel.

Data Element Name	Positive Sign Notation Indicates
Longitudinal Velocity Change	Forward
Lateral Velocity Change	Left to Right
Lateral Acceleration	Left to Right
Yaw Rate	Clockwise *
Steering Wheel Angle	Clockwise *

*For Cadillac STS model vehicles with StabiliTrak 3.0 systems (RPO JL7), the positive sign notation Indicates a counterclockwise rotation.

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 tool.

01016_SDMEps_r011

Multiple Event Data

Associated Events Not Recorded	0
An Event(s) Preceded the Recorded Event(s)	No
An Event(s) was in Between the Recorded Event(s)	No
An Event(s) Followed the Recorded Event(s)	No
The Event(s) Not Recorded was a Deployment Event(s)	No
The Event(s) Not Recorded was a Non-Deployment Event(s)	No

System Status At AE

Vehicle Identification Number	**1ZA5E0*C*******
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
Brake System Warning Lamp (If Equipped)	OFF

System Status At 1 second

Transmission Range (If Equipped)	Sixth Gear
Transmission Selector Position (If Equipped)	Sixth Gear
Traction Control System Active (If Equipped)	No
Service Engine Soon (Non-Emission Related) Lamp	OFF
Service Vehicle Soon Lamp	OFF
Outside Air Temperature (degrees F) (If Equipped)	46
Left Front Door Status (If Equipped)	Closed
Right Front Door Status (If Equipped)	Closed
Left Rear Door Status (If Equipped)	Unused
Right Rear Door Status (If Equipped)	Unused
Rear Door(s) Status (If Equipped)	Closed

Pre-crash data

Parameter	-2 sec	-1 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

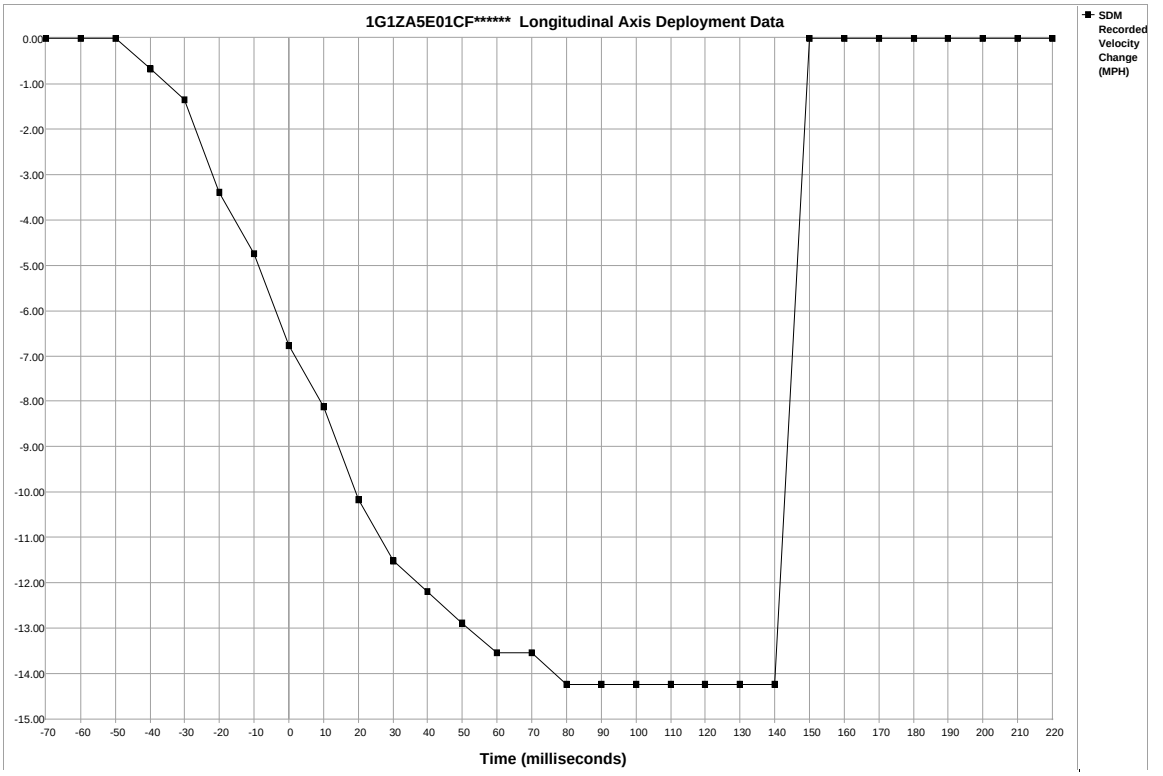
Pre-Crash Data

Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Vehicle Speed (MPH)	49	48	48	48	49
Engine Speed (RPM)	1408	1280	1152	2176	2368
Percent Throttle	9	9	9	40	40
Brake Switch Circuit State	OFF	OFF	OFF	OFF	OFF
Accelerator Pedal Position (percent)	0	0	0	18	17
Antilock Brake System Active (If Equipped)	No	No	No	No	No
Lateral Acceleration (feet/s²)(If Equipped)	-0.82	0.00	-1.64	-2.46	-2.46

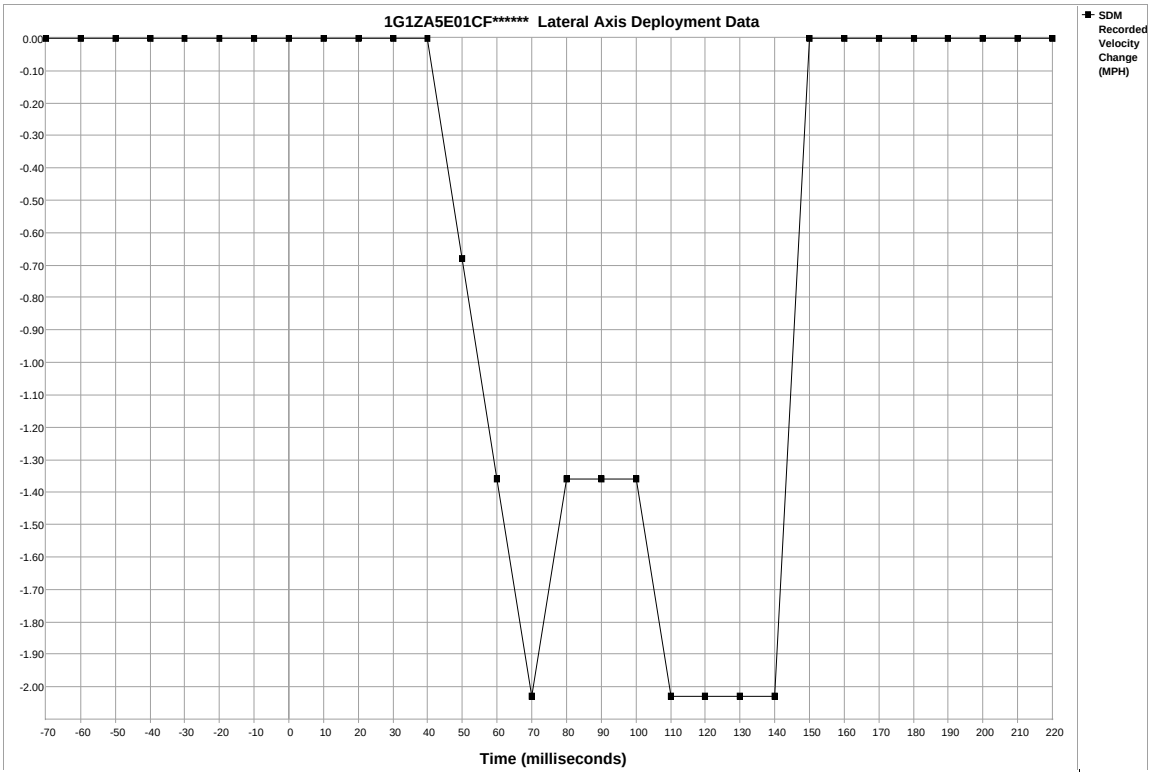
Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Yaw Rate (degrees per second) (If Equipped)	-1	-1	-3	-3	-3
Steering Wheel Angle (degrees) (If Equipped)	-16	-16	-16	-16	-16
Vehicle Dynamics Control Active (If Equipped)	No	No	No	No	No

System Status At Deployment

Ignition Cycles At Investigation	14745
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time (seconds)	655200
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	6802
Ignition Cycles At Event	14745
Ignition Cycles Since DTCs Were Last Cleared	254
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Belt Switch Circuit Status (If Equipped)	UNBUCKLED
Diagnostic Trouble Code at Event Enable, fault number: 1	N/A
Diagnostic Trouble Code at Event Enable, fault number: 2	N/A
Diagnostic Trouble Code at Event Enable, fault number: 3	N/A
Diagnostic Trouble Code at Event Enable, fault number: 4	N/A
Diagnostic Trouble Code at Event Enable, fault number: 5	N/A
Diagnostic Trouble Code at Event Enable, fault number: 6	N/A
Automatic Passenger SIR Suppression System Validity Status at AE	Valid
Automatic Passenger SIR Suppression System Status at AE	Air Bag Suppressed
Automatic Passenger SIR Suppression System Validity Status at First Deployment Command	Valid
Automatic Passenger SIR Suppression System Status at First Deployment Command	Air Bag Suppressed
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	38
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	48
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
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
Time Between Events (sec)	3.24
Driver First Stage Deployment Loop Commanded	Yes
Driver Second Stage Deployment Loop Commanded	Yes
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	Yes
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger First Stage Deployment Loop Commanded	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	Yes
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Third Row Left Roof Rail/Head Curtain Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Third Row Right Roof Rail/Head Curtain Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No
Driver 2nd Stage Deployment Loop Commanded for Disposal	No
Passenger 2nd Stage Deployment Loop Commanded for Disposal	No
Crash Record Locked	Yes
Vehicle Event Data (Pre-Crash) Associated With This Event	No
Event Recording Complete	Yes



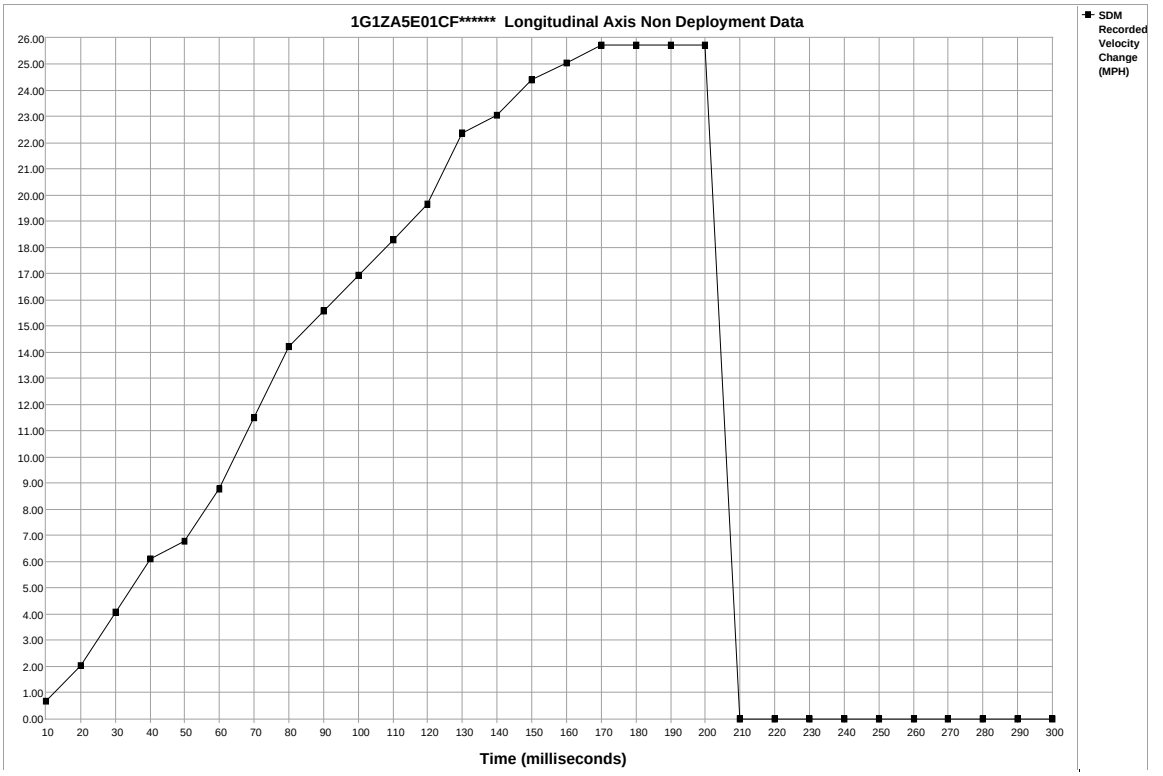
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	-0.68	-1.36	-3.39	-4.74	-6.78	-8.13	-10.17	-11.52	-12.20	-12.88	-13.55	-13.55
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-14.23	-14.23	-14.23	-14.23	-14.23	-14.23	-14.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



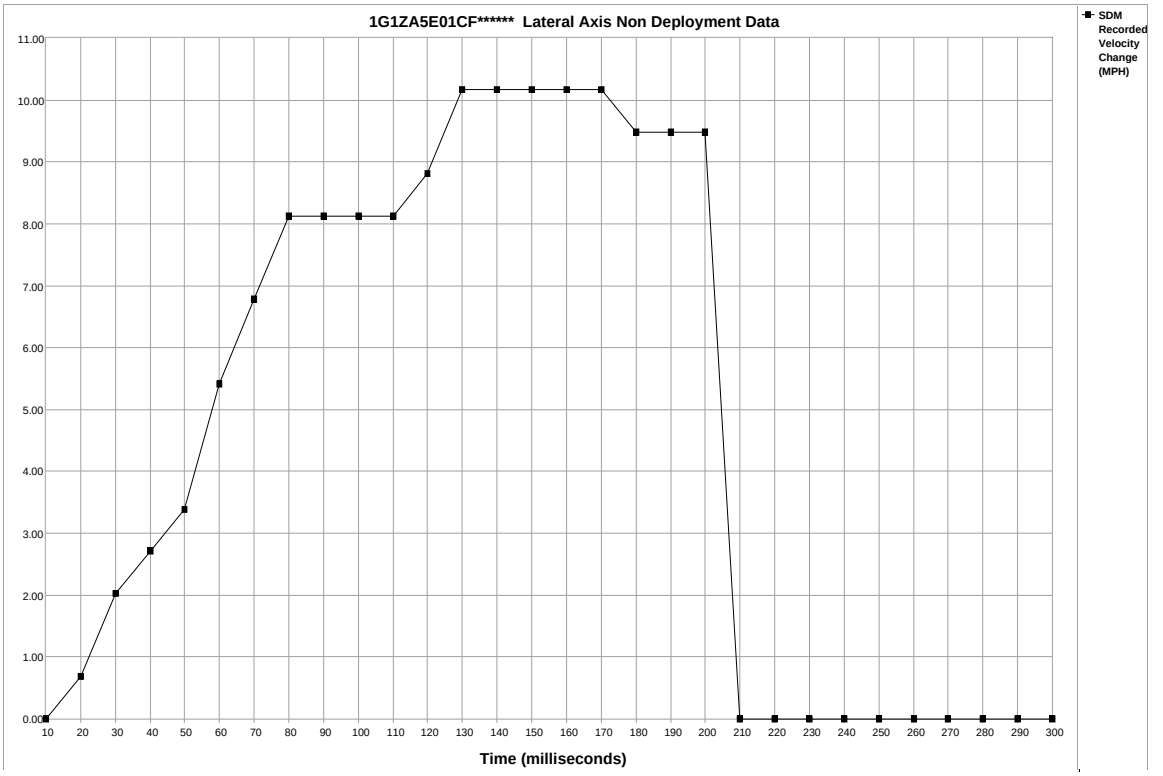
Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.68	-1.36	-2.03
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Lateral Axis Recorded Velocity Change (MPH)	-1.36	-1.36	-1.36	-2.03	-2.03	-2.03	-2.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

System Status At Non-Deployment

Ignition Cycles At Investigation	14745
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time (seconds)	655200
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	6802
Ignition Cycles At Event	14745
Ignition Cycles Since DTCs Were Last Cleared	254
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Belt Switch Circuit Status (If Equipped)	UNBUCKLED
Automatic Passenger SIR Suppression System Validity Status at AE	Valid
Automatic Passenger SIR Suppression System Status at AE	Air Bag Suppressed
Diagnostic Trouble Code at Event Enable, fault number: 1	N/A
Diagnostic Trouble Code at Event Enable, fault number: 2	N/A
Diagnostic Trouble Code at Event Enable, fault number: 3	N/A
Diagnostic Trouble Code at Event Enable, fault number: 4	N/A
Diagnostic Trouble Code at Event Enable, fault number: 5	N/A
Diagnostic Trouble Code at Event Enable, fault number: 6	N/A
Maximum Resultant SDM Recorded Vehicle Velocity Change (MPH)	27.69
Time From Algorithm Enable to Maximum Resultant SDM Recorded Vehicle Velocity Change (msec)	170
Driver First Stage Deployment Loop Commanded	No
Driver Second Stage Deployment Loop Commanded	No
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	No
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger First Stage Deployment Loop Commanded	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	No
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Third Row Left Roof Rail/Head Curtain Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Third Row Right Roof Rail/Head Curtain Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No
Crash Record Locked	Yes
Vehicle Event Data (Pre-Crash) Associated With This Event	Yes
Deployment Event Recorded in the Non-Deployment Record	No
Event Recording Complete	Yes



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.68	2.03	4.07	6.10	6.78	8.81	11.52	14.23	15.59	16.94	18.30	19.65	22.36	23.04	24.40
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Longitudinal Axis Recorded Velocity Change (MPH)	25.07	25.75	25.75	25.75	25.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



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	0.68	2.03	2.71	3.39	5.42	6.78	8.13	8.13	8.13	8.13	8.81	10.17	10.17	10.17
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
SDM Lateral Axis Recorded Velocity Change (MPH)	10.17	10.17	9.49	9.49	9.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Hexadecimal Data

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$33  67 67 17 17 18 00 00
$34  25 22 12 14 16 00 00
$35  4F 4D 4D 4E 4F 00 00
$36  FF FF FF FF FF 00 00
$37  00 00 00 06 06 00 00
$38  5F 00 00 00 03 C0 00
$39  FD FD FE 00 FF 00 00
$3A  FD FD FD FF FF 00 00
$3B  03 06 0C 00 00 00 00
$3C  00 00 00 00 00 00 C0
$3D  31 5A 41 35 45 30 00
$3E  43 FF FF FF 00 00 00
$3F  00 00 90 00 00 00 00
$40  A0 A5 00 00 00 00 00
$41  00 00 00 00 00 00 00
```

```
$42  00 FF F0 1A 92 00 00
$43  FE 39 99 00 00 00 00
$44  00 00 00 00 00 00 00
$45  00 00 00 00 00 00 00
$46  00 00 00 00 00 00 00
$47  00 01 01 03 03 06 00
$48  04 09 05 0A 08 0D 00
$49  0A 11 0C 15 0C 17 00
$4A  0C 19 0C 1B 0D 1D 00
$4B  0F 21 0F 22 0F 24 00
$4C  0F 25 0F 26 0E 26 00
$4D  0E 26 0E 26 00 00 00
$4E  00 00 00 00 00 00 00
$4F  00 00 00 00 00 00 00
$50  00 00 00 00 00 00 00
$51  D0 00 00 00 00 00 00
$52  00 00 00 00 00 00 00
$53  11 06 85 00 00 00 00
$54  00 00 00 00 00 00 00
$55  00 00 00 00 00 00 00
$67  80 A5 00 00 00 00 00
$68  D0 10 00 00 00 00 00
$69  00 FF F0 1A 92 00 00
$6A  FE 39 99 00 00 00 00
$6B  00 00 00 00 00 00 00
$6C  00 00 00 00 00 00 00
$6D  00 00 00 00 00 00 00
$6E  00 00 00 00 00 00 00
$6F  00 FF 00 FE 00 FB 00
$70  00 F9 00 F6 00 F4 00
$71  00 F1 00 EF 00 EE 00
$72  FF ED FE EC FD EC 00
$73  FE EB FE EB FE EB 00
$74  FD EB FD EB FD EB 00
$75  FD EB 00 00 00 00 00
$76  00 00 00 00 00 00 00
$77  00 00 00 00 00 00 00
$78  D0 00 00 00 00 00 00
$79  00 00 00 00 00 00 00
$7A  00 00 00 00 00 00 00
$7B  13 18 00 00 00 00 51

$01  41 55 31 30 39 38 52 30 30 33 35 34 31 37 32 42
$02  3F 0A 00 00
$03  41 54 31 30 39 38 52 30 30 33 31 43 31 42 32 42
$04  3F 0A 00 00
$05  42 55 00 00 00 00 52 FF FF FF FF FF FF FF FF FF
$06  FF FF 00 00
$07  42 54 00 00 00 00 52 FF FF FF FF FF FF FF FF FF
$08  FF FF 00 00
$0D  41 48 31 30 39 37 52 30 30 44 38 42 39 43 32 42
$0E  3F 0A 00 00
$0F  41 4A 31 30 39 37 52 30 30 38 35 30 39 43 32 42
$10  3F 0A 00 00
$13  42 52 32 37 35 38 4A 33 32 30 34 38 33 59 36 32
$14  4B 18 00 41
$17  42 54 FF FF FF FF FF FF FF FF FF FF FF FF FF FF
$18  FF FF FF FF
$21  31 E2 26 FE 62 E9 9E 3F
$22  95 89
$23  FA 5A FA FA FA FA FA
$24  FA 5A FA FA FA FA FA
$25  FA 5A FA FA FA FA FA
$26  FA 5A FA FA FA FA FA
$40  00 00
```

```
$41  FF 33 00 66 00 1A
$42  D0 E4
$43  00 00 8E 80
$44  C6 08 00 FC C0 C2
$45  07 01 07 01 05 01
$46  00 0F 0F 64 64
$47  0A 64 02 04 04 05 0A 06 04 0A 00 00 FA 00 00 FF 04 64
$48  18 08 08
$B0  58
$B1  FD FE 00
$B2  FF FF FF FF FF
$B4  41 53 39 35 38 39 32 31 35 41 58 58 20 20 20 20
$B7  50 AA 01 03 11
$B8  52 47 84 03 17
$C1  30 33 31 31
$CA  30 33 31 31
$CB  01 5B E4 E5
$CC  01 5B E4 E5
$D1  00 00
$DB  00 00
$DC  00 00
```

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APPENDIX C: 2011 Toyota Highlander Event Data Recorder Report

The EDR report contained in this technical report was imaged using the current version of the Bosch CDR software at the time of the vehicle inspection. The CDR report contained in the associated Crash Viewer application may differ relative to this report.

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/Frame Number	5TDYK3EH1BS******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	CR18009_V3_ECU.CDRX
Saved on	
Imaged with CDR version	Crash Data Retrieval Tool 17.7.1
Imaged with Software Licensed to (Company Name)	Company Name information was removed when this file was saved without VIN sequence number
Reported with CDR version	Crash Data Retrieval Tool 21.0.1
Reported with Software Licensed to (Company Name)	NHTSA
EDR Device Type	Airbag Control Module
Event(s) recovered	Front/Rear (1), Rollover (1)

Comments

No comments entered.

Data Limitations

CDR Record Information:

- Due to limitations of the data recorded by the airbag ECU, such as the resolution, data range, sampling interval, time period of the recording, and the items recorded, the information provided by this data may not be sufficient to capture the entire crash.
- Pre-Crash data is recorded in discrete intervals. Due to different refresh rates within the vehicle's electronics, the data recorded may not be synchronous to each other.
- Airbag ECU data should be used in conjunction with other physical evidence obtained from the vehicle and the surrounding circumstances.
- If the airbags did not deploy or the pretensioners did not operate during an event that meets a specified recording threshold, it is called a Non-Deployment Event. Data from a Non-Deployment Event can be overwritten by a succeeding event that meets the specified recording threshold. If the airbag(s) deploy or the pretensioners are operated, it is called a Deployment Event. Deployment Event data cannot be overwritten or deleted by the airbag ECU following that event.
- If power supply to the airbag ECU is lost during an event, all or part of the data may not be recorded.
- "Diagnostic Trouble Codes" are information about faults when a recording trigger is established. Various diagnostic trouble codes could be set and recorded due to component or system damage during an accident.
- The airbag ECU records only diagnostic information related to the airbag system. It does not record diagnostic information related to other vehicle systems.
- The TaSCAN, Global Tech Stream, or Intelligent Tester II devices (or any other Toyota genuine diagnostic tool) can be used to obtain detailed information on the diagnostic trouble codes from the airbag system, as well as diagnostic information from other systems. However, in some cases, the diagnostic trouble codes of the airbag system recorded by the airbag ECU when the event occurred may not match the diagnostic trouble codes read out when the diagnostic tool is used.

General Information:

- The data recording specifications of Toyota's airbag ECUs are divided into the following categories. The specifications for 12EDR or later are designed to be compatible with NHTSA's 49CFR Part 563 rule.
  - 00EDR / 02EDR / 04EDR / 06EDR / 10EDR / 12EDR / 13EDR / 15EDR / 17EDR / 19EDR
- The airbag ECU records data for all or some of the following accident types: frontal crash, rear crash , side crash, and rollover events. Depending on the installed airbag ECU, data for side crash and/or rollover events may not be recorded.
- This airbag ECU records post-crash data, and depending on the airbag ECU, may record pre-crash data.
  - If a single event occurs independently, the data for that event is recorded on a one-to-one basis.
  - If multiple events occur successively (within a period of approximately 500ms), the establishment of the recording trigger for the first event is defined as the "pre-crash recording trigger". Pre-crash data for the first event and post-crash data for each successive event is then recorded.
- The airbag ECU has two recording pages (memory maps) to store pre-crash data. Additionally, to store post-crash data, the airbag ECU has two recording pages for each accident type: two pages for frontal and rear crash, two pages for a side crash, and two pages for rollover event.

- The data recorded by the airbag ECU includes correlating information between each previously occurring event (i.e., information that clarifies the collision event sequence. This correlation information consists of the following items.
  - Time from Previous Pre-Crash TRG
  - Linked Pre-Crash Page
  - Time from Pre-Crash TRG
  - TRG Count
  - Previous Crash Type
- The point in time at which the recording trigger is established is regarded as time zero for the recorded data.
- The recording trigger judgment threshold value differs depending on the collision type (i.e., frontal crash, rear crash, side crash, or rollover event).
- Time series data for side crash may have 24 or 25 sampling points.
- Some of the data recorded by the airbag ECU is transmitted to the airbag ECU from various vehicle control modules by the vehicle's Controller Area Network (CAN).
- In some cases, the airbag ECU part number printed on the ECU label may not match the airbag ECU part number that the CDR tool reports. The part number retrieved by the CDR tool should be considered as the official ECU part number.

Data Element Sign Convention:
The following table provides an explanation of the sign notation for data elements that may be included in this CDR report.

Data Element Name	Positive Sign Notation Indicates
Max. Longitudinal Delta-V	Forward
Longitudinal Delta-V	Forward
Max. Lateral Delta-V , B-Pillar Sensor	Outside to Inside
Max. Lateral Delta-V , C-Pillar Sensor	Outside to Inside
Max. Lateral Delta-V , Front Door Sensor	Outside to Inside
Max. Lateral Delta-V , Slide Door Sensor	Outside to Inside
Lateral Delta-V , B-Pillar Sensor	Outside to Inside
Lateral Delta-V , C-Pillar Sensor	Outside to Inside
Lateral Delta-V , Airbag ECU Sensor	Left to Right
Roll Angle Peak	Clockwise Rotation
Roll Angle	Clockwise Rotation
Lateral Acceleration , Airbag ECU Sensor *	Right to Left

* For sensing a rollover

Data Definitions:

- The "ON" setting for the "Freeze Signal" indicates a state in which the non-volatile memory can not be overwritten or deleted by the airbag ECU. After "Freeze Signal" has been turned ON, subsequent events will not be recorded.
- "Recording Status" indicates a state in which all recorded event data has been written into the non-volatile memory, or a state in which this process was interrupted and not fully written into the non-volatile memory. If "Recording Status" is "Incomplete", recorded event data may not be valid.
- "Time to Deployment Command" indicates the time between recording trigger establishment and the determination of airbag deployment. This value may differ from the actual time it takes for the airbag to fully deploy.
- Even if an airbag/pretensioner did not deploy due to the "front passenger airbag disable switch and/or "RSCA Disable Switch" in the ON position or other disabling criteria are met, the "Time to deployment command" data element for that airbag/pretensioner may still be recorded.
- "Engine RPM" indicates the number of engine revolutions, not the number of motor revolutions. The recorded value has an upper limit of 5,200 rpm. Resolution is 400 rpm and the value is rounded down and recorded. For example, if the actual engine speed is 799 rpm, the recorded value will be 400 rpm.
- The upper limit for the recorded "Vehicle Speed" value is 122 km/h (75.8mph). Resolution is 2km/h (1.2mph) and the value is rounded down and recorded. The accuracy of the "Vehicle Speed" value can be affected by various factors. These include, but not limited, to the following.
  - Significant changes in the tire's rolling radius
  - Wheel lock and wheel slip
- "Accelerator Rate" has two recording specifications. Both the recorded value increases as the driver depresses the accelerator.
  - Percentage of accelerator pedal depressed (recorded as 0-100(%)).
  - Output voltage of accelerator pedal module (recorded as 0-5(V)).
- The "Drive" setting for the "Shift Position" value indicates the shift position state is other than "R,"(Reverse), "N" (Neutral), or "P" (Park). If sequential shift had been used, "Invalid" may be displayed.
- Depending on the type of occupant sensor installed in the vehicle, one of the following four recording formats for "Occupancy Status, Passenger" will be utilized.
  - Occupied / Not Occupied
  - Adult / Child / Not Occupied
  - AM50 / AF05 / Child / Not Occupied
  - AM50 / AF05 / Child or Not Occupied
- Resolution of the "Air Bag Warning Lamp ON Time Since DTC was Set" is 15 minutes, and the value is rounded down and recorded.
- "Longitudinal Delta-V" indicates the change in forward speed after establishment of the recording trigger. This does not refer to vehicle speed, and it does not include the change in speed during the period from the start of the actual collision to establishment of the recording trigger.

- "Roll Angle peak" may not always match the peak value within the "Roll Angle" sampling points due to differences in data calculation method.
- For "Lateral Delta-V", the sensor location (B-pillar, front door, C-pillar, and slide door) shows the outline of a typical sensor position. Sensory location can be confirmed using the repair manual.
- "Time from Previous Pre-Crash TRG" indicates the time between the establishment of an event's pre-crash recording trigger to the establishment of a more recent event's pre-crash recording trigger. The upper limit for the recorded value is 16,381 milliseconds. In the event of establishment of the first pre-crash recording trigger after the ignition is switched ON, the upper limit value(max value) is recorded.
- "TRG Count" indicates a calculated value of the number of times recording triggers have been established for all crash types. The sequence in which each event occurred can be verified from the "TRG Count". The smaller the "TRG Count" value, the older the data. The upper limit for the recorded value is 65,533 times. When more than one event reaches the upper limit, the actual "TRG Count" may be greater than what is displayed for that event.
- "Linked Pre-Crash Page" is used to link 'paged" pre-crash data with 'paged" post-crash data. When old pre-crash data is overwritten by new pre-crash data, the "Linked Pre-Crash Page" value may record a page number that is not actually linked.
- Resolution of the "Time from Pre-Crash to TRG" is 100 [ms], and the value is rounded down and recorded.

05006_ToyotaDENSO_r028

System Status at Time of Retrieval

ECU Part Number	89170-0E060
ECU Generation	06EDR
Recording Status, All Pages	Complete
Freeze Signal	OFF
Freeze Signal Factor	None
Diagnostic Trouble Codes Exist	No
Time from Previous Pre Crash TRG (msec)	16381 or greater
Latest Pre-Crash Page	0
Contains Unlinked Pre-Crash Data	No

Event Record Summary at Retrieval

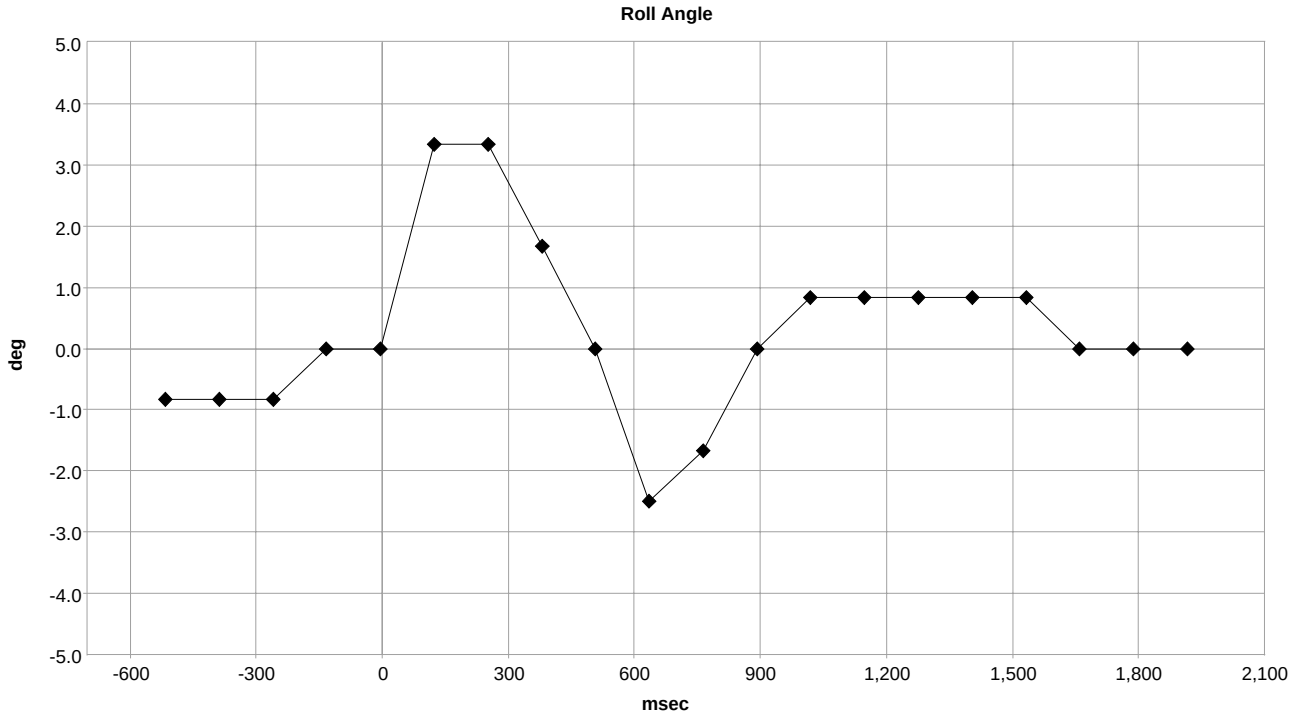
Events Recorded	TRG Count	Crash Type	Time (msec)	Pre-Crash and/or DTC Data Recording Status	Event & Crash Pulse Data Recording Status
Most Recent Event	2	Rollover	0	Complete (Page 0)	Complete (Rollover Page 0)
1st Prior Event	1	Front/Rear Crash	-11	Complete (Page 0)	Complete (Front/Rear Page 0)

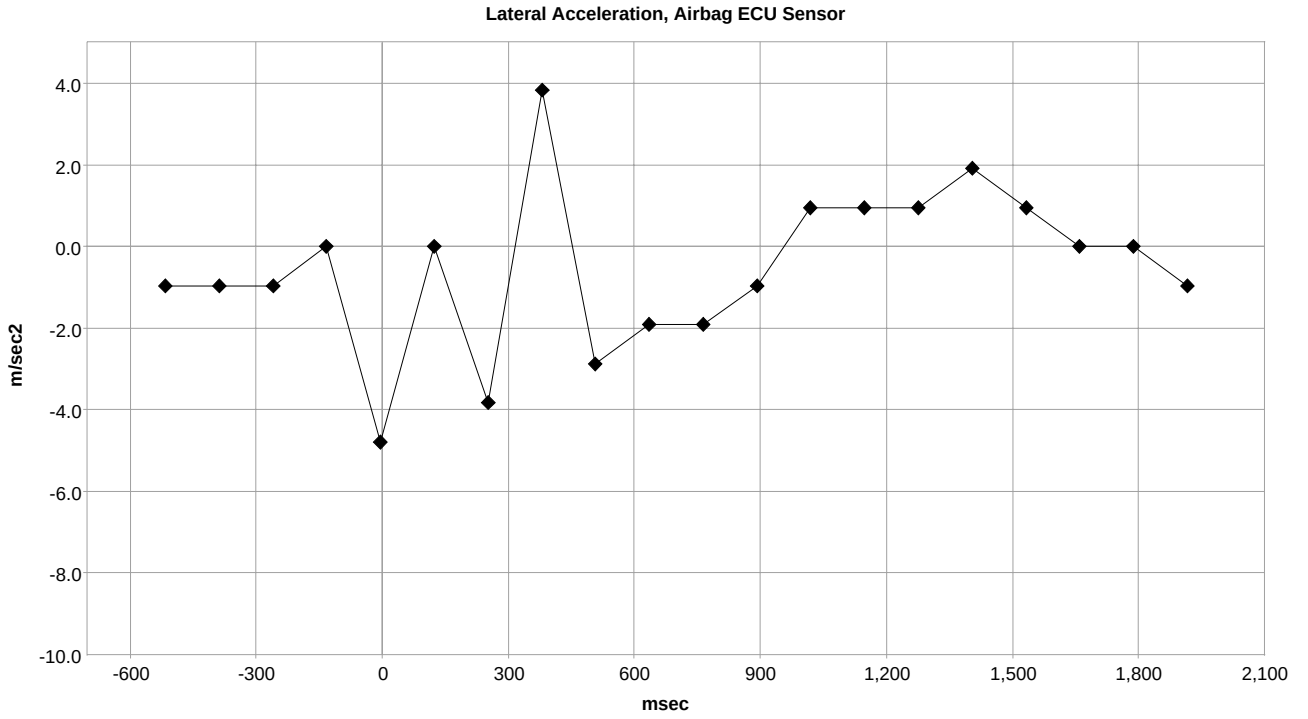
System Status at Event (Most Recent Event, TRG 2)

Recording Status, Rollover Crash Info.	Complete
Crash Type	Rollover
TRG Count (times)	2
Previous Crash Type	Frontal/Rear
Time from Pre-Crash TRG (msec)	11
Linked Pre-Crash Page	0
Time to Deployment Command, Rollover Airbag (msec)	Not Commanded

Rollover Crash Pulse (Most Recent Event, TRG 2 - table 1 of 2)

Recording Status, Time Series Data	Complete
Time from TRG to Next Sample (msec)	124
Roll Angle Peak (degrees)	4.6





Rollover Crash Pulse (Most Recent Event, TRG 2 - table 2 of 2)

Time (msec)	Roll Angle (degrees)	Lateral Acceleration, Airbag ECU Sensor (m/sec^2)
-516	-0.8	-1.0
-388	-0.8	-1.0
-260	-0.8	-1.0
-132	0.0	0.0
-4	0.0	-4.8
124	3.3	0.0
252	3.3	-3.8
380	1.7	3.8
508	0.0	-2.9
636	-2.5	-1.9
764	-1.7	-1.9
892	0.0	-1.0
1020	0.8	1.0
1148	0.8	1.0
1276	0.8	1.0
1404	0.8	1.9
1532	0.8	1.0
1660	0.0	0.0
1788	0.0	0.0
1916	0.0	-1.0

DTCs Present at Time of Event (Most Recent Event, TRG 2)

Recording Status, Diagnostic	Complete
Ignition Cycle Since DTC was Set (times)	0
Airbag Warning Lamp ON Time Since DTC was Set (min)	0
Diagnostic Trouble Codes	None

Pre-Crash Data, 1 Sample (Most Recent Event, TRG 2)

Recording Status, Pre-Crash/Occupant	Complete
Time from Pre-Crash to TRG (msec)	0
Buckle Switch, Left Seat	Buckled
Buckle Switch, Right Seat	Buckled
Occupancy Status, Passenger	AM50
Seat Position, Driver	Rearward
Shift Position	Drive

Pre-Crash Data, -5 to 0 seconds (Most Recent Event, TRG 2)

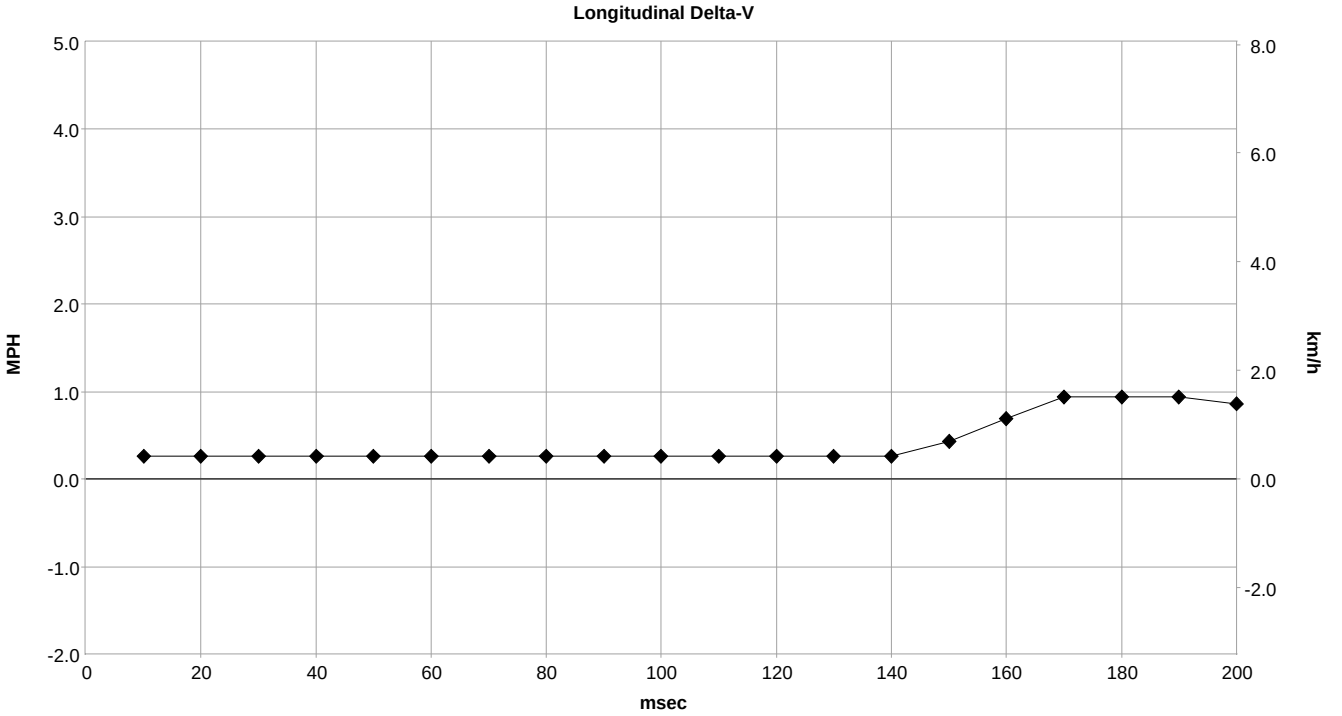
Time (sec)	-4	-3	-2	-1	0	0 (TRG)
Vehicle Speed (MPH [km/h])	47.2 [76]	47.2 [76]	47.2 [76]	46 [74]	46 [74]	46 [74]
Brake Switch	OFF	OFF	OFF	OFF	OFF	OFF
Accelerator Rate (V)	1.13	0.94	0.78	0.82	1.13	1.13
Engine RPM (RPM)	1,200	1,200	1,200	1,200	1,200	1,200

System Status at Event (1st Prior Event, TRG 1)

Recording Status, Front/Rear Crash Info.	Complete
Crash Type	Front/Rear Crash
TRG Count (times)	1
Previous Crash Type	No Event
Time from Pre-Crash TRG (msec)	0
Linked Pre-Crash Page	0
Time to Deployment Command, Front Airbag, Driver (msec)	Not Commanded
Time to Deployment Command, Front Airbag, Passenger (msec)	Not Commanded
Event Severity Status, Driver	N/A
Event Severity Status, Passenger	N/A
Time to Deployment Command, Pretensioner (msec)	Not Commanded

Longitudinal Crash Pulse (1st Prior Event, TRG 1 - table 1 of 2)

Recording Status, Time Series Data	Complete
Max Longitudinal Delta-V (MPH [km/h])	0.9 [1.5]



Longitudinal Crash Pulse (1st Prior Event, TRG 1 - table 2 of 2)

Time (msec)	Longitudinal Delta-V (MPH [km/h])
10	0.3 [0.4]
20	0.3 [0.4]
30	0.3 [0.4]
40	0.3 [0.4]
50	0.3 [0.4]
60	0.3 [0.4]
70	0.3 [0.4]
80	0.3 [0.4]
90	0.3 [0.4]
100	0.3 [0.4]
110	0.3 [0.4]
120	0.3 [0.4]
130	0.3 [0.4]
140	0.3 [0.4]
150	0.4 [0.7]
160	0.7 [1.1]
170	0.9 [1.5]
180	0.9 [1.5]
190	0.9 [1.5]
200	0.9 [1.4]

DTCs Present at Time of Event (1st Prior Event, TRG 1)

Recording Status, Diagnostic	Complete
Ignition Cycle Since DTC was Set (times)	0
Airbag Warning Lamp ON Time Since DTC was Set (min)	0
Diagnostic Trouble Codes	None

Pre-Crash Data, 1 Sample (1st Prior Event, TRG 1)

Recording Status, Pre-Crash/Occupant	Complete
Time from Pre-Crash to TRG (msec)	0
Buckle Switch, Left Seat	Buckled
Buckle Switch, Right Seat	Buckled
Occupancy Status, Passenger	AM50
Seat Position, Driver	Rearward
Shift Position	Drive

Pre-Crash Data, -5 to 0 seconds (1st Prior Event, TRG 1)

Time (sec)	-4	-3	-2	-1	0	0 (TRG)
Vehicle Speed (MPH [km/h])	47.2 [76]	47.2 [76]	47.2 [76]	46 [74]	46 [74]	46 [74]
Brake Switch	OFF	OFF	OFF	OFF	OFF	OFF
Accelerator Rate (V)	1.13	0.94	0.78	0.82	1.13	1.13
Engine RPM (RPM)	1,200	1,200	1,200	1,200	1,200	1,200

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.

```
PIDs          PID    Data
               00    BC 60 00 01
               01    00
               03    30 45 30 36 30 30 30 30 45 35 30 30 30 45 35 30 30 30 45 35 30 30
                     30 45 35 30 30 30 45 38 30 30 30 45 38 30 30 30 45 42 30 30 30 45
                     42
               04    02 02 01 01
               05    01
               06    00
               0A    01
               0B    00
               20    80 00 00 01
               21    00 51
               40    00 00 00 01
               60    00 00 00 01
               80    00 00 00 01
               A0    00 00 00 01
               C0    00 00 00 01
               E0    C0 10 00 00
               E1    00 00
               E2    00 5B 19 11 00
               EC    00

EEPROM      Address  Data (-- = data not imaged from ECU)
                          (** = no response from ECU)

                0    -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
               10    -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
               20    -- -- -- -- -- -- -- -- -- -- -- -- -- -- 00 00
               30    00 00 00 00 3F FD 00 00 00 00 00 00 00 00 -- --
               40    -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
               50    -- -- 11 31 01 94 1D 33 94 1D 33 94 15 33 98 14
               60    98 18 98 1D 00 00 00 55 00 00 00 00 00 00 00 00
               70    00 00 00 00 00 00 00 00 00 55 00 00 00 00 00 00
               80    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
               90    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
               A0    00 00 -- -- FD 00 00 00 00 00 00 00 00 00 00 00
               B0    00 00 FE FD FD 00 00 01 FF 87 00 55 00 01 E0 00
               C0    FE FE 00 55 00 00 00 00 00 00 00 00 00 00 00 00
               D0    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
               E0    00 00 00 00 -- -- 00 00 00 00 00 00 00 00 00 00
               F0    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              100    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              110    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              120    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              130    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              140    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              150    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              160    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              170    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              180    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              190    00 00 FF FF FF 00 00 04 04 02 00 FD FE 00 01 01
              1A0    01 01 01 00 00 00 FF FF FF 00 FB 00 FC 04 FD FE
              1B0    FE FF 01 01 01 02 01 00 00 FF 00 B1 7C 55 FF FE
              1C0    00 0B 00 02 00 55 00 00 00 00 00 00 00 00 00 00
              1D0    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              1E0    00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
              1F0    00 00 00 00 00 00 00 00 00 00
```

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U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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