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Special Crash Investigation On-Site Alleged Unintended Acceleration Crash Investigation Vehicle: 2008 Kia Optima Location: Tennessee Crash Date: December 2015

DISCLAIMER

The crash investigation process is an inexact science that requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicles 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.

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15. Supplementary Note

An investigation of the severe front-to-rear crash of a 2008 Kia Optima that traveled at a high rate of speed into the rear of a 2003 Ford Windstar that was stopped at an intersection.

16. Abstract

This on-site investigation involved the police-reported allegation of an unintended acceleration of a 2008 Kia Optima that may have contributed to a severe front-to-rear crash with a stopped 2003 Ford Windstar. The crash occurred when the Kia approached the intersection at a high rate of speed and struck the rear plane of the Ford Windstar, which was stopped at a controlled intersection. The Ford Windstar was displaced through the intersection by the impact, and its front plane struck the front plane of a 2015 Ford F-150. At the time of the crash, the Kia was occupied by an 83-year-old belted female driver and a 75-year-old belted female in the front right position. The Ford Windstar was occupied by a 48-year-old belted male driver, a 45-year-old belted female in the front row right position, and twin 7-year-old males restrained in booster child restraint systems in the second row. Following the crash, the Kia driver was extricated from the vehicle and transported to a regional trauma center with police-reported incapacitating (A-level) injuries. She died at the hospital one day post-crash due to complications of her injuries. Additionally, both 7-year-old males from the Ford Windstar sustained fatal injuries. The SCI inspection of the Kia involved an assessment of the foot controls, documentation of the exterior and interior damage, identification of occupant contact points and passenger compartment intrusion, and an evaluation of the manual and supplemental restraint systems. The on-site activities also included the exterior documentation of the Ford Windstar and the Ford F-150. The crash site was also inspected and documented. A mechanical cause of the Kia's unintended acceleration and high rate of speed was not identified through the course of the SCI inspection. A scan of the Kia for diagnostic trouble codes did not find any stored historical faults.

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LOCATION: TENNESSEE
CRASH DATE: DECEMBER 2015

BACKGROUND

Figure 1: Front right oblique view of the 2008 Kia Optima.

This on-site investigation involved the police-reported allegation of unintended acceleration of a 2008 Kia Optima (**Figure 1**) that may have contributed to a severe front-to-rear crash with a stopped 2003 Ford Windstar. The crash occurred when the Kia approached an intersection at a high rate of speed and struck the rear plane of the Ford Windstar, which was stopped at the controlled intersection. The Ford Windstar was then displaced through the intersection by the impact, and its front plane struck the front plane of a 2015 Ford F-150. At the time of the crash, the Kia was occupied by an 83-year-old belted female driver and a 75-year-old belted female in the front row right position. The Ford Windstar was occupied by a 48-year-old belted male driver, a 45-year-old belted female in the front row right position, and two 7-year-old males restrained in booster child restraint systems (CRS) in the second row. The Kia driver was extricated from the vehicle and transported to a regional trauma center with police-reported incapacitating (A-level) injuries. She died at the hospital three days post-crash due to complications of her injuries. Additionally, both 7-year-old males in the Ford Windstar sustained fatal injuries.

Notification of the crash was sent to the National Highway Traffic Safety Administration by the police investigator on January 4, 2016. The notification was forwarded to the Special Crash Investigations (SCI) group for further research on January 11, 2016, and assigned for on-site investigation. The on-site investigation included an inspection of the Kia on January 20, 2016, which was attended by technical representatives from Kia Motors and legal representatives for the involved parties. The SCI inspection of the Kia involved an assessment of the foot controls, documentation of the exterior and interior damage, identification of occupant contact points and passenger compartment intrusion, and an evaluation of the manual and supplemental restraint systems. The SCI on-site activities also included the exterior documentation of the Ford Windstar and the Ford F-150. The crash site was also inspected.

Due to its age, the Kia was not equipped with an event data recorder (EDR) that was compatible with any commercially available scan tool. The manufacturer's representatives participating in the inspection scanned the vehicles' diagnostics; however, this data did not include any type of pre-crash or crash-related parameters (refer to Attachment A). There were no stored historical trouble codes. A mechanical cause of the Kia's unintended acceleration and high rate of speed were not identified through the course of the SCI inspection. A root cause of the Kia's high-speed travel, other than inadvertent driver input, could not be identified.

CRASH SUMMARY

Crash Site

This multiple-event crash occurred during daylight hours in December 2015 at the four-leg intersection of two multi-lane roadways that were located in an urban commercial setting. The police–reported environmental conditions at the time of the crash were daylight, clear, and dry. The National Weather Service reported a temperature of 5.0 ˚C (41 ˚F), 87 percent relative humidity, north winds at 16.7 km/h (10.4 mph), and overcast skies.

The physical environment of the crash site was documented during the SCI inspection using a Nikon Nivo 5.M+ total station measurement device. In the pre-crash trajectory for the Kia, the primary roadway descended into a sag and then transitioned to a positive 3.4 percent grade along a large radius right curvature to the intersection. This roadway was oriented southwest/northeast in direction and consisted of six lanes. The width of the travel lanes was 3.4 m (11.2 ft). Speed was regulated by a posted limit of 48 km/h (30 mph). At the intersection for the southwest travel direction, the lanes were configured with two left-turn-only lanes and two through lanes (**Figure 2)**. The right-most lane also accommodated right-turning traffic into a parking lot located on the west side of the road. A double-yellow centerline separated the southwest lanes from the two northbound lanes. In the opposing (northeast) travel direction, the lanes were configured with one left-turn-only lane, two through lanes and one right turn-only lane.

Figure 2: Southwest trajectory view of the lane configuration at the intersection.

Figure 3: Image depicting the approximate sight line of the surveillance camera.

A three-lane roadway intersected the primary roadway from the east. Traffic movement through the intersection was controlled by standard overhead (red/amber/green) signals. Commercial businesses populated both roadsides. A surveillance camera, located on a business in the northeast quadrant of the intersection, captured a portion of the crash sequence on video. The investigating officer obtained a digital copy of the surveillance footage and shared this with the SCI team. **Figure 3** is a view depicting the approximate sight line of the camera. The utility pole on the right side of the image was used as a reference point during a time-distance analysis of the video. This pole was also documented and used as a reference point during SCI documentation of the crash site. Crash Diagrams are included on Pages 21 and 22 of this technical report.

Pre-Crash

A review of the surveillance footage depicted the following pre-crash movements of the vehicles. The 2003 Ford Windstar was traveling southwestward in the left lane on an approach to the signalized intersection. The vehicle was driven by the 48-year-old belted male and occupied by the 45-year-old belted female in the front row right position and two 7-year-old males secured in CRS booster seats in the vehicle's second row. As the Ford Windstar approached the intersection, the traffic signal had cycled to the red phase for northeast bound/southwest bound traffic flow. The driver decelerated the Ford Windstar and entered the right-most left-turn-only lane, then stopped at the mouth of the intersection. Three non-contact vehicles were stopped adjacent to the Ford Windstar in the left-most left-turn-only lane, and two other non-contact vehicles occupied the two through lanes at the mouth of the intersection. A third non-contact vehicle approached the intersection in the right-most lane. The presence of the Ford Windstar and the non-contact vehicles blocked the passage of the Kia through the intersection. Completely out of the camera view, the 2015 Ford F-150 pickup truck was stopped at the stop bar on the opposing side of the intersection, facing northeast.

The 2008 Kia Optima was driven by the 83-year-old belted female and occupied by the 75-year-old belted female in the front row right position. The Kia traveled southwestward in the left-through lane and entered the right-most left-turn-only lane as it approached the intersection. As the Kia entered the field of view of the camera, it was traveling at a high rate of speed. An analysis of the video footage determined that the Kia traveled the distance from the reference pole to the impact in approximately 1 second. The SCI mapping of the crash site determined that the distance from the reference pole to the area of impact was approximately 38 m (125 ft). This distance was in agreement with the measurements of the police investigation. Based on this distance, a time/distance calculation determined that the pre-crash speed of the Kia was approximately 137 km/h (85 mph). Video analysis determined that the brake lights of the Kia were not illuminated during this travel segment. However, brake lights and active turn signals were observed on other non-contact vehicles both stopped and/or approaching the intersection during the video footage review. It was not possible to interview the Kia's front right passenger regarding the vehicle's operation due to pending litigation and attorney refusal.

Crash

The front plane of the Kia struck the back plane of the stopped Ford Windstar in an in-line/100 percent overlap configuration (Event 1). The resulting force directions were 12 o'clock for the Kia and 6 o'clock for the Ford. Gouge marks in the asphalt pavement identified the area of the impact. The severity of the crash crushed the back plane of the Ford Windstar to the level of its C-pillars, resulting in collapse of the cargo space and severe intrusion into the passenger compartment. The frontal plane of the Kia also sustained severe crush, with engagement that extended to its A-pillars.

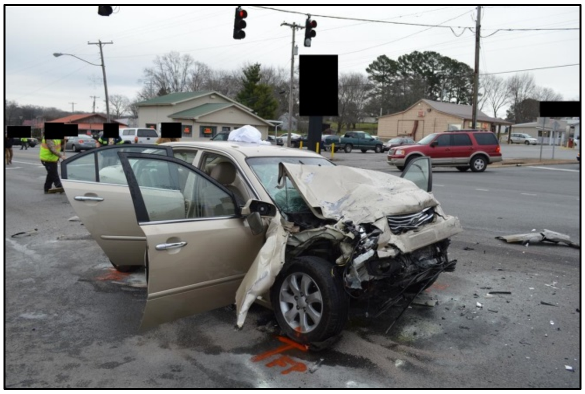


Figure 4: On-scene police image depicting the deformation and final rest position of the Kia Optima.

Figure 5: On-scene police image depicting the deformation and final rest position of the Ford Windstar.

The impact momentum of the Kia displaced the Ford forward, as the vehicles crushed and then separated. The Ford Windstar was displaced forward and slightly to its left as it traveled 44 m (144 ft) across the intersection and entered the left north eastbound-through lane, directly toward the stopped 2015 Ford F-150 pickup truck. The front plane/center and right aspect of the Ford Windstar struck the front plane/center and right aspect of the Ford F150 (Event 2), which resulted in impact force directions of 12 o'clock for both vehicles. The force of this impact displaced both vehicles approximately 3.7 m (12.0 ft) to the southwest. At final rest, the front plane of the Ford Windstar was engaged against the front plane of the Ford F150 (**Figure 6**).

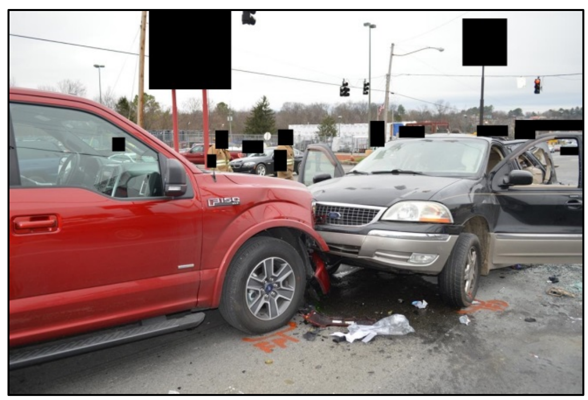


Figure 6: On-scene police image depicting the final rest positions of the Ford F-150 and Ford Windstar.

The Kia separated from the Ford Windstar with a forward and slightly right trajectory. It slid to rest in the center of the intersection facing southwest, in the left through lane. The final rest position was approximately 25.3 m (85.0 ft) southwest of the point of impact.

Reconstruction of the crash calculated through the use of the WinSMASH program produced results that were considered too high based on SCI field experience. These high results were probably due to the severity of the crash, the age of the vehicle, and the limited stiffness data available for the back plane of the Ford Windstar relative to the depth of crush. The total calculated velocity change (delta-V) of the Kia was 122 km/h (76 mph). The calculated barrier equivalent speed (BES) was 60 km/h (37 mph). Based on SCI field experience, the magnitude of the BES value was more consistent with the Kia's damage. The total calculated velocity change (delta-V) of the Ford was 100 km/h (62 mph) and the BES was 138 km/h (86 mph). Conservation-of-momentum calculations estimated that the delta-V of the Ford was approximately 64 to 72 km/h (40 to 45 mph). Based on field experience, the momentum-based delta-V appeared to be more a representative estimate.

Post-Crash

Immediately following the crash, numerous cellular calls were placed to the emergency response system. Firefighters, police and emergency medical personnel were dispatched to the crash site. The first responders initially conducted an assessment of the crash site and requested ambulance and helicopter transport for the injured. The driver and front row right occupant of the Kia remained conscious and coherent. The driver of the Kia stated to one of the firefighters that "something happened to her car, she couldn't control it." Another firefighter observed a pooling of blood on the front left floor mat of Kia and lifted the right pant leg of the driver. He observed an open fracture of her right lower extremity and entrapment of her lower legs under the instrument panel. Firefighters used hydraulic equipment and cut the left A-pillar at the beltline, and then placed a hydraulic ram between the A- and lower B-pillars to lift the left instrument panel forward and upward. To provide additional clearance, the seatback was cut away from the seat cushion. Also, a strap was used to pull the brake pedal laterally left to provide clearance for her lower extremities. The driver's seat belt webbing was cut at the D-ring. The driver was removed from the vehicle, placed on a backboard, and transported from the crash scene to a local hospital. She was then airlifted by helicopter to a regional trauma center, where she underwent surgical repair of her injuries. The driver ultimately succumbed to her injuries one day after the crash. The front row right occupant of the Kia was removed from the vehicle and transported by ambulance to an awaiting helicopter for transport to a regional trauma center. She sustained police-reported C-level (possible) injuries.

An assessment of the Ford's occupants by EMS determined that the two second-row 7-year-old male occupants were in critical condition. The seat belts that restrained each child were cut and both children were removed from their respective booster seats. The child seated in the second row left position was pronounced deceased at the crash scene. The child in the second row right position was transported by helicopter and admitted to a regional trauma center. Medical intervention to treat his injuries was unsuccessful and he died at the hospital two days post-crash. The driver and front row right occupant of the Ford Windstar were assisted from the vehicle and transported by ambulance with police-reported C-level (possible) injuries. None of the occupants in the Ford F-150 were injured.

2008 KIA OPTIMA

Description

Figure 7: Front view of the Kia Optima.

The 2008 Kia Optima (**Figure 7**) was a four-door sedan equipped with the EX trim package. It was identified by Vehicle Identification Number (VIN): KNAGE123885xxxxxx and was manufactured in Korea in February 2008. The front-wheel drive unibody platform had a 272 cm (107.1 in) wheelbase. The Kia was powered by a transverse-mounted 2.4 liter I-4 gasoline engine that was linked to a 5-speed automatic transmission. Its gross vehicle weight rating (GVWR) was 1,930 kg (4,255 lb), with specific gross axle weight ratings (GAWR) of 1,120 kg (2,469 lb) front and 1,020 kg (2,249 lb) rear. The Kia's curb weight was 1,422 kg (3,135 lb). Its service brakes were four-wheel discs with antilock brakes (ABS). The vehicle manufacturer's recommended tire size was P205/60R16 with cold tire pressure of 221 kPa (32 PSI) for all four axle positions. At the time of the crash, the Kia was equipped with Goodyear Eagle all-season radial tires of the recommended size.

The interior of the Kia was configured for the seating of up to five occupants, with front bucket seats and a split-bench second row seat that had a fold-down center armrest. The front row seats were separated by a fixed center console that contained the transmission shifter and the parking brake lever. All five seat positions were configured with adjustable head restraints. Both front head restraints were adjusted 3 cm (1.2 in) above the seatbacks, while the second row head restraints were all in their full-down positions. All seating surfaces were leather-trimmed. Two aftermarket seat or backrest cushions were found in the vehicle during the SCI investigation. The specific positioning of these cushions at the time of the crash remains unknown. Manual safety systems consisted of 3-point lap and shoulder seat belts for all five positions, with the front row retractors equipped with pretensioners. The front D-rings were adjusted to their full-down positions. Supplemental restraint systems consisted of certified advanced 208-compliant (CAC) dual-stage frontal air bags, front seat-mounted side impact air bags, and roof side rail-mounted side impact inflatable curtain (IC) air bags. Crash forces resulted in the deployment of only the frontal air bags.

History

The driver of the 2008 Kia purchased the vehicle new in July 2008. At the time of purchase, the odometer reading was 478 km (297 mi). The service history documented through a vehicle history report during the seven year, five month period of ownership consisted of routine oil and filter changes at frequent intervals by the manufacturer's dealership. The vehicle's radio was replaced twice, once in 2010 and again in 2011. There was no other noted service. The last entry recorded on the history record was this air bag deployment crash.

NHTSA Recalls and Investigations

A VIN-specific search of recalls for the 2008 Kia Optima was made in November 2017 using the NHTSA website www.safercar.gov. There were no active recalls or investigations pertaining to this 2008 Kia Optima.

Exterior Damage

The combined width of the direct and induced damage to the Kia was distributed across the entire 152 cm (59.8 in) width of the front plane. The damage pattern was consistent with the in-line front-to-rear impact configuration (**Figure 8**). As the front plane crushed rearward, the hood buckled, tented upward, and was displaced into the windshield. The laminated windshield was fractured across its entire width. Both front fenders were crushed rearward into the lower A-pillars. The maximum extent of the direct contact between the vehicles was located at the left lower A-pillar, 30 cm (11.8 in) aft of the left front axle, due to the crush and overlapping engagement of the Kia with the Ford Windstar. Both of the Kia's front axle positions were displaced rearward and restricted, such that the left wheel base was reduced 13 cm (5.1 in) (**Figure 9**) and the right wheelbase was reduced 8 cm (3.1 in). Residual crush accounting for free space was measured along the front bumper reinforcement by Nikon Total Station using a Field-L of 115 cm (45.2 in). The crush profile was as follows: C1 = 30 cm (11.8 in), C2 = 51 cm (20.0 in), C3 = 57 cm (22.4 in), C4 = 60 cm (23.6 in), C5 = 48 cm (18.9 in), C6 = 34 cm (13.4 in). The maximum crush was located 15 cm (5.9 in) right of center at C4. The Collision Deformation Classification (CDC) for this event was 12FDEW3.

Figure 8: Overhead view depicting the frontal crush of the Kia. The horizontal tape measure represents the original length of the vehicle.

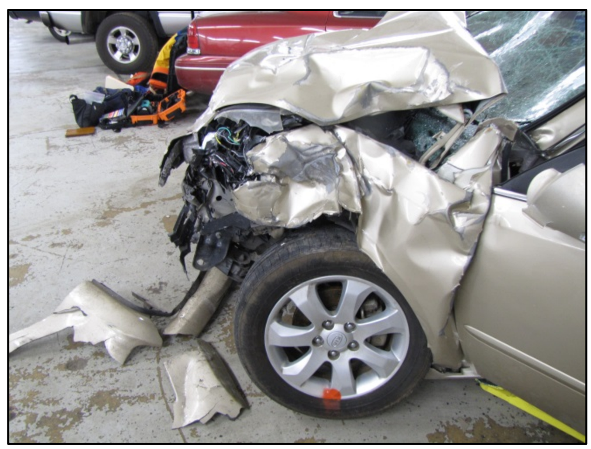


Figure 9: Left lateral view depiting the extent of crush to the Kia.

A borderline reconstruction of the crash was calculated using the WinSMASH program. The results were considered high, due to the severity of the crash and the limited stiffness data available for the back plane of the Ford Windstar relative to the depth of crush. The total calculated velocity change (delta-V) of the Kia was 128 km/h (80 mph). The calculated BES was 61 km/h (38 mph).

Based on SCI field experience, the magnitude of the BES value was more consistent with the Kia's damage.

Brake Light Bulbs

An assessment of the Kia's brake light bulbs was conducted during the joint SCI/Kia vehicle inspection. The bulbs were double filament bulbs with one filament used for taillights and turn signal and the other filament used for brake lights (**Figure 10**). The straight filament in the image was the brake light filament. The curve in the taillight filament was a natural curve from its manufacture. Both filaments were intact post-crash. If the brake light filament was illuminated at crash, the incandescent filament probably would have stretched and/or fractured due to the sudden deceleration produced by the impact. Since the filament was intact, it was determined that the brake lights were not on pre-crash and that the driver was not applying the brakes in an attempt to slow the Kia. This determination was consistent with the observations of the video surveillance footage. Additionally, the brake rotors did not appear scorched or heat stressed based on a limited visual inspection. The rotors only exhibited surface rust, consistent with the vehicle's storage since the time of the crash. The tires were not removed during the inspection.

Figure 10: Image depicting the condition of the brake light filaments in the Kia.

Event Data Recorder

Due to its age, the 2008 Kia Optima was not equipped with an EDR that met the requirements of the United States Code of Federal Regulations Title 49 Part 563. The Kia's manufacturer did not begin equipping its vehicles with EDRs until the 2012 model year, and associated crash data for those EDRs is only accessible through the use of a global diagnostic systems vehicle communication interface (GDS VCI). The GDS VCI is a software-driven scan tool manufactured by GTI Inc. in cooperation with the Kia's manufacturer.

However, the air bag control module (ACM) in the 2008 Kia Optima did have the capability to record a data set that consisted of current and historical diagnostic trouble codes (DTCs), as well as a limited set of crash data. At NHTSA's request, the ACM was queried by the manufacturer representative participating in the inspection with a proprietary GTI scan tool to retrieve any available data.

The scan tool was connected to the vehicle's communication bus through the diagnostic link connector (DLC) that was located adjacent to the interior fuse panel at the lower left instrument panel. Electrical power (12-volt) was supplied through the fuse panel to vehicle's instrument panel, ACM, and scan tool via a portable battery pack. The application of electrical power allowed for communication with the ACM and retrieval of the stored DTC's.

The recorded data indicated that there were no historical trouble codes. The current DTC's all related to the state of deployed/actuated frontal air bags and pretensioners. There was no other additional data related to the crash. Images of the retrieved data are included at end of this technical report as Attachment A.

Interior Damage

The Kia's interior damage (**Figure 11**) consisted of component intrusion associated with the exterior force of the crash, the deployment of the frontal air bags, and interior contact associated with occupant motion. The maximum intrusion was located at the left toe pan and floor, with associated intrusion of the foot controls. It should be noted that the intrusion of the left instrument panel was altered post-crash by rescue personnel, as a hydraulic ram was used to push the lower A-pillar and instrument panel forward to extricate the driver from the Kia.

Based on exemplar measurements, the longitudinal intrusion of the toe pan measured 13 cm (5.1 in) at the left aspect, 10 cm (3.9 in) along the centerline of the brake pedal, and 7 cm (2.8 in) adjacent to the accelerator pedal. The lateral width of the foot well was unchanged at 53 cm (20.8 in). The floor was buckled and intruded vertically adjacent to the accelerator. The toe of the accelerator pedal was trapped by contact with the floor. Refer to the *Foot Control Section* of this report below for further detail. The longitudinal intrusion of the right toe pan measured 10 cm (4.1 in).

Figure 11: Image depicting the condition of the Kia's interior at the time of the SCI inspection.

Figure 12: Interior image of the Kia depicting the contacts to the driver bolster.

The 8-way powered driver seat was adjusted to a mid-to-rear track position that measured 6 cm (2.5 in) forward of full rear. Although restrained by the 3-point lap and shoulder seat belt, the driver slid forward on the seat cushion and loaded the deployed driver air bag with her chest. This contact and loading also deformed the lower aspect of the steering wheel rim forward approximately 1 cm (0.5 in). The driver's left knee heavily loaded the left mid and lower instrument panel, 20 cm (7.9 in) left of the steering column (**Figure 12**).

The left instrument panel was also fractured and deformed to a residual depth of 3 cm (1.2 in). The driver's right knee engaged the right aspect of the lower instrument panel 23 cm (9 in) left of the vehicle's centerline, adjacent to the center console. This contact also fractured and deformed the plastic panel. Fabric transfers from the driver's pant legs were present at both knee contact locations.

The front row right occupant loaded the manual seat belt webbing and the deployed passenger's frontal air bag. Subtle frictional abrasions were present on the latch plate of the restraint system. There was no loading evidence on the air bag. Her lower extremities contacted the glove box door, with her right knee contact resulting in a scuff and fracture to the upper aspect of this component.

The police investigation performed at the time of the crash observed that the gauges of the Kia's combination meter (tachometer and speedometer) displayed elevated values. These gauges were still stuck in their respective positons at the time of the SCI inspection (**Figure 13**). The tachometer read approximately 4,300 RPM and the speedometer reading was approximately 148 km/h (92 mph). The displayed values were within the performance limits of the vehicle. The gauge displays of the combination meter operated via stepper motors. These stepper motors responded to the voltage changes transmitted from the engine and transmission sensors by the rotation of the display needles to the current performance values. At impact, the force of the collision suddenly removed the voltage source (the battery) from the communication loop. Absent this voltage to drive the stepper motors, the display needles were stuck at the approximate performance values that existed at the time of the impact. Possible error could be introduced into the displayed values through multiple sources, including wheel spin and transient voltage spikes. Although unconfirmed indicators of the Kia's speed and performance at impact, the gauge displays were in general agreement with the SCI crash reconstruction and the vehicle speed calculated from the surveillance video.


Figure 13: View of the tachometer and speedometer in the Kia at the time of the SCI inspection.

It was noted that during the process of imaging the Kia's diagnostic data that the status of the gauge displays changed. To image the vehicle, 12-volt power was applied through the fuse panel to the instrument panel and combination meter. This application of electrical power caused the stepper motors to reset the tachometer and speedometer gauges to zero. The police also observed during their on-scene investigation that the Kia's ignition key was turned to the Accessory Position and the transmission was in Neutral. It remains unknown if a first responder or tow operator changed the state of these controls post-crash or if driver action immediately prior to the impact was involved.

Floor Mats

Figure 14: Interior image of the floor mats in the driver compartment of the Kia.

The Kia was configured with OEM equipped carpeted floors with OEM carpeted floors mats in the front positions. The floor mats were secured in placed by the pins that were positioned at the aft area of the mats. An additional aftermarket vinyl floor mat was placed over the OEM floor mat of the Kia (**Figure 14**). This mat was compliant to form fit over the contour of the floor and toe pan. Numerous molded pins on the bottom side of the mat engaged the carpeted mat and held the aftermarket mat in place. At the time of the SCI inspection, this mat was firmly in place and did not interfere with the movement of the accelerator pedal. It was determined through the course of the post-crash inspection that the OEM and aftermarket mats did not play a role in this crash.

Accelerator Pedal

The Kia Optima used an electronic throttle control for powertrain management. Driver input was provided through the accelerator pedal that used a position sensor to control the throttle input. The accelerator pedal assembly consisted of a molded plastic arm, shaped in an S-pattern, which was attached to the position sensor. The position sensor was fastened to the toe pan such that the pedal was suspended. The position sensor was identified by the following number: DA20051A-3L100. Based on exemplar measurements, the static undamaged clearance between the toe of the accelerator pedal and the floor pan was 11 cm (4.2 in). When the pedal was fully depressed, the floor clearance reduced to 2 cm (0.8 in). The physical dimensions of the foot of the accelerator pedal measured 4 cm x 10 cm (1.6 in x 4.0 in), width by length. The offset distance between the accelerator and brake pedals measured 8 cm (3.3 in). The horizontal centerline of the brake pedal measured 19 cm (7.5 in) above the floor, while that of the accelerator pedal measured 17 cm (6.5 in).

The crash induced longitudinal intrusion of the toe pan and vertical intrusion of the floor pan that jammed the pedal (**Figure 15**). The upper curve of the arm was jammed by the toe pan. The toe of the pedal was jammed by the floor (**Figure 16**). The deformed toe pan also caused the accelerator assembly to rotate clockwise into near-contact with the center console. The gap between the accelerator and the center console measured 5 cm (2.0 in) in an exemplar vehicle.

Figure 15: Image depicting the brake and accelerator pedals of the Kia at the time of the SCI inspection.

Figure 16: Image depicting the post-impact jammed accelerator pedal of the Kia.

Manual Restraint Systems

The Kia was equipped with continuous loop 3-point lap and shoulder seat belt systems for all five seat positions. All of the seat belt systems used sliding latch plates. The driver's seat belt retracted onto an emergency locking retractor (ELR), while the front right and all three second row seat belts retracted onto switchable ELR/automatic locking retractors (ALR). Both front D-rings were adjusted to their respective lowest positions. Retractor pretensioners were incorporated into the front row seat belt systems, both of which actuated during the frontal crash event.

The driver was restrained by the manual seat belt system. Restraint usage was determined from frictional abrasions on the polymer surface of the latch plate. The seat belt webbing was minimally abraded at the area of the latch plate and D-ring. Rescue personnel cut the webbing at the level of the D-ring during the extrication of the driver. The front right seat belt exhibited similar loading evidence to that of the driver's system, thus supporting the belted status of the front row right occupant at the time of the crash. The passenger belt webbing was also cut by rescue personnel during the in-vehicle evaluation of her status and prior to her removal from the Kia.

Supplemental Restraint Systems

The Kia was equipped with the CAC dual-stage frontal air bags for the driver and front right passenger positions, front seat-mounted side impact air bags, and the side impact-sensing IC air bags. In addition to the frontal air bags, the CAC system used a front right occupant weight sensor, seat belt buckle switch sensors, seat-track positioning sensors, and front row retractor pretensioners. The severe crash force deployed the frontal air bags and actuated the retractor pretensioners, locking the retractors in their respective at-crash positions. The seat-mounted side impact and IC air bags were not commanded to deploy in this front plane crash, which had a direction of impact force in the 12 o'clock sector.

The driver's frontal air bag deployed through the I-configuration module cover flaps from the OEM module that was mounted to the hub of the four-spoke steering wheel. It was tethered internally and directly vented into the occupant compartment through two ports located on the back side of the air bag. Although the driver loaded the air bag during the crash with her face and torso, there was no specific occupant contact visible on the air bag. However, two small blood stains were present on the air bag at the 3 o'clock position. There was no inflation or crash related damage to the air bag.

The passenger's air bag deployed from the top instrument panel-mounted module, which was concealed by a single cover flap hinged at its forward aspect. The leading edge of the module engaged the windshield. Similar to the driver, it was presumed based on crash severity and position of the front right seat track that the front row right occupant engaged the deployed air bag with her face, torso, and upper extremities. However, there was no contact evidence to support this contact, and no damage to the air bag had occurred. The front right air bag was tethered, and vented through a large port on the right lateral aspect of the air bag.

2008 KIA OPTIMA OCCUPANTS

Driver Demographics

Age/Sex:	83 years / Female
Height:	160 cm (63 in)
Weight:	63 kg (140 lb)
Eyewear:	Unknown
Seat Type:	Forward-facing bucket seat with adjustable head restraint
Seat Track Position:	Mid-to rear 6 cm (2.5 in) forward of full rear
Manual Restraint Usage:	3-point lap and shoulder seat belt
Usage Source:	Vehicle inspection
Air Bags:	CAC frontal deployed, Front seat-mounted side impact and IC air bags not deployed
Alcohol/Drug Involvement:	None
Egress From Vehicle:	Extricated from vehicle by emergency response personnel
Transport From Scene:	Ambulance to a local hospital, then transferred by helicopter to a Level 1 regional trauma center
Type of Medical Treatment:	Admitted to the trauma center, died 1 day post-crash

Driver Injuries

Injury No.	Injury	AIS 2015	Injury Source	Confidence
1	Bilateral rib fractures, Right: 1-4, Left: 1, 2, 4-8	450203.3	Seat belt/Steering wheel/column	Certain
2	Right pneumothorax	442202.2	Seat belt/Steering wheel/column	Certain
3	Left pneumothorax	442202.2	Seat belt/Steering wheel/column	Certain
4	C6 transverse process fracture	650220.1	Seat belt webbing	Probable

Injury No.	Injury	AIS 2015	Injury Source	Confidence
5	C7 transverse process fracture	650220.1	Seat belt webbing	Probable
6	Two spleen lacerations, Grade 1; 2.1 cm and 1.5 cm	544222.2	Seat belt webbing	Certain
7	Open distal left femur fracture, Type II, severely comminuted	853332.3	Left lower instrument panel	Certain
8	Type III open distal right tibia fracture at ankle	854332.3	Toe an	Probable
9	Open right fibula fracture at ankle	854462.2	Toe pan	Probable
10	Periprosthetic fracture of the proximal right tibia	854111.2	Left lower instrument panel	Certain
11	Hemorrhage in left thyroid gland	341402.1	Seat belt webbing	Certain
12	Neck contusion, left side	310402.1	Seat belt webbing	Certain

Source – Level 1 Regional Trauma Center Medical Records

Driver Kinematics

The driver of the Kia was seated in an upright driving posture with the seat adjusted to a mid-to-rear track position. The position of the seatback remains unknown due to post-crash damage by rescue personnel. As found during the vehicle inspection, the adjustable head restraint was positioned 3 cm (1.2 in) above the seatback. An aftermarket seat cushion and a wedge-shaped lumbar support cushion were found in the vehicle during the SCI inspection. These may have been used by the driver at the time of the crash. The driver was restrained by the manual seat belt system. Belt usage was determined from frictional abrasions on the latch plate and seat belt webbing caused by driver loading, the locked status of the webbing due to pretensioner actuation, and the buckled status of the latch plate following driver extrication. The pre-crash positioning of the driver's lower extremities remains unknown; however, it is presumed that her right foot was firmly and inadvertently depressing the accelerator pedal. There was no evidence of pre-crash braking.

At impact with the back plane of the stopped Ford Windstar, the Kia sustained a longitudinal impact force and underwent severe crash forces that actuated the front retractor pretensioners and deployed the frontal air bags. The driver responded to the crash force with a forward trajectory. Due to the probable use of the aftermarket seat cushion, the driver's pelvic region slid forward on the seat cushion as she partially submarined and then loaded the seat belt system with her torso evidenced by the frictional abrasions on the latch plate and belt webbing. The loading of the seat belt webbing resulted in the soft tissue injury to the neck, the thyroid and the spleen.

During this forward trajectory, her chest contacted and loaded the deployed frontal air bag. Due to the magnitude of the crash force, the driver loaded through the air bag and engaged the steering assembly. Her loading of the steering assembly resulted in multiple rib fractures and the bilateral pneumothorax. The driver's left knee and lower leg engaged the lower instrument panel with sufficient force to deflect forward and fracture the plastic panels. Blood and fabric transfers were present on the fractured components. This contact caused fracture of the left femur. Her right knee and lower leg contacted the lower instrument panel right of the steering column, adjacent to the to the center console. This contact fractured the plastic panel and compressed it forward. A large fabric transfer also surrounded the contact area. This contact resulted in fracture of the proximal right tibia. The intruding toe pan was the probable involved component contributing to the fracture of the distal right tibia and fibula at the ankle.

The driver came to rest with her lower legs captured and entrapped beneath the lower instrument panel. Her upper body remained on the seat and positioned in the seat belt. The first arriving firefighter assessed the condition of the driver, and observed that she was conscious and communicative. He then observed a large pool of blood on the aftermarket vinyl floor mat and reached in to lift the driver's right pant leg. At that point, he identified an open fracture of the driver's right lower leg. Due to the entrapment of her lower extremities, firefighters used hydraulic rescue equipment to extricate the driver from the Kia. She was placed on a backboard and transported by ambulance to a local hospital. Due to her condition she was immediately transferred to an awaiting helicopter for air transport to a regional trauma center and was admitted. Multiple procedures ensued to stabilize her condition and surgically repair the multiple fractures. The driver become hypotensive and required mechanical life support. Her medical condition deteriorated and she succumbed to her injuries one day after the crash. Her cause of death was listed as cardiopulmonary arrest.

Front Row Right Occupant Demographics

Age/Sex:	75 years / Female
Height:	150 cm (59 in)
Weight:	69 kg (153 lb)
Eyewear:	Unknown
Seat Type:	Forward-facing bucket seat with adjustable head restraint
Seat Track Position:	Mid-to-rear track
Manual Restraint Usage:	3-point lap and shoulder seat belt
Usage Source:	Vehicle inspection
Air Bags:	CAC frontal deployed, Seat-mounted side impact and IC air bags not deployed
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Removed from vehicle by EMS
Transport from Scene:	Ambulance to a local hospital and transferred by helicopter to a regional trauma center
Type of Medical Treatment:	Admitted, length of stay unknown

Front Row Right Occupant Injuries

Injury No.	Injury	AIS 2015	Injury Source	Confidence
1	Unknown right lower extremity injuries, NFS	800099.9	Lower right instrument panel	Probable
2	Unknown left lower extremity injuries, NFS	800099.9	Lower right instrument panel	Probable

Source – Investigating Police Officer. Medical record request denied.

Front Row Right Occupant Kinematics

The front row right occupant was seated in a rear track position with the seatback reclined to a measured angle of 10 degrees aft of vertical. The adjustable head restraint was positioned 3 cm (1.2 in) above the seatback. In this adjusted position, the mid aspect of the seatback was 79 cm (31.1 in) rearward of the instrument panel. The front row right occupant was restrained by the manual seat belt system, evidenced by subtle frictional abrasions on the polymer surface of the latch plate.

At impact with the back plane of the Ford Windstar, the retractor pretensioner actuated and the passenger's frontal air bag deployed. The occupant initiated a forward trajectory in response to the 12 o'clock direction of impact force. She loaded the seat belt webbing and the deployed air bag. Her knees and lower extremities contacted the glove box door, which deformed and fractured the top right aspect of this component. The front row right occupant sustained unspecified lower extremity injuries.

Rescue personnel assessed her condition, cut the seat belt webbing, and removed her from the vehicle. She was transported by ambulance to a local hospital, transferred to an awaiting helicopter, and transported to a regional trauma center where she was admitted for treatment. Specifics concerning the front row right occupant's injuries remain unknown due to a lack of cooperation by the treating medical facility.

2003 FORD WINDSTAR

Description

The 2003 Ford Windstar (**Figure 17**) was a seven-passenger minivan identified by the VIN: 2FMZA53443Bxxxxxx. The Ford was manufactured in May 2003 and was equipped with the SEL trim package. The digital odometer read 294,507 km (182,998 miles). The body was configured on a 307 cm (121.0 in) wheelbase and had hinged front doors, second row sliding doors and a rear lift gate. The front wheel drive platform was powered by a 3.8 liter gasoline engine that was linked to a 4-speed automatic transmission with a steering column-mounted shifter. The service brakes were power-assisted front disc/rear drum with ABS. The GVWR was placarded at 2,549 kg (5,620 lb), with axle ratings of 1,315 kb (2,900 lb) front and 1,251 kg (2,760 lb rear). The curb weight was 1,761 kg (2,882 lb).

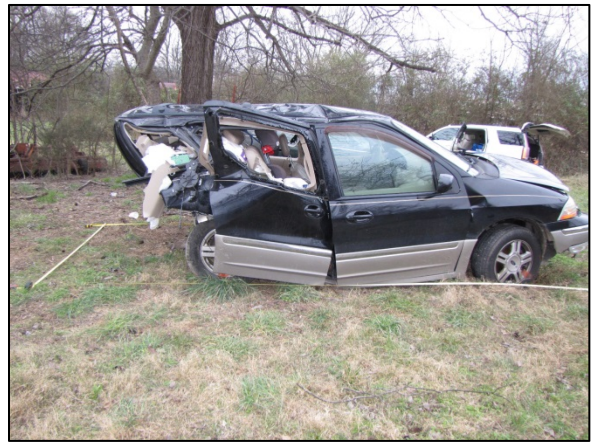


Figure 17: Right side view of the Ford Windstar depicting the back plane damage.

The interior was configured with three rows of leather-surfaced seats. The front seats were bucket seats with reclining seatbacks and adjustable head restraints, while the second row was equipped with forward-facing captain chairs. Specifics of the third row seating and cargo area could not be determined during inspection due to the rear plane deformation and compression associated with the impact. Manual restraint systems consisted of 3-point lap and shoulder seat belts for all seat positions. Both front seat belts were equipped with pretensioners. Supplemental restraints consisted of driver and front row right air bags. No safety systems were commanded to deploy during the crash.

Exterior Damage

The Ford sustained impact damage to its front and rear planes, consistent with the events of the crash. Direct contact and induced damage to the vehicle's back plane extended across the entire 152 cm (59.8 in) end-width (**Figure 18**). The force of the Event 1 impact compressed the rear structure forward to the rear axle and C-pillars. As a result, the cargo area was completely collapsed, with intrusion through the third and into the second rows of the occupant compartment. The left and right wheelbase dimensions of the Ford Windstar were reduced 18 cm (7.1 in) and 34 cm (13.4 in), respectively. Residual crush was documented along the rear bumper reinforcement with a Field-L of

Figure 18: Image depicting the damage to the back plane of the Ford Windstar.

122 cm (48.0 in) as follows: C1 = 105 cm (41.3 in), C2 = 145 cm (57.1 in), C3 = 149 cm (58.7 in), C4 = 142 cm (55.9 in), C5 = 142 cm (55.9 in), C6 = 134 cm (52.8 in). The CDC assigned to this damage pattern was 06BDEW5.

Reconstruction of the crash calculated through the use of the WinSMASH program produced results that were considered too high based on SCI field experience. These high results were probably due to the severity of the crash, the age of the vehicle, and the limited stiffness data available for the back plane of the Ford Windstar relative to the depth of crush. The total calculated velocity change (delta-V) of the Ford was 104 km/h (65 mph) and the BES)was 144 km/h (89 mph). Conservation-of-momentum calculations estimated that the delta-V of the Ford was approximately 64 to 72 km/h (40 to 45 mph).

The Event 2 impact damage to the Ford was located at the right and center aspects of the vehicle's front plane (**Figure 19**). The direct contact damage began at the centerline and extended 76 cm (30 in) to the right. The impact force was absorbed and managed by the bumper reinforcement. The fascia and foam absorber were fractured in the damaged region. The residual crush profile measured along the front bumper was: C1 – C3= 0, C4 = 1 cm (0.4 in), C5 = 5 cm (2.1 in), C6 = 1 cm (0.5 in). The CDC assigned to this pattern was 12FZEW1. Using the WinSMASH program, the calculated delta-V of the Ford Windstar for the Event 2 impact with the Ford F150 was 17 km/h (11 mph). Longitudinal and lateral components of the calculated delta-V were -17 km/h (-11 mph) and zero, respectively.

Figure 19: Front view of the Ford Windstar depicting the impact damage.

Event Data Recorder

The Ford Windstar was equipped with a restraint control module (RCM) that controlled the diagnostic, sensing and control functions for the vehicle's supplement restraint systems. The RCM also had EDR capabilities. The module was located on the centerline of the vehicle under the center instrument stack. The EDR was imaged during the SCI inspection using the Bosch crash data retrieval scan tool and software version 16.2.1 via a hardware connection to the diagnostic link connector. External 12-volt power was applied to the vehicle's battery and the Ford's electrical system was energized. The imaged data was reported using software version 17.6.1, and is included at the end of this report as **Attachment B**.

A review of the imaged data indicated that one non-deployment event had been recorded. The recorded data set only provided limited parameters. This EDR did not provide an ignition cycle counter. There was no acceleration or delta-V information. The driver and front passenger seat belts were reported as "Unbuckled" and the passenger classification status was "Undefined." While it was possible that the recorded event was related to the frontal impact Event 2, given the age of the Ford it was probable that this data may have actually occurred earlier in its history. This EDR did not have the capability to record any associated pre-crash data. The sensors of the RCM were designed primarily for the detecting frontal impacts; therefore, recording of crash data in a rear impact event (Event 1) would not be expected.

Occupant Data

The 48-year-old restrained male driver and 45-year-old restrained female passenger sustained police-reported incapacitating (A-level) injuries. Both were non-responsive upon the arrival of emergency response personnel. They were removed from the vehicle and transported by ambulances to a local hospital for examination and treatment.

The two 7-year-old males secured in booster seats in the vehicle's second row both sustained life-threatening internal injuries due to the force of the impact and resultant intrusion. The male in the second row left position was seated in a Harmony Youth Low-Back Booster CRS that was manufactured in April 2012. This occupant was removed from the CRS and vehicle by medical personnel, who immediately began cardiopulmonary resuscitation. Their efforts were unsuccessful, and the second row left occupant of the Ford Windstar was pronounced deceased at the crash scene. The male in the second row right position was seated in a Graco Turbobooster High Back CRS, which was manufactured in September 2012. This occupant was removed from the CRS and vehicle and transported by helicopter to a regional trauma center. Although he was admitted for treatment, he succumbed to his injuries the day after the crash.

2015 FORD F150 PICKUP

Description

The 2015 Ford F-150 was a four-door pickup truck with the Supercrew cab configuration, identified by the VIN: 1FTEW1CP6FKxxxxxx. It was manufactured in October 2015. The body-on-frame design was built on a 368 cm (145.0 in) wheelbase. The drive train consisted of a 3.5 liter V-6 gasoline engine that was linked to a 6-speed automatic transmission with rear wheel drive. The GVWR was 2,835 kg (6,250 lb), with GAWR of 1,429 kg (3,150 lb) front and 1,497 kg (3,300 lb) rear. The curb weight was 2,024 kg (4,462 lb). Service brakes were power-assisted four-wheel disc with ABS. Additional systems included traction control, electronic stability control, and a tire pressure monitoring system for the OEM P265/60R18 tires. The interior of the Ford F-150 was configured for the seating of up to five occupants, with front bucket seats separated by a center console and a second row bench seat. Safety systems included 3-point lap and shoulder seat belts for all seat positions, CAC frontal air bags for the driver and front row right occupant positions, front seat-mounted side impact air bags, and dual-sensing (side impact and rollover) IC air bags.

Exterior Damage

The front plane of the Ford F-150 sustained minor severity damage from its Event 2 impact with the Ford Windstar (**Figure 20**). Direct contact damage began 8 cm (3.1 in) right of center and extended 48 cm (18.9 in) to the right. Induced damage also began 8 cm (3.1 in) right of center, and extended to the front right corner. Damage was limited to the front bumper, grille, right headlamp, and surrounding trim. A residual crush profile documented at bumper level across the end-width of 188 cm (74.0 in) included: C1 – C2 = 0, C3 = 1 cm (0.4 in), C4 = 4 cm (1.6 in), C5 = 5 cm (2.0 in), C6 = 0 cm. The CDC for this damage pattern was 12FZEW1. The delta-V calculated by the damage algorithm of the WinSMASH program was 15 km/h (9 mph), with longitudinal and lateral components of -15 km/h (-9 mph) and zero, respectively.

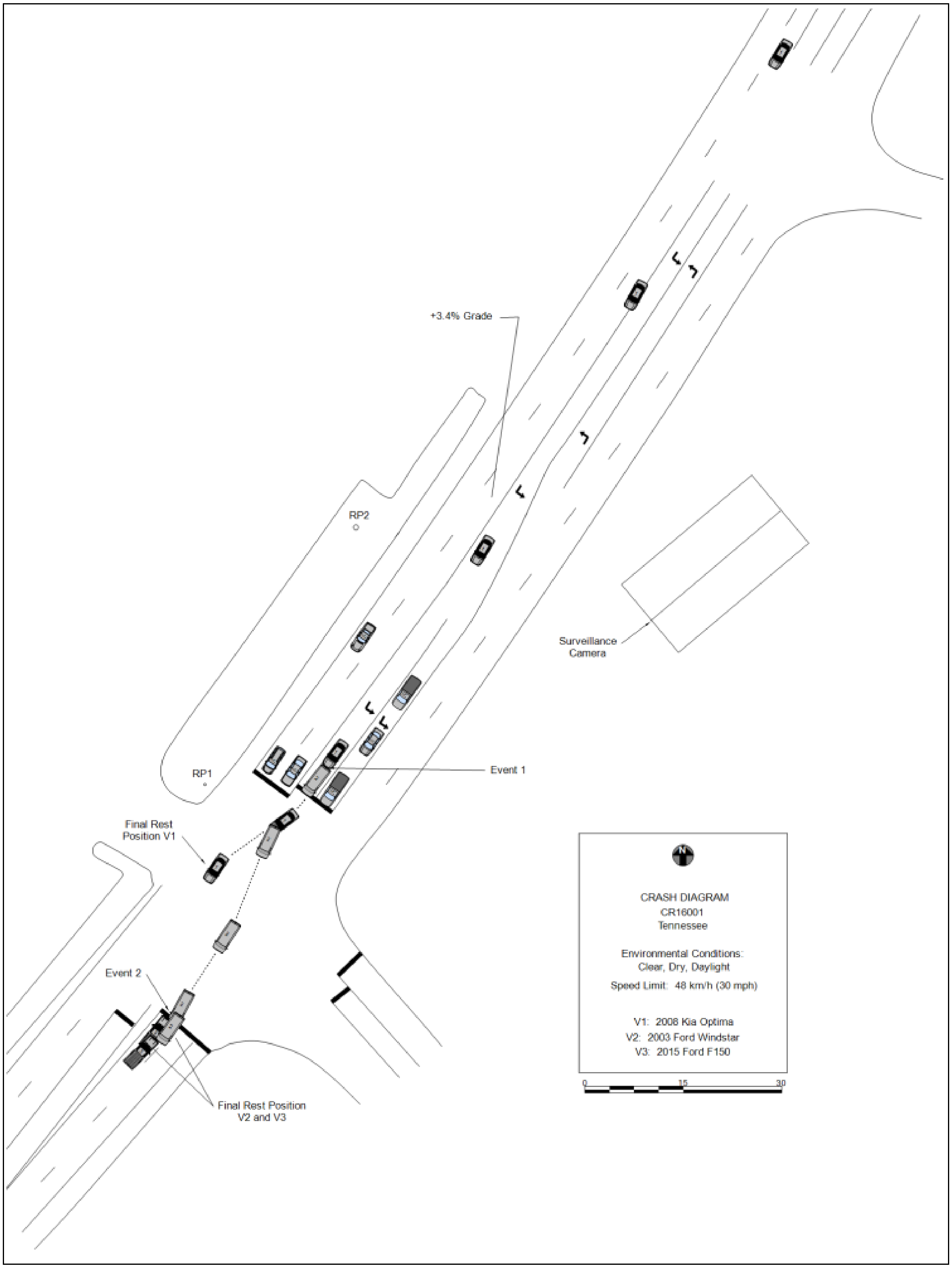
Figure 20: Front view of the 2015 Ford F150 depicting the impact damage.

The Ford was equipped with an EDR; however, attempts to image the data from the vehicle's electrical buss were unsuccessful. A hardware cable for direct-to-module imaging was not available at the time of the SCI inspection.

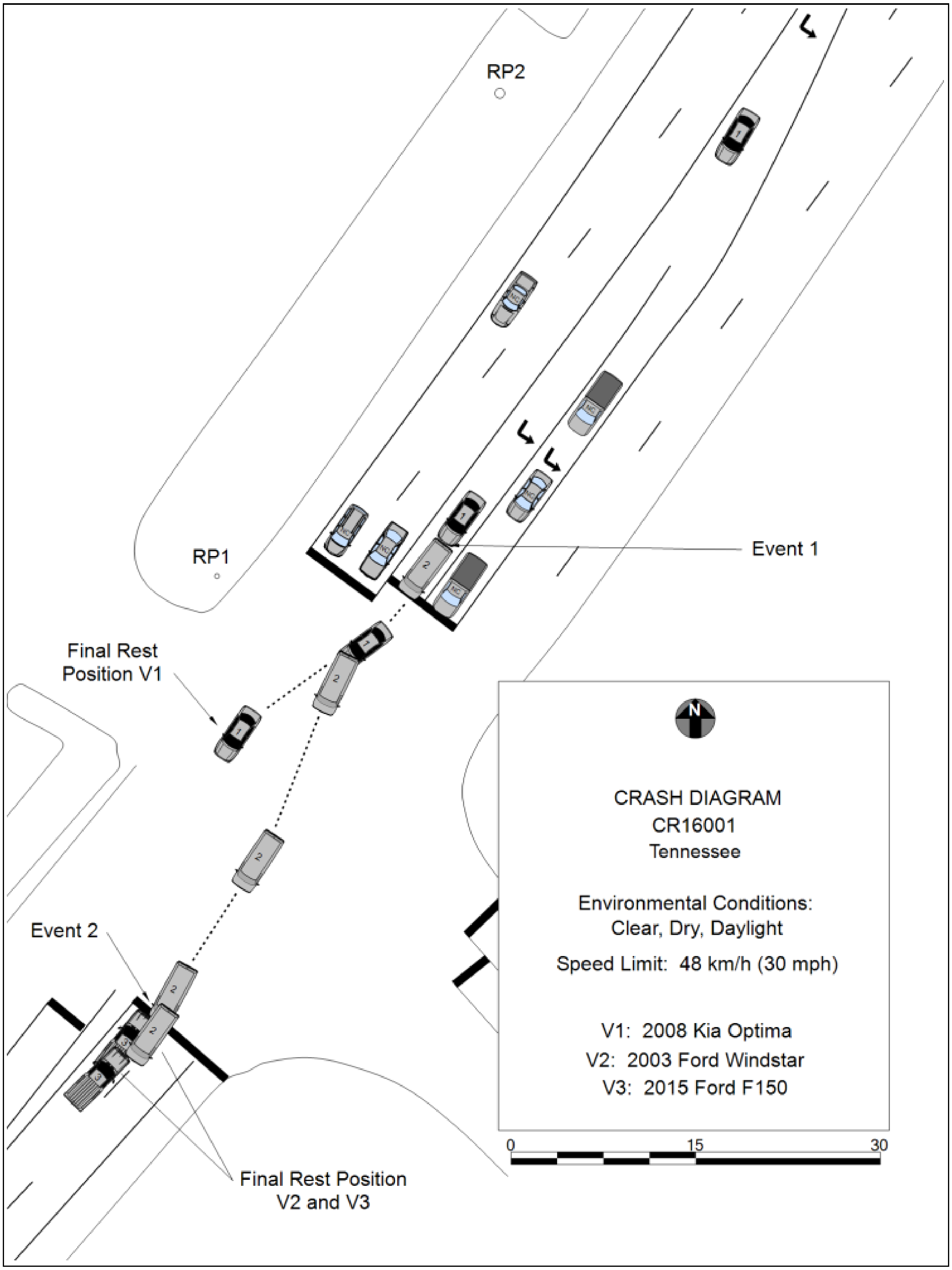
Occupant Data

The 2015 Ford F-150 was driven by a 67-year-old male and occupied by a 73-year-old male in the front row right position. Both occupants were police-reported as restrained by the 3-point lap and shoulder belt systems during the crash. Neither occupant was injured as a result of the crash.

CRASH DIAGRAM

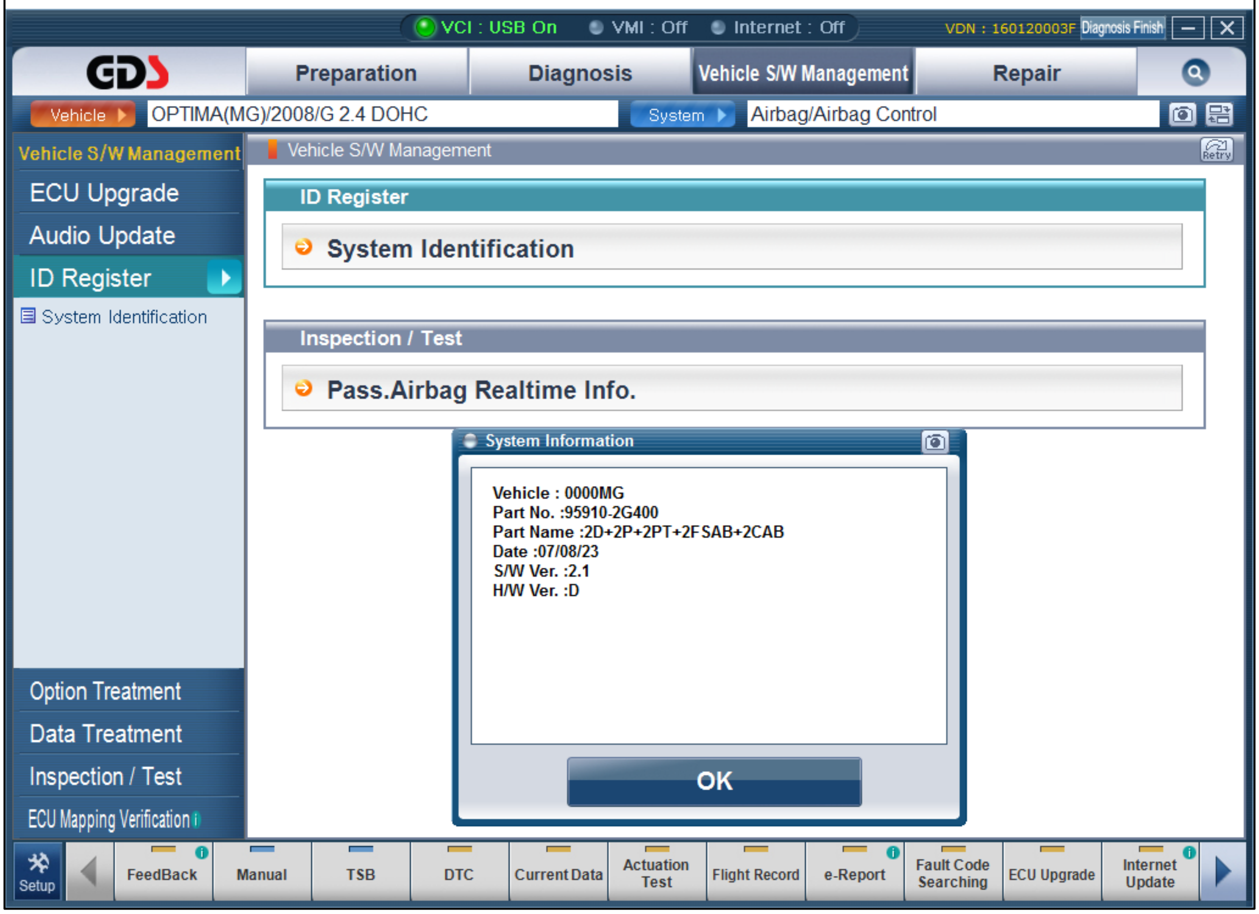


CRASH DIAGRAM – DETAILED VIEW



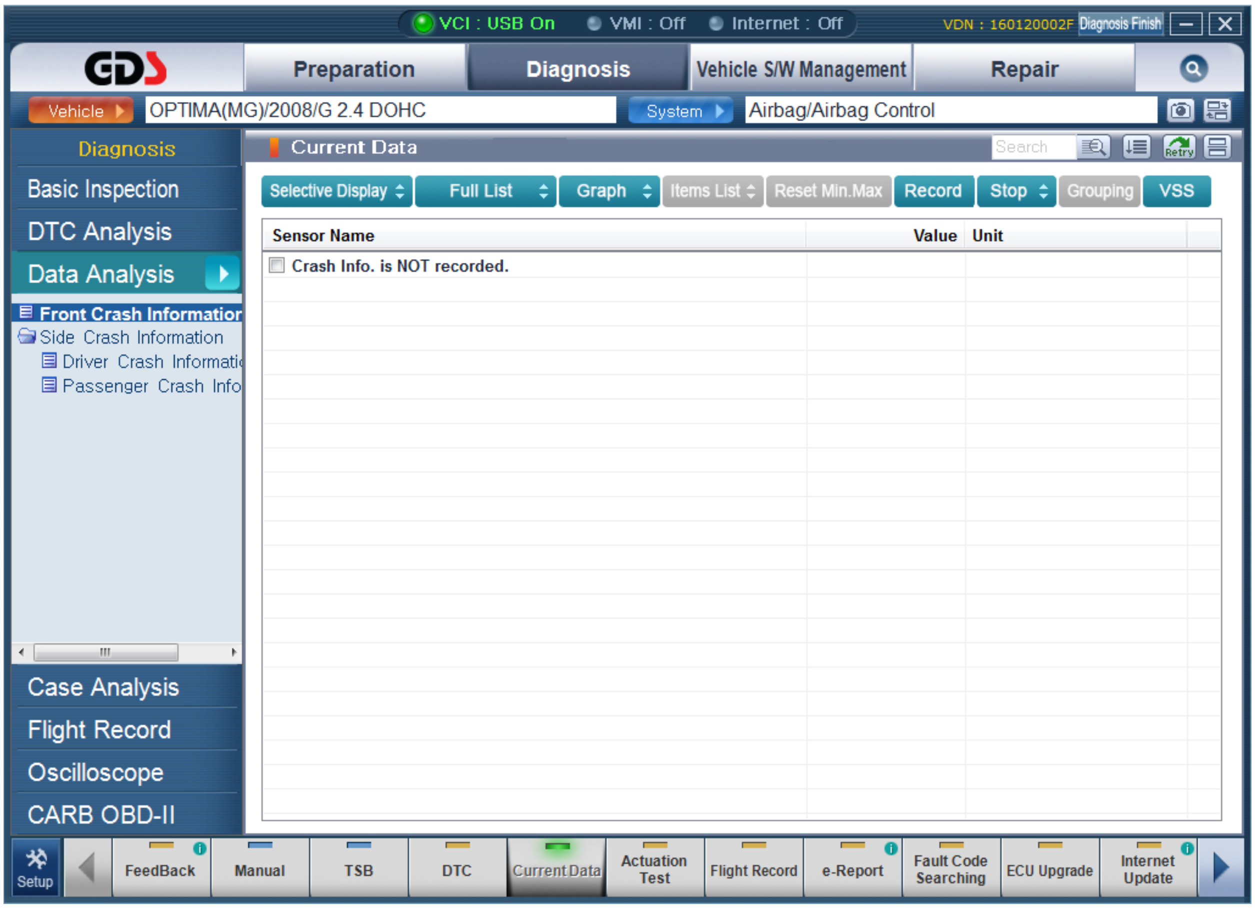
Appendix A
2008 Kia Optima Air Bag Control Module Diagnostic Data

VIN	KNAGE12388[redacted]		
Maker	Kia Motor Company	Vehicle	OPTIMA(MG)
Model Year	2008	Engine Type	G 2.4 DOHC
System	Airbag/Airbag Control	Date Time	01/20/2016 11:41:28
Software Version	N-K-01-15-0019	Content Version	N-K-01-15-0019
ECU Upgrade Version	N-K-01-15-0019	VCI Version	2.19
Dealer	GT200	Name	
Tel.		e-mail	
Address			

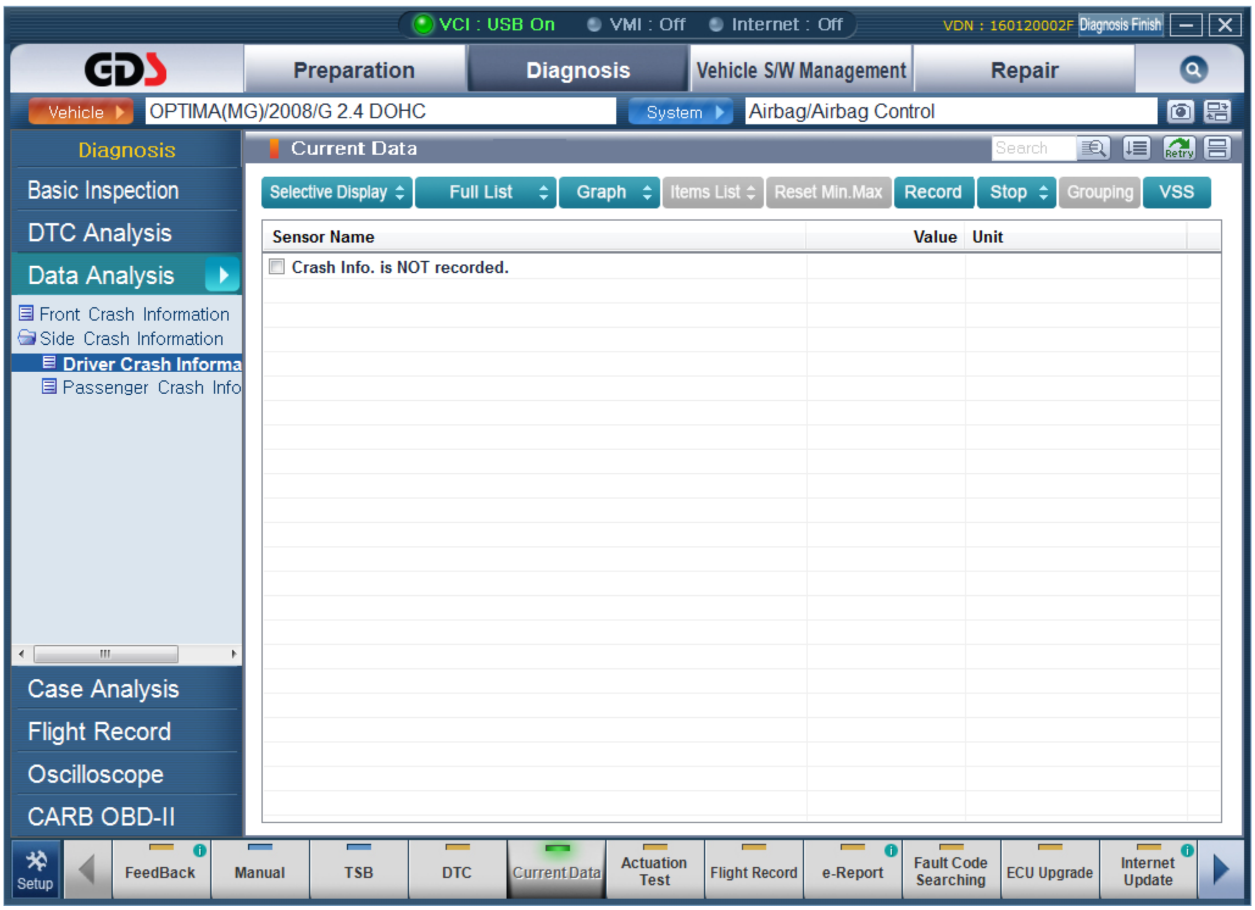


VIN	KNAGE12388[redacted]		
Maker	Kia Motor Company	Vehicle	OPTIMA(MG)
Model Year	2008	Engine Type	G 2.4 DOHC
System	Airbag/Airbag Control	Date Time	01/20/2016 11:38:31
Software Version	N-K-01-15-0019	Content Version	N-K-01-15-0019
ECU Upgrade Version	N-K-01-15-0019	VCI Version	2.19

Dealer	GT200	Name	
Tel.		e-mail	
Address			

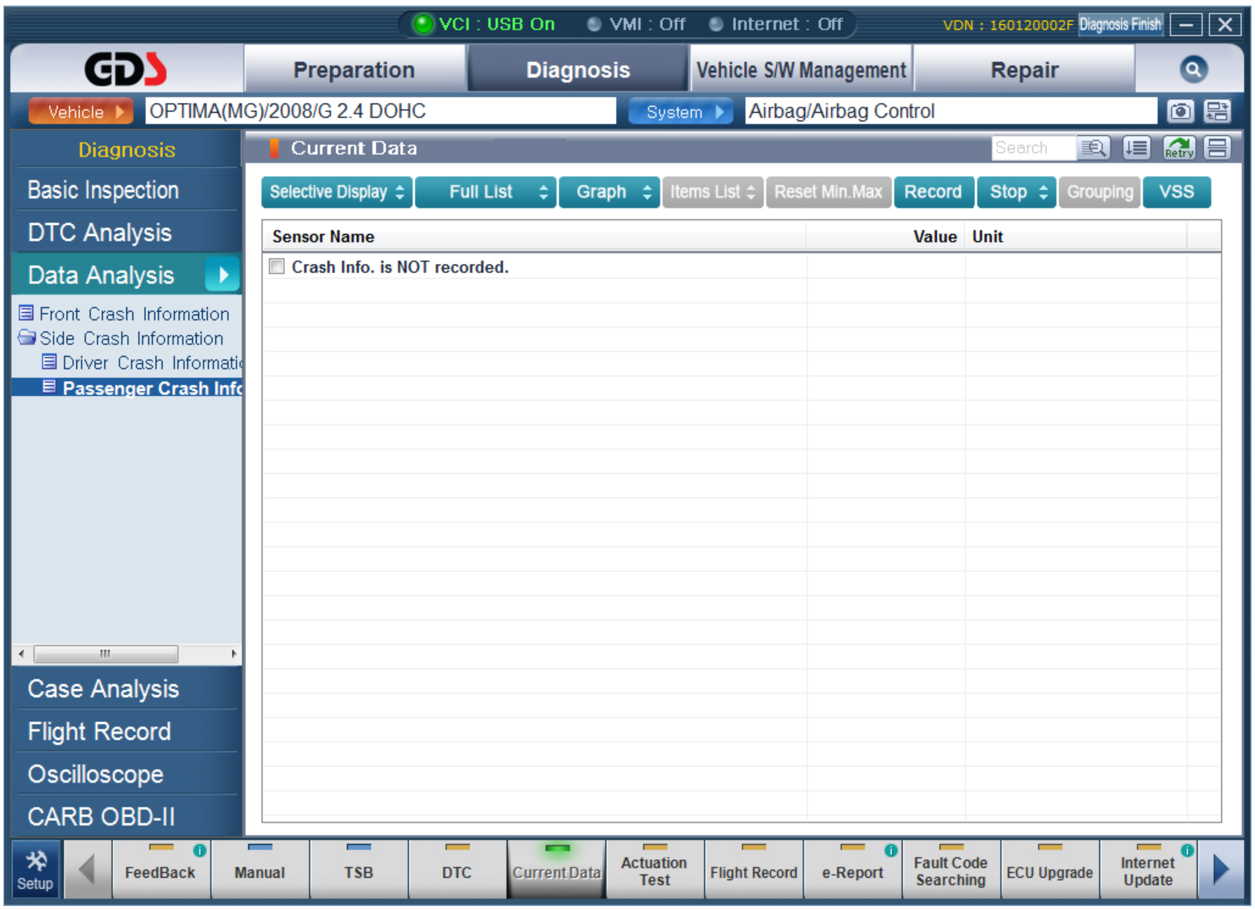


VIN	KNAGE12388 [redacted]		
Maker	Kia Motor Company	Vehicle	OPTIMA(MG)
Model Year	2008	Engine Type	G 2.4 DOHC
System	Airbag/Airbag Control	Date Time	01/20/2016 11:38:59
Software Version	N-K-01-15-0019	Content Version	N-K-01-15-0019
ECU Upgrade Version	N-K-01-15-0019	VCI Version	2.19
Dealer	GT200	Name	
Tel.		e-mail	
Address			



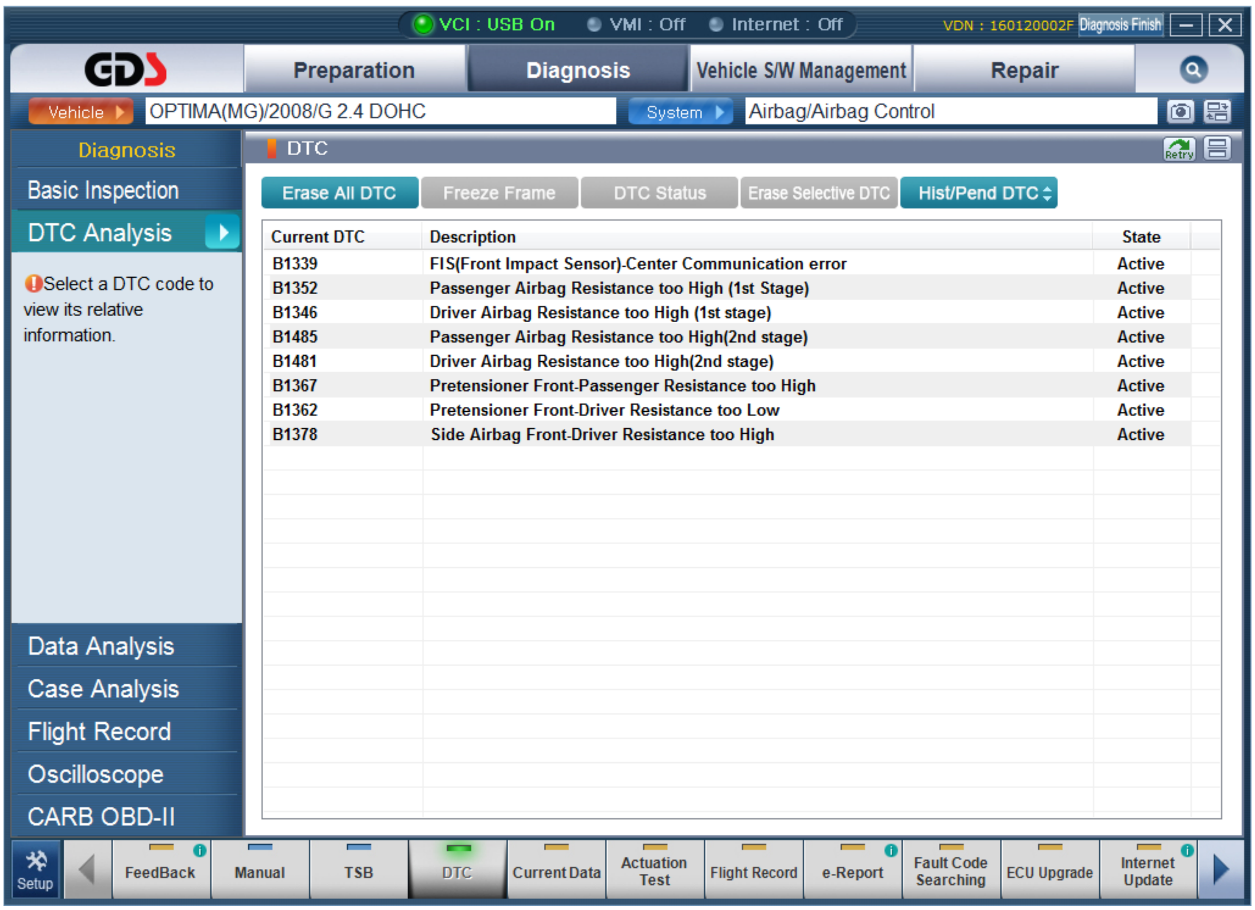
VIN	KNAGE12388[redacted]		
Maker	Kia Motor Company	Vehicle	OPTIMA(MG)
Model Year	2008	Engine Type	G 2.4 DOHC
System	Airbag/Airbag Control	Date Time	01/20/2016 11:39:41
Software Version	N-K-01-15-0019	Content Version	N-K-01-15-0019
ECU Upgrade Version	N-K-01-15-0019	VCI Version	2.19

Dealer	GT200	Name	
Tel.		e-mail	
Address			



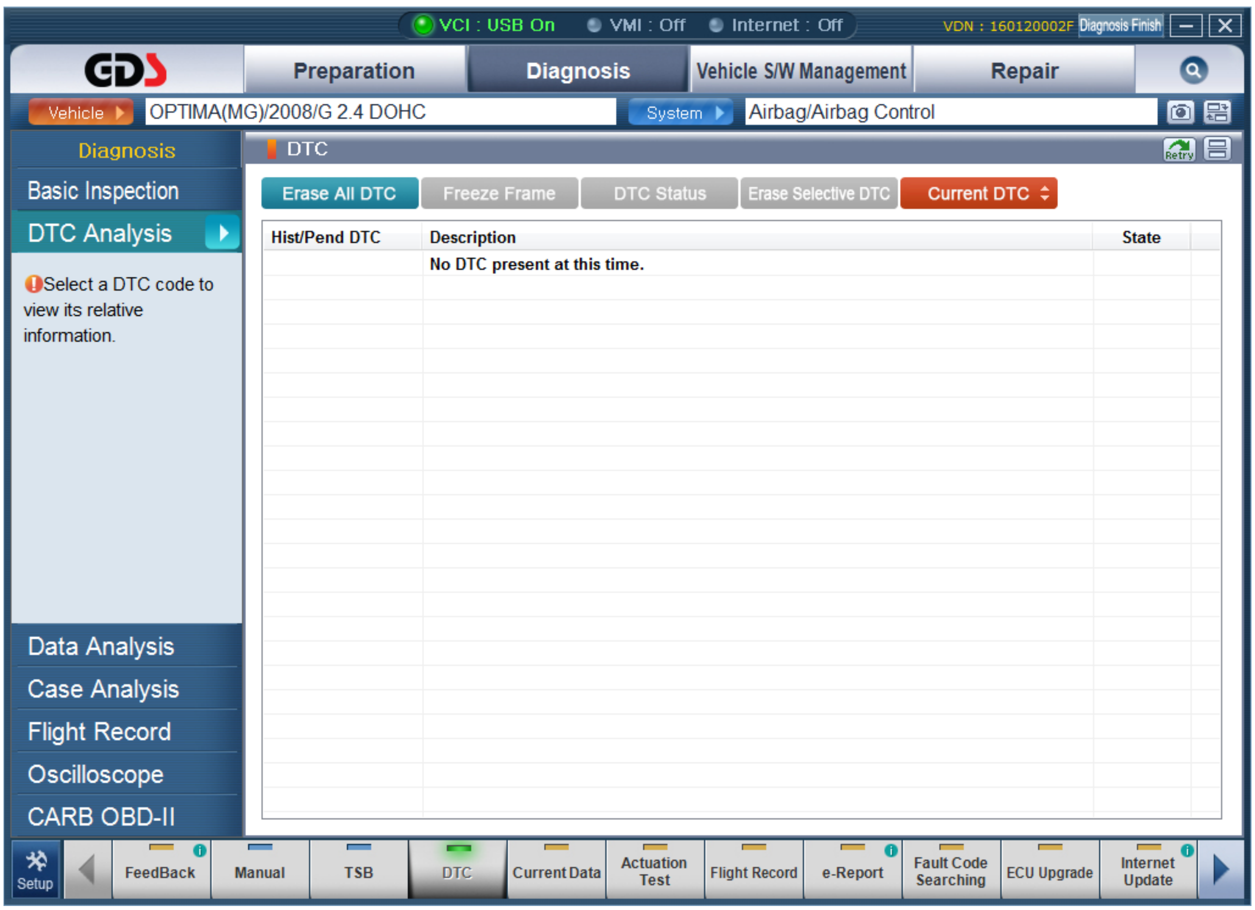
GDS

VIN	KNAGE12388[redacted]		
Maker	Kia Motor Company	Vehicle	OPTIMA(MG)
Model Year	2008	Engine Type	G 2.4 DOHC
System	Airbag/Airbag Control	Date Time	01/20/2016 11:36:50
Software Version	N-K-01-15-0019	Content Version	N-K-01-15-0019
ECU Upgrade Version	N-K-01-15-0019	VCI Version	2.19
Dealer	GT200	Name	
Tel.		e-mail	
Address			



VIN	KNAGE12388[redacted]		
Maker	Kia Motor Company	Vehicle	OPTIMA(MG)
Model Year	2008	Engine Type	G 2.4 DOHC
System	Airbag/Airbag Control	Date Time	01/20/2016 11:37:41
Software Version	N-K-01-15-0019	Content Version	N-K-01-15-0019
ECU Upgrade Version	N-K-01-15-0019	VCI Version	2.19

Dealer	GT200	Name	
Tel.		e-mail	
Address			



Appendix B
2003 Ford Windstar Event Data Recorder 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	2FMZA53443B******
User	
Case Number	
EDR Data Imaging Date	01/19/2016
Crash Date	
Filename	201650S1CR16001_V2_ACM.CDRX
Saved on	Tuesday, January 19 2016 at 17:07:32
Imaged with CDR version	Crash Data Retrieval Tool 16.2.1
Reported with CDR version	Crash Data Retrieval Tool 17.6.1
Reported with Software Licensed to (Company Name)	NHTSA
EDR Device Type	Airbag Control Module
Event(s) recovered	Non Deployment

Comments

No comments entered.

The retrieval of this data has been authorized by the vehicle's owner, or other legal authority such as a court order or search warrant, as indicated by the CDR tool user on Tuesday, January 19 2016 at 17:07:32.

Data Limitations

Important Limitations on Bosch Crash Data Retrieval (CDR) Tool Capabilities.

Disclaimer: This Restraint Control Module (RCM) records longitudinal deceleration data for the purpose of understanding the input data the Restraint Control Module used to determine whether or not to deploy restraint devices. This module does not record vehicle speed, throttle position, brake on-off, and other data, which may be recorded in some 1999 model year and later General Motors modules. The deceleration data recorded by Ford's module during a crash can subsequently be mathematically integrated into a longitudinal delta-V. Delta-V is the change in velocity during the recording time and is NOT the speed the vehicle was traveling before the accident, and is also not the Barrier Equivalent Velocity. The Bosch CDR Tool will read and interpret both acceleration in G's and delta-V in mph. RCM's in Ford vehicles that can be read by the Bosch CDR tool are listed in the Bosch Help Files.

Important

If there is any question that the restraint system did not perform as it was designed to perform, please read the system only through the diagnostic link connector. The Bosch CDR kit provides an RCM interface cable to plug directly into the restraint control module. The Bosch CDR RCM Interface Cable connects only power, ground, and memory read pins to the relevant vehicle restraint control module. The other RCM pins normally connect to inputs, such as sensors, and outputs, such as airbags, are not connected when you use the RCM Interface Cable to plug directly into the module. Since the vehicle restraint control module is constantly monitoring airbag system readiness, it will detect that the sensors and airbags are not connected. The restraint control module may record a new diagnostic trouble code into memory for each device that is not connected. These new diagnostic trouble codes may record over previously written diagnostic trouble codes present prior to the accident and spoil evidence necessary to determine if the restraint system performed in the accident as it was designed to perform. Not only could this prevent Ford from being able to determine if the system performed as it was designed to perform, but, regardless of innocent inadvertence, you could raise issues of evidence spoliation in any litigation that may arise out of the accident. If you cannot read the module via the diagnostic link connector, and if you suspect improper system performance, contact Ford Motor Company and request their assistance to read the module with a proper vehicle simulator attached. If you choose to read via the module connector, Ford recommends that you do so in the vehicle and that you leave the second large connector plugged into the vehicle wiring harness to minimize the number of new diagnostic trouble codes created.

While data stored in RCM's is accurate, accident reconstructionists must be aware of the limitations of the data recorded in Ford's control modules and should compare the recorded data with the physical evidence at the accident scene using professional accident reconstruction techniques (i.e. vehicle crush characteristics, skid marks, etc.) before making any assumptions about the import and validity of the data recorded in the module with respect to the crash event being analyzed. The following describes specific limitations that must be considered when analyzing recorded data. Investigators should obtain permission of the vehicle owner prior to reading any data.

1. There may be no deceleration data recorded in the module.

Loss of power (cut wires, damaged battery, crushed fuse box) to the module during or immediately after the crash may prevent the crash data from being recorded. A backup power supply in the module has sufficient power to continue to analyze the deceleration data and deploy restraint devices if needed, but there is no backup power for recording.

If the deceleration input does not create a vehicle longitudinal delta-V above 4 mph in 100 milliseconds, there may not be any data recorded.

2. In unusual circumstances, deceleration data stored in the module may be from a crash other than the one you are currently analyzing.

The module will record data from some non-deploy events. If, after the module has recorded data from a non-deploy event, and there is a subsequent event in which there is a loss of power and no new recording is made for that subsequent event, the deceleration data in the module's memory may be from the prior event. If the new, subsequent event is a deploy event and recording has occurred, the deployment times should be recorded. If there are no deployment times recorded, but airbags or other restraint devices are observed to have deployed, the recorded data that you read are most likely from a prior event.

Once an airbag or other restraint device has been commanded to deploy, the data recorded in connection with that deployment are "locked", and subsequent crashes cannot be recorded.

If a vehicle is being repaired, the RCM should be replaced after any crash in which restraint devices deploy. Early printed shop manuals refer to re-using modules by clearing the "crash data memory full" code, but this is no longer true and the latest on-line electronic shop manual directs that modules be replaced.

Crashes that involve multiple impacts will record only one of the impacts. If there is a deployment, the deployment event will be recorded and locked. If no restraint device is commanded to deploy, the recorded data are not "locked", and subsequent impacts may record over any previous recorded data. Further analysis will be required to determine that of the events was actually recorded.

3. The computed longitudinal delta-V may understate the total delta-V
Many real-world crashes can last longer than the memory has the capacity to record. Therefore, the actual delta-V of the event may be higher than the delta-V calculated and displayed by the Bosch CDR System output. Review the end of the longitudinal acceleration/deceleration pulse - if it has not settled to zero G's by the end of the recording, the vehicle longitudinal delta-V is most likely understated. If there is a clear decaying trend line you may choose, at your own risk, to estimate the total delta-V by extrapolating the decay trend to zero and to calculate the additional delta-V not captured.

Under some circumstances where power is interrupted, during the recording of data, or the module re-sets during the recording of data, a partial recording may occur. This will be shown as "no data" in the data table and will not be plotted on the graph of acceleration. The "no data" sections may be at the beginning, in the middle, or at the end(s) - it will not be consistent from one occurrence to another. When some portion of the acceleration data is not recorded, the delta-V during that time cannot be calculated. A delta-V will be calculated for the points that are valid, but the user must be aware that the partial delta-V calculated will further underestimate the actual event total delta-V. Restraint device deployment times are recorded first in to memory, and the acceleration data is recorded last. Thus, even with partial acceleration traces, deployment times are valid.

4. This module records only longitudinal acceleration/deceleration of the vehicle. You must compute lateral or resultant total acceleration based on your estimated Principal Direction of Force (PDOF).

5. Vertical acceleration/decelerations are not recorded. Vehicle spin about a point not centered on the Restraints Control Module sensor may add or subtract from bulk vehicle motion.

6. This module is not intended to record acceleration/deceleration in a side-impact event. If the side impact generates a longitudinal deceleration component sufficient to wake up the frontal deployment algorithm, there may be a recording of longitudinal deceleration in a side impact event.

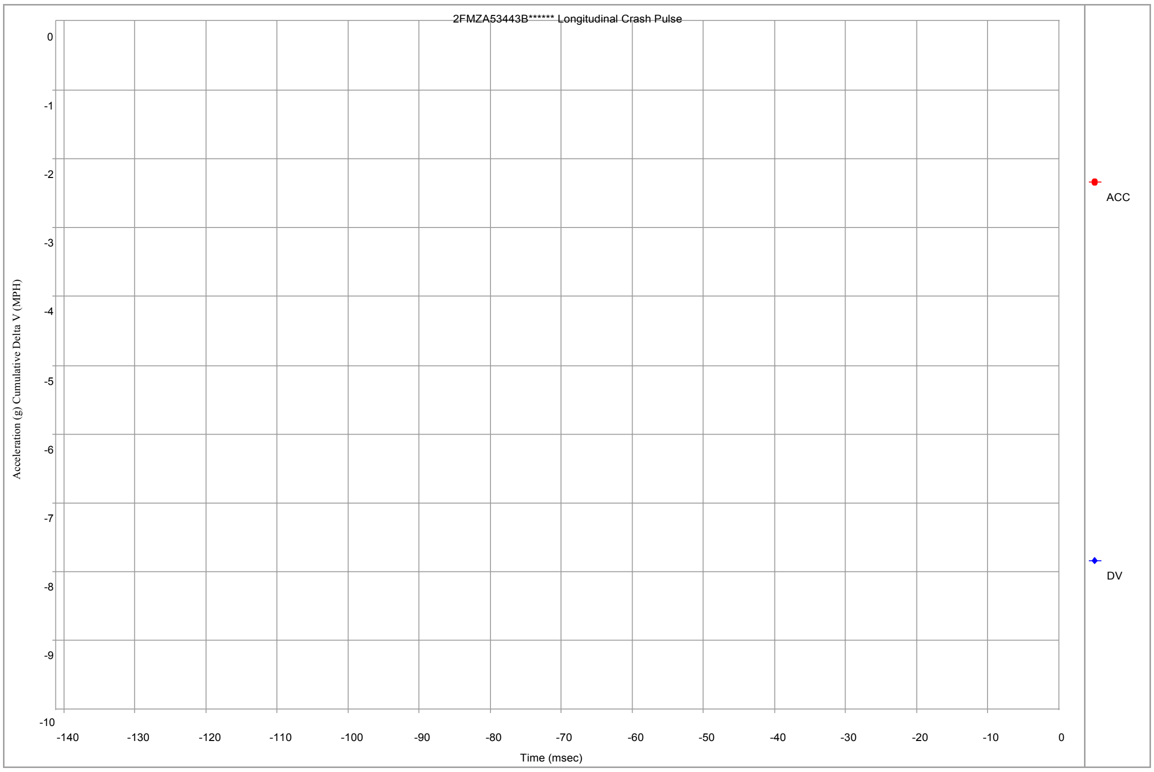
Any Longitudinal delta-V determined by using data read from the air bag module should be verified with physical evidence from the crash (such as vehicle crush, skid marks) and assumed accident sequence. Multiple impacts, angular collisions, side impacts, vehicle spin, etc., should be considered in addition to the data read from the air bag module.

02003_RCM-Takata_r002

System Status at Non-Deployment

Ford part number prefix	3F23
Diagnostic codes active when event occurred	1
Driver seat belt circuit status	Unbuckled
Driver seat forward of switch point	No
Right front passenger seat belt circuit status	Unbuckled
Passenger occupant classification status	Undefined
Driver pretensioner	Not Enabled
Passenger pretensioner	Not Enabled
Unbelted Stage 1	Not Enabled
Unbelted Stage 2	Not Enabled
Belted Stage 1	Not Enabled
Belted Stage 2	Not Enabled

Parameter	Driver	Passenger
Time between algorithm enable and seat belt pretensioner deployment (ms)	No deploy	No deploy
Time between algorithm enable and air bag first stage deployment (ms)	No deploy	No deploy
Time between algorithm enable and air bag second stage deployment (ms)	No deploy	No deploy


2FMZA53443B****** Longitudinal Crash Pulse
Acceleration (g) Cumulative Delta V (MPH)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-140
-130
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
Time (msec)
ACC
DV

Crash Pulse Data

Milliseconds	Long. Acceleration (Gs)	Long. Cumulative Delta V (MPH)
-141.0	No Data	No Data
-140.0	No Data	No Data
-139.0	No Data	No Data
-138.0	No Data	No Data
-137.0	No Data	No Data
-136.0	No Data	No Data
-135.0	No Data	No Data
-134.0	No Data	No Data
-133.0	No Data	No Data
-132.0	No Data	No Data
-131.0	No Data	No Data
-130.0	No Data	No Data
-129.0	No Data	No Data
-128.0	No Data	No Data
-127.0	No Data	No Data
-126.0	No Data	No Data
-125.0	No Data	No Data
-124.0	No Data	No Data
-123.0	No Data	No Data
-122.0	No Data	No Data
-121.0	No Data	No Data
-120.0	No Data	No Data
-119.0	No Data	No Data
-118.0	No Data	No Data
-117.0	No Data	No Data
-116.0	No Data	No Data
-115.0	No Data	No Data
-114.0	No Data	No Data
-113.0	No Data	No Data
-112.0	No Data	No Data
-111.0	No Data	No Data
-110.0	No Data	No Data
-109.0	No Data	No Data
-108.0	No Data	No Data
-107.0	No Data	No Data
-106.0	No Data	No Data
-105.0	No Data	No Data
-104.0	No Data	No Data
-103.0	No Data	No Data
-102.0	No Data	No Data
-101.0	No Data	No Data
-100.0	No Data	No Data
-99.0	No Data	No Data
-98.0	No Data	No Data
-97.0	No Data	No Data
-96.0	No Data	No Data
-95.0	No Data	No Data
-94.0	No Data	No Data
-93.0	No Data	No Data
-92.0	No Data	No Data
-91.0	No Data	No Data
-90.0	No Data	No Data
-89.0	No Data	No Data

Milliseconds	Long. Acceleration (Gs)	Long. Cumulative Delta V (MPH)
-88.0	No Data	No Data
-87.0	No Data	No Data
-86.0	No Data	No Data
-85.0	No Data	No Data
-84.0	No Data	No Data
-83.0	No Data	No Data
-82.0	No Data	No Data
-81.0	No Data	No Data
-80.0	No Data	No Data
-79.0	No Data	No Data
-78.0	No Data	No Data
-77.0	No Data	No Data
-76.0	No Data	No Data
-75.0	No Data	No Data
-74.0	No Data	No Data
-73.0	No Data	No Data
-72.0	No Data	No Data
-71.0	No Data	No Data
-70.0	No Data	No Data
-69.0	No Data	No Data
-68.0	No Data	No Data
-67.0	No Data	No Data
-66.0	No Data	No Data
-65.0	No Data	No Data
-64.0	No Data	No Data
-63.0	No Data	No Data
-62.0	No Data	No Data
-61.0	No Data	No Data
-60.0	No Data	No Data
-59.0	No Data	No Data
-58.0	No Data	No Data
-57.0	No Data	No Data
-56.0	No Data	No Data
-55.0	No Data	No Data
-54.0	No Data	No Data
-53.0	No Data	No Data
-52.0	No Data	No Data
-51.0	No Data	No Data
-50.0	No Data	No Data
-49.0	No Data	No Data
-48.0	No Data	No Data
-47.0	No Data	No Data
-46.0	No Data	No Data
-45.0	No Data	No Data
-44.0	No Data	No Data
-43.0	No Data	No Data
-42.0	No Data	No Data
-41.0	No Data	No Data
-40.0	No Data	No Data
-39.0	No Data	No Data
-38.0	No Data	No Data
-37.0	No Data	No Data
-36.0	No Data	No Data
-35.0	No Data	No Data
-34.0	No Data	No Data
-33.0	No Data	No Data

Milliseconds	Long. Acceleration (Gs)	Long. Cumulative Delta V (MPH)
-32.0	No Data	No Data
-31.0	No Data	No Data
-30.0	No Data	No Data
-29.0	No Data	No Data
-28.0	No Data	No Data
-27.0	No Data	No Data
-26.0	No Data	No Data
-25.0	No Data	No Data
-24.0	No Data	No Data
-23.0	No Data	No Data
-22.0	No Data	No Data
-21.0	No Data	No Data
-20.0	No Data	No Data
-19.0	No Data	No Data
-18.0	No Data	No Data
-17.0	No Data	No Data
-16.0	No Data	No Data
-15.0	No Data	No Data
-14.0	No Data	No Data
-13.0	No Data	No Data
-12.0	No Data	No Data
-11.0	No Data	No Data
-10.0	No Data	No Data
-9.0	No Data	No Data
-8.0	No Data	No Data
-7.0	No Data	No Data
-6.0	No Data	No Data
-5.0	No Data	No Data
-4.0	No Data	No Data
-3.0	No Data	No Data
-2.0	No Data	No Data
-1.0	No Data	No Data
0.0	No Data	No Data

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.


```
0000:  14 BB F6 00 46 00 00 F5 0E 22 0E 2B 38 55 18 1E
0010:  00 7D 13 26 13 26 05 CC 33 46 32 33 04 00 71 7D
0020:  44 00 48 33 33 46 38 34 30 39 00 00 00 00 00 00
0030:  00 00 00 00 00 00 00 00 00 00 33 33 33 46 38 39
0040:  34 34 74 88 78 75 49 40 31 26 4F 40 01 80 1D 02
0050:  01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0060:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0070:  00 00 00 00 00 04 00 00 00 00 00 01 00 00 00 00
0080:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0090:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00A0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00B0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00C0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00D0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00E0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00F0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0100:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0110:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0120:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0130:  00 00 00 00 02 6C 05 02 02 05 02 6C 04 D7 01 00
0140:  00 00 03 03 05 06 02 03 FC 5A 00 00 00 A9 00 00
0150:  01 83 00 00 00 91 02 6C 13 5C 01 03 01 2F 00 DC
0160:  02 53 00 72 00 1F 01 83 00 B3 01 D3 01 31 00 85
0170:  03 87 FF 0E 01 3F 02 31 00 A9 FF FE 00 E6 00 2C
0180:  02 5D 03 13 00 3A 00 6D 00 B6 00 91 00 91 00 91
0190:  00 91 00 91 0A 02 02 02 04 D7 04 D7 00 00 00 00
01A0:  04 05 03 01 04 03 00 F2 00 F2 00 91 00 91 00 00
01B0:  00 30 02 6C 13 5C 02 BB 01 2A 01 F0 03 7F 02 BB
01C0:  01 F0 01 2A 1B 3A 20 FE 01 F3 02 56 00 F0 08 37
01D0:  00 72 01 16 06 1E 06 C7 09 50 01 3D 00 8C 66 00
01E0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
01F0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 A5
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May 2018

U.S. Department
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**National Highway
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