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Special Crash Investigations: On-Site Reported Unintended Acceleration Crash Investigation; Vehicle: 2011 Kia Sorento; Location: Georgia; Crash Date: July 2020

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15. Supplementary Notes

Each crash represents a unique sequence of events, and 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 submitted.

16. Abstract

This on-site investigation documents a reported unintended acceleration of a 2011 Kia Sorento that resulted in a front-to-rear collision with a 2014 Toyota RAV4 in Georgia in July 2020. The crash sequence began at the exit of a fuel station when the Kia accelerated forward and struck the back of the Toyota. The Kia then continued to accelerate, pushing the Toyota across the intersecting roadway and into a second parking lot, where the 26-year-old female Toyota driver was able to maneuver her vehicle and separate from the Kia. The Kia then continued to accelerate striking a curb, a fence, and then crashed into the embankment of a dry retention pond, coming to rest approximately 3 m (9 ft) below the impact point. The 75-year-old female driver of the Kia sustained police-reported incapacitating (A-level) injuries because of the crash. The Toyota driver was transported to a hospital with police-reported possible (C-level) injuries.

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On-Site Reported Unintended Acceleration Crash Investigation
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Vehicle: 2011 Kia Sorento
Location: Georgia
Crash Date: July 2020

Background

This on-site investigation documents a reported unintended acceleration of a 2011 Kia Sorento (Figure 1) that resulted in a front-to-rear collision with a 2014 Toyota RAV4. The crash sequence began at the exit of a fuel station when the Kia accelerated forward and struck the back of the Toyota. The Kia then continued to accelerate, pushing the Toyota across the intersecting roadway and into a second parking lot, where the 26-year-old female Toyota driver was able to maneuver her vehicle and separate from the Kia. The Kia then continued to accelerate striking a curb, a fence, and then crashed into the embankment of a dry retention pond coming to rest approximately 3 m (9 ft) below the impact point. The 75-year-old female driver of the Kia sustained police-reported incapacitating (A-level) injuries because of the crash. The Toyota driver was transported to a hospital with police-reported possible (C-level) injuries. Both vehicles were towed from the scene.

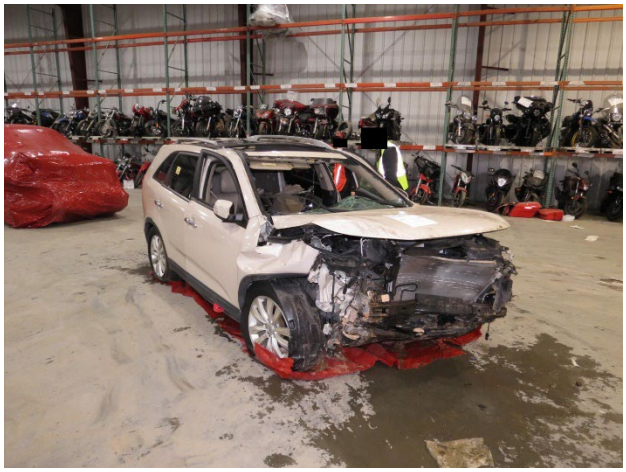


Figure 1. Right front oblique view of the Kia

The law firm representing the Kia driver notified the National Highway Traffic Safety Administration of the crash in October 2021 and NHTSA assigned an onsite investigation to the Special Crash Investigations (SCI) team at Crash Research & Analysis, Inc., in November 2021. A joint inspection of the vehicle, coordinated with Kia Motors America, was conducted in December 2021 at a regional insurance vehicle salvage facility.

The on-site SCI investigation consisted of documenting the Kia's exterior and interior damage, identifying the points of occupant contact, and inspecting the manual restraint and supplemental restraint systems. The vehicle's foot controls were examined and documented. The Kia was not equipped with an event data recorder (EDR) supported by a commercially available data retrieval tool. However, the vehicle manufacturer was able to successfully image data from the vehicle's

EDR using the Hyundai/Kia scan tool. The Toyota was sold for salvage by its insurance company and was not inspected. The SCI investigator also inspected the crash site and documented the environment using photographs and a total station mapping system.

The police crash report stated that the Kia driver may have suffered a sudden and acute medical episode that precipitated her loss of vehicle control. After SCI inspection, EDR analysis, and crash reconstruction, the circumstances of the control loss aligned with a pedal misapplication by the driver.

Crash Summary

Crash Site

The crash occurred on an afternoon in July 2020. The police reported the environmental conditions as clear, daylight, and dry. The National Weather Service reported a temperature of 32.2 °C (90 °F), 43 percent relative humidity, 4 km/h (7 mph) southeast winds, and partly cloudy conditions. The crash site consisted of a non-traffic-controlled intersection at the exit/entrance of a business and a four-lane north/south roadway. The intersecting roadways (heading east and west) exited at the gas station and entered a small strip mall (Figures 2, 3, and 4). The westerly directional road had a positive 9.5 percent grade into the intersection followed by a negative 7.4 percent grade on entry into the strip mall. Approximately 16 m (52 ft) into the strip mall parking lot entrance was a speed bump. This driving lane extended east approximately 155 m (509 ft), becoming a level grade, and terminating at a (dry) retention pond that was gated off with a chain link fence. In the area of the crash, the retention pond measured approximately 15 m (49 ft) across and 3 m (9 ft) deep.

Figure 2. Trajectory view looking east at the gas station/grocery store parking lot entrance/exit

Figure 3. Looking east at the strip mall entrance/exit

Figure 4. East trajectory view of the Kia toward the retention pond

Pre-Crash

The 2014 Toyota RAV4 was stopped, attempting to make a left turn from the fuel station parking lot onto the northbound roadway. The 2011 Kia Sorento was traveling east out of the grocery/fuel parking lot approaching the rear of the Toyota.

Crash

The Kia proceeded to accelerate and struck the back of the Toyota (Event 1) pushing it into and then across the intersection. The vehicles proceeded together into the parking lot of the strip mall and over the first set of speed bumps. At this time, the Toyota driver was able to take control of her vehicle and steer it to the right, separating from the Kia. The Toyota came to a controlled stop approximately 50 m (164 ft) from the initial contact point.

Figure 5. East looking on-scene law enforcement image at the retention pond

The Kia continued to accelerate approximately 150 m (492 ft) through the strip mall parking lot along a straight trajectory. At the end of the driving lane, the Kia impacted the curb and chain link fence (Events 2 to 5) (Figure 5). The Kia then vaulted approximately 12 m (39 ft) and struck the far side embankment of the pond with its front undercarriage and front plane. The Kia's recorded speed at algorithm enable (AE) was 91.0 km/h (56.5 mph).

The Kia gouged up the embankment approximately 2 m (6 ft) before rolling down the embankment towards the bottom of the dry retention pond, coming to rest below the point of impact (Figure 6).

Figure 6. East looking on-scene law enforcement image of the Kia at final rest

Post-Crash

Police and EMS responded to the scene. The driver was removed from the Kia by EMS on a backboard through the rear lift gate, transported to a local medical center, and was hospitalized with multiple rib fractures, bilateral pneumothoraces, a left lung contusion, multiple lower extremity fractures, subarachnoid brain hemorrhages, and related soft tissues injuries. A small dog was found in the front passenger's position of the Kia. The dog expired 30 minutes after the crash. The Kia was recovered from the pond and moved to an insurance salvage yard where it was stored until the investigation was conducted. The Toyota was removed from the scene and deemed a total loss by its insurance company and sold. The Toyota driver was transported by ambulance to the hospital for evaluation with police-reported possible (C-level) injuries.

2011 Kia Sorento

Description

The Kia Sorento (Figure 7) was manufactured in October 2010 and was identified by the VIN 5XYKU4A29BGXXXXXX. The curb weight was 1,635 kg (3,605 lb.). The gross vehicle weight rating was 2,360 kg (5,203 lb.) with a front axle rating of 1,350 kg (2,976 lb.) and a rear axle rating of 1,450 kg (3,197 lb.). The 4-door, front-wheel drive, SUV was powered by a 3.5-liter 6-cylinder gasoline engine connected to an automatic transmission. The engine power was controlled by an electronic throttle control system. There was no mechanical linkage between the accelerator pedal and the throttle body. The service brakes were a four-wheel disk system combined with an antilock braking system (ABS). The vehicle manufacturer's recommended tire size was P235/60R18 front and rear with a recommended cold tire pressure of 230 kPa (33 psi). At the time of the SCI inspection, the Kia was equipped with Falken Pro G5 CVS model tires of the recommended size and mounted on OEM aluminum alloy wheels. The tire tread depth was 6 mm (7/32 in) or greater.

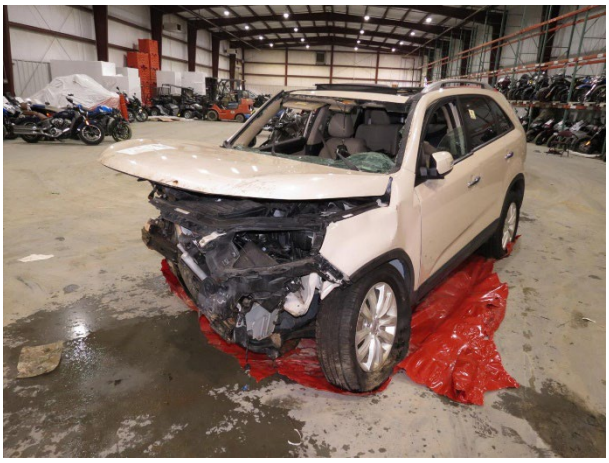


Figure 7. Left/front oblique view of the Kia

The Kia had leather upholstery seating for up to five occupants, two in the front and three in the rear. At the time of the inspection, the driver seat was reclined approximately 75°aft of vertical due to EMS removing the driver through the rear lift gate on a backboard. The vehicle was equipped with a three-point-lap and shoulder seat belt with retractor and lower anchor pretensioners for manual restraints. Supplemental restraint was provided by the driver's and passenger's frontal air bags, front outboard seat-mounted side-impact air bags, and roof side rail-mounted inflatable curtain (IC) air bags.

Vehicle History

The Kia was purchased new by the driver in December 2010, and she was the vehicle's sole owner. It was registered in Georgia throughout the ownership without any reported crashes until the July 2020 crash that is the subject of this investigation.

NHTSA Recalls and Investigations

Recall queries on the NHTSA website www.nhtsa/recall using the VIN at the time of the October 2021 investigation assignment and again at the time this April 2024 report was submitted revealed no unrepaired recalls for this 2011 Kia Sorento.

Exterior Damage

The Kia sustained minor damage from contact with the Toyota (Event 1), estimated minor damage from contact with the curb and fence (Events 2, 3, 4, and 5), and severe damage from impact with the embankment of the retention pond (Event 6; Figures 8 and 9).

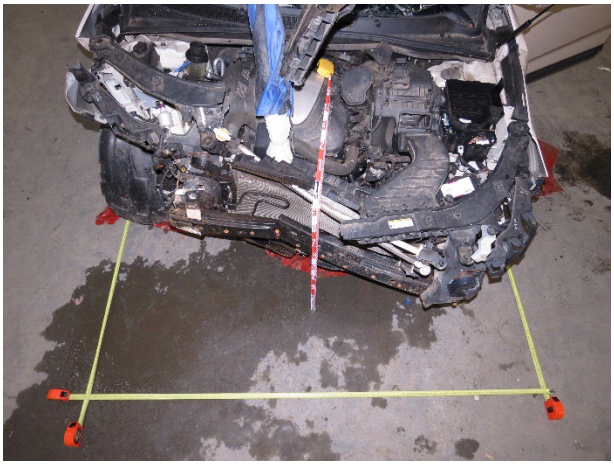


Figure 8. Front view of the Kia

Figure 9. Right side view of the Kia

The collision deformation classification (CDC) assigned to the damage pattern for the Event 1 impact with the Toyota was 12FDEW1 and overlapped with the impact damage from Event 6. The front tires struck the curb (Events 2 and 3), resulting in rim damage to both wheels with CDCs of 12FLWN3 and 12FRWN3. The Kia's front plane struck the fence (Event 4) with an estimated CDC of 12FDEW1. As the Kia continued forward, the right rear wheel struck the curb (Event 5), resulting in rim damage with the corresponding CDC of 12FRWN9. The Kia's front

undercarriage and end plane struck the embankment of the retention pond (Event 6) with a CDC of 12FDEW2. Due to the vehicle's estimated vault trajectory and the angle of the embankment, there was a non-horizontal component to this impact.

The impact damage to the front plane was measured across the front bumper reinforcement. The width of the direct contact damage measured 117 cm (46.1 in). The residual crush profile was C1 = 6 cm (2.4 in), C2 = 9 cm (3.5 in), C3 = 20 cm (7.9 in), C4 = 30 cm (11.8 in), C5 = 29 cm (11.4 in), C6 = 26 cm (10.2 in). Maximum crush was located 18 cm right of center and measured 30 cm (11.8 in). The left wheelbase was reduced by 3 cm (1.2 in). The right wheelbase was reduced by 20 cm (7.9 in). For comparative purposes, the severity of the impact was calculated by the barrier algorithm of the WinSMASH program. The total change in velocity (delta V) was 34 km/h (21 mph). The longitudinal and lateral components were -34 km/h (-21 mph) and -6 km/h (-4 mph). The calculated result was considered borderline and low, in part due to the non-horizontal nature of the impact.

Event Data Recorder

A representative from Kia imaged the vehicle's EDR with the Hyundai/Kia scan tool and gave the SCI investigator a PDF copy of the data that is attached to the end of this report as an appendix. Due to its date of manufacture and the regulated availability of EDR data, the scan tool required that the 2011 Kia Sorento be imaged as a 2013 model year. The Kia representative imaged the vehicle using the VIN sequence from a 2013 Kia Sorento allowing the Hyundai/Kia scan tool to communicate with the EDR. The representative assured the SCI investigator and other representatives that changing the year would not alter the data stored in the EDR and would provide a correct data translation. The tool did write that the stored data occurred on the ignition cycle at 572. However, due to the age of the vehicle, the Kia representative agreed that this value was most likely incorrect. The ignition cycle at the time of imaging was reported as invalid.

The EDR recorded one deployment event with 5 seconds of pre-crash data. At the time of the recording, the driver's seat belt was buckled, the air bag warning lamp was off and the data file was completely written. The wake-up for the crash algorithm occurred when the Kia's front undercarriage struck the embankment in a non-horizontal capacity (Event 6). The vehicle-to-vehicle crash (Event 1) was not recorded. The maximum recorded longitudinal delta V was -71 km/h (-44.1 mph) and the maximum lateral delta V was -17 km/h (-10.5 mph). Actuation of the seat belt pretensioners and deployment of the driver's frontal airbag stage 1 occurred at 161 milliseconds. Stage 2 of the driver's air bag deployed at 165 milliseconds. The following table summarizes the pre-crash data.

Times (sec)	**Speed km/h (mph)**	**Engine throttle, % full**	**Service brake, on/off**	**Engine rpm**	**ABS activity**	**Stability control (on/off) engaged**	**Steering wheel angle +L**
-5.0	50 (31)	40	Off	4,900	Off	On	10
-4.5	54 (34)	100	Off	4,000	Off	On	5
-4.0	58 (36)	100	Off	4,300	Off	On	5
-3.5	63 (39)	100	Off	4,400	Off	On	0
-3.0	67 (42)	100	Off	4,700	Off	On	-5

Times (sec)	Speed km/h (mph)	Engine throttle, % full	Service brake, on/off	Engine rpm	ABS activity	Stability control (on/off) engaged	Steering wheel angle +L
-2.5	72 (45)	100	Off	5,100	Off	On	-55
-2.0	79 (49)	100	Off	5,400	Off	On	5
-1.5	83 (52)	100	Off	5,700	Off	On	15
-1.0	83 (52)	100	Off	5,800	Off	On	0
-0.5	88 (55)	99	Off	6,000	Off	On	25
0.0	91 (57)	100	Off	6,500	Off	Engaged	85

The data trends showed that the engine throttle was at or near 100 percent for approximately 4.5 seconds leading up to the crash. There was no recorded driver brake application. The SCI team's crash reconstruction determined from this EDR pre-crash data that the Kia's movement through the strip mall parking lot approaching the retention pond occurred after the Toyota had separated from the Kia.

Interior Damage

The interior damage was minor with the right portion of the instrument panel intruding 2 cm (0.8 in). The firewall forward of the driver's foot controls intruded an estimated 15 cm (6 in). The driver was belted with the seat adjusted between the forwardmost and middle track positions. The driver significantly loaded the steering wheel-mounted airbag and the steering wheel rim, compressing the column forward into the instrument panel (Figure 10).

Figure 10. Compression of the steering column from driver loading

There were several post-crash blood stains on the driver's frontal air bag. A long scuff contact attributed to the driver's left knee was observed under the steering column and directed left toward the fuse panel cover.

Foot Controls

Due to the complaint of this vehicle being a reported sudden unintended acceleration incident, the foot controls (Figure 11) were documented and examined in detail. With the seat being 4 cm (1.6 in) rearward of full forward, the brake pedal was located 48 cm (18.9 in) from the upholstery seam of the seat and the accelerator pedal was 51 cm (20.1 in) from the seat. The brake pedal was trapezoidal in shape with 11 cm (4.3 in) measured across the top and 9 cm (3.5 in) on the bottom with a height of 6 cm (2.4 in). The accelerator pedal was rectangular in shape and measured 4.5 cm by 10 cm (1.8 by 3.9 in). The center of the pedals were offset by 15 cm (5.9 in). At inspection, the brake pedal was jammed due to intrusion of the firewall. The accelerator pedal was at idle, actuated its full range, and returned by spring pressure. The pedal did not contact the floor pad or floor mat. The accelerator pedal was identified by the part number 32700-1U000. The floor mat was an OEM weather mat of a rubberized material with grips on the bottom. The mat was not connected to the OEM contact points in the vehicle (Figure 12); however, due to the grips on its underside, the mat would not slip.

Figure 11. Foot controls of the Kia

Figure 12. Driver's floor mat in the Kia

The force of the impact displaced the engine 14 cm (5.5 in) rearward into the firewall. The throttle body was located on the backside of the engine and was inaccessible for inspection.

Manual Restraint Systems

The Kia had three-point continuous loop lap and shoulder seat belts for each seat position. They used sliding latch plates and adjustable D-rings. Both front seat belts were equipped with retractor and anchor pretensioners. The driver was alone in the vehicle. She was belted, and at the time of the inspection it was observed that the seat belt had been cut by the EMS approximately 10 cm (4 in) from the anchor pretensioner. The web had spooled into the B-pillar by the retractor. The latch plate was still located in the buckle and revealed minor abrasions at the seat belt path.

The front passenger's seat belt was buckled and taut due to the pretensioner's actuation. There was a small dog in the front passenger's seat position attached to the lower lap portion of the webbing by a small animal tether. The dog expired a short time after the crash.

Supplemental Restraint Systems

The Kia was equipped with dual-stage driver's and passenger's frontal air bags, outboard seatback-mounted side-impact air bags for the front seats and roof side rail-mounted IC air bags. The driver's frontal air bag deployed at 161 milliseconds into the crash algorithm wake up with the second stage deploying 4 milliseconds after the first. The driver's frontal airbag was tethered and vented with several post-crash blood smears.

The air bag control module recognized the weight of the dog on the seat and registered this reading as a belted child in the passenger's seat position. This recognition suppressed the deployment of the passenger's frontal air bag.

2011 Kia Sorento Occupant

Driver Demographics

Age/sex:	75 years/female
Height:	150 cm (59 in)
Weight:	72 kg (159 lb.)
Eyewear:	Unknown
Seat type:	Forward-facing bucket seat with active head restraint
Seat track position:	Between the forwardmost and middle track
Manual restraint usage:	Three-point lap and shoulder seat belt
Usage source:	Vehicle inspection EDR, PCR
Air bags:	Frontal, seat-mounted side-impact, and IC air bags available; Frontal deployed
Alcohol/drug involvement:	None
Egress from vehicle:	Removed by EMS due to perceived serious injury
Transport from scene:	Transported to a level II trauma center
Type of medical treatment:	Hospitalized 12 days, then transferred to a rehabilitation facility

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Open displaced left trimalleolar fracture with articular surface exposed	854466.3	Isolated IPC Floor – Floor (including toe pan)	Certain
2	Rib fractures: Left 2 anterior, right 2-7 anterior	450203.3	Tandem IPC Primary: Interior – Shoulder portion of belt restraint Secondary: Left Air Bag – Steering wheel hub Tertiary: Front – Steering wheel (combination of rim and hub/spoke)	 Possible Possible Certain

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
3	Right pneumothorax	442202.2	Tandem IPC Primary: Interior – Shoulder portion of belt restraint Secondary: Left Air Bag – Steering wheel hub Tertiary: Front – Steering wheel (combination of rim and hub/spoke)	 Possible Possible Certain
4	Left pneumothorax	442202.2	Tandem IPC Primary: Interior – Shoulder portion of belt restraint Secondary: Left Air Bag – Steering wheel hub Tertiary: Front – Steering wheel (combination of rim and hub/spoke)	 Possible Possible Certain
5	Mild left apical lung contusion	441407.2	Tandem IPC Primary: Interior – Shoulder portion of belt restraint Secondary: Left Air Bag – Steering wheel hub Tertiary: Front – Steering wheel (combination of rim and hub/spoke)	 Possible Possible Certain
6	Left subarachnoid hemorrhage over parietal area	140693.2	Tandem IPC Primary: Left Air Bag – Steering wheel bub Secondary: Front – Steering wheel rim	 Possible Probable
7	Right subarachnoid hemorrhage over temporal area	140693.2	Tandem IPC Primary: Left Air Bag – Steering wheel bub Secondary: Front – Steering wheel rim	 Possible Probable

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
8	Right proximal tibia plateau fracture, bicondylar, intra-articular	853371.2	Critical IPC 2-point Critical #1: Front – Left lower instrument panel (includes knee bolster) Critical #2: Floor – Floor (including toe pan)	Certain Probable
9	Right proximal fibular fracture	854471.2	Isolated Front – Left lower instrument panel (includes knee bolster)	Certain
10	Left proximal tibia fracture, NFS	854111.2	Critical IPC 2-point Critical #1: Front – Left lower instrument panel (includes knee bolster) Critical #2: Floor – Floor (including toe pan)	Certain Probable
11	Right calcaneus fracture, comminuted, intra-articular with disruption of all subtalar joints	857371.2	Isolated IPC Floor – Floor (including toe pan)	Certain
12	Right talar neck fracture	857251.2	Isolated IPC Floor – Floor (including toe pan)	Certain
13	Left talus fracture, NFS	857200.2	Isolated IPC Floor – Floor (including toe pan)	Certain
14	Small avulsion fracture at lateral base of right cuboid	857651.2	Isolated Floor – Floor (including toe pan)	Certain
15	Right lateral meniscus avulsion	840300.2	Isolated Left lower instrument panel (includes knee bolster)	Certain
16	Left ankle posterior medial retinaculum injury	840899.1	Isolated Floor – Floor (including toe pan)	Certain
17	Left lateral patella subluxation	874020.1	Isolated Left lower instrument panel (includes knee bolster)	Certain

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
18	Disruption of all subtalar joints	877230.1	Isolated Floor – Floor (including toe pan)	Certain
19	Right frontal scalp hematoma	110402.1	Isolated Front – Steering wheel rim	Probable
20	Frontal scalp abrasion	110202.1	Isolated Left Air Bag – Steering wheel hub	Probable
21	Superficial laceration between eyebrows	210602.1	Isolated Front – Steering wheel rim	Probable
22	Right periorbital bruising	210402.1	Isolated Front – Steering wheel rim	Probable
23	Left periorbital bruising	210402.1	Isolated Front – Steering wheel rim	Probable
24	Left neck contusion	310402.1	Isolated Interior – Shoulder portion of belt restraint	Certain
25	Large ecchymosis to right breast	410402.1	Isolated Interior – Shoulder portion of belt restraint	Certain
26	Ecchymosis to right upper abdomen	510402.1	Isolated Front – Steering wheel (combination of rim and hub/spoke)	Probable
27	Lower abdomen bruising	510402.1	Isolated Interior – Lap portion of belt restraint	Certain
28	Laceration to left index finger	710600.1	Injured, Unknown Source	Unknown
29	Ecchymosis to right hip	810402.1	Isolated Interior – Center console first row	Possible
30	Right knee ecchymosis	810402.1	Isolated Left lower instrument panel (includes knee bolster)	Certain

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
31	Right tibia ecchymosis	810402.1	Isolated Left lower instrument panel (includes knee bolster)	Certain
32	Right ankle ecchymosis	810402.1	Isolated Floor – Floor (including toe pan)	Probable
33	Left ankle ecchymosis	810402.1	Isolated Floor – Floor (including toe pan)	Probable
34	Left dorsal foot ecchymosis	810402.1	Isolated Caused by other injury (injury #1)	Possible

Source: Hospital records

Driver Kinematics

The 75-year-old female was belted and seated between the forwardmost and middle track position consistent with her small stature. The front plane of the Kia struck the back plane of the Toyota (Event 1). The Kia accelerated and the two vehicles traveled across the intersecting roadway into the strip mall parking lot, with the Kia pushing the Toyota forward. Once in the opposing parking lot, the Toyota driver steered her vehicle to the right and separated from the Kia. This impact did not contribute to the Kia driver's injuries. She likely was able to maintain her seated position by bracing.

The Kia continued east, accelerating through the parking lot to an EDR-recorded speed at AE was 91 km/h (57 mph). At the end of the parking lot, the vehicle struck the curb and a fence surrounding the retention pond. Impact with the curb resulted in damage to the rims at the left front, right front and right rear wheels (Events 2, 3, and 5), and impact with the fence caused body panel abrasions to the front plane and forward aspect of the hood (Event 4). These minor impacts did not affect the driver's kinematics or contribute to her injuries.

The Kia vaulted across the (dry) retention pond because of the sudden change in the terrain and struck the embankment on the far side. Due to the trajectory of the vehicle and slope of the embankment, the Kia's front undercarriage and front bumper impacted and then gouged the ground. The force of the impact actuated the seat belt pretensioners and deployed the driver's frontal air bag. The seat belt pretensioners actuated at 161 milliseconds and the two stages of the air bag deployed at 161 and 165 milliseconds.

The driver responded to the impact with a forward trajectory and loaded the seat belt, driver's frontal air bag, and steering wheel spoke/hub/rim, displacing the steering column. Her tandem loading of these restraint systems resulted in multiple rib fractures, bilateral pneumothoraces, and a left lung contusion. As the driver loaded through the air bag, her head struck the steering wheel rim resulting in soft tissue scalp injuries and bilateral subarachnoid brain hemorrhages. Her

lower extremities contacted the knee bolster. This loading and the condition of her feet on the floor resulted in multiple fractures of her lower legs, ankles, and feet.

The driver rebounded and came to rest in the driver seat. She was removed from the vehicle by EMS and transported by ambulance to a level II trauma center. She was hospitalized for 12 days and then transferred to a rehabilitation facility.

2014 Toyota RAV4

Description

The Toyota (Figure 13) was identified by the VIN 2T3WFREV0EWXXXXXX. The 4-door SUV was powered by a 2.5 liter, inline 4-cylinder, gasoline engine connected to an automatic transmission with front-wheel drive. Although drivable, the owner was advised by police to have her vehicle towed to a local yard, where it was totaled by the insurance company and later sold off at an insurance vehicle salvage auction. This vehicle was not available for inspection. All vehicle information was derived from the VIN and on-scene and salvage yard pictures.

Figure 13. Police image of the Toyota

Exterior Damage

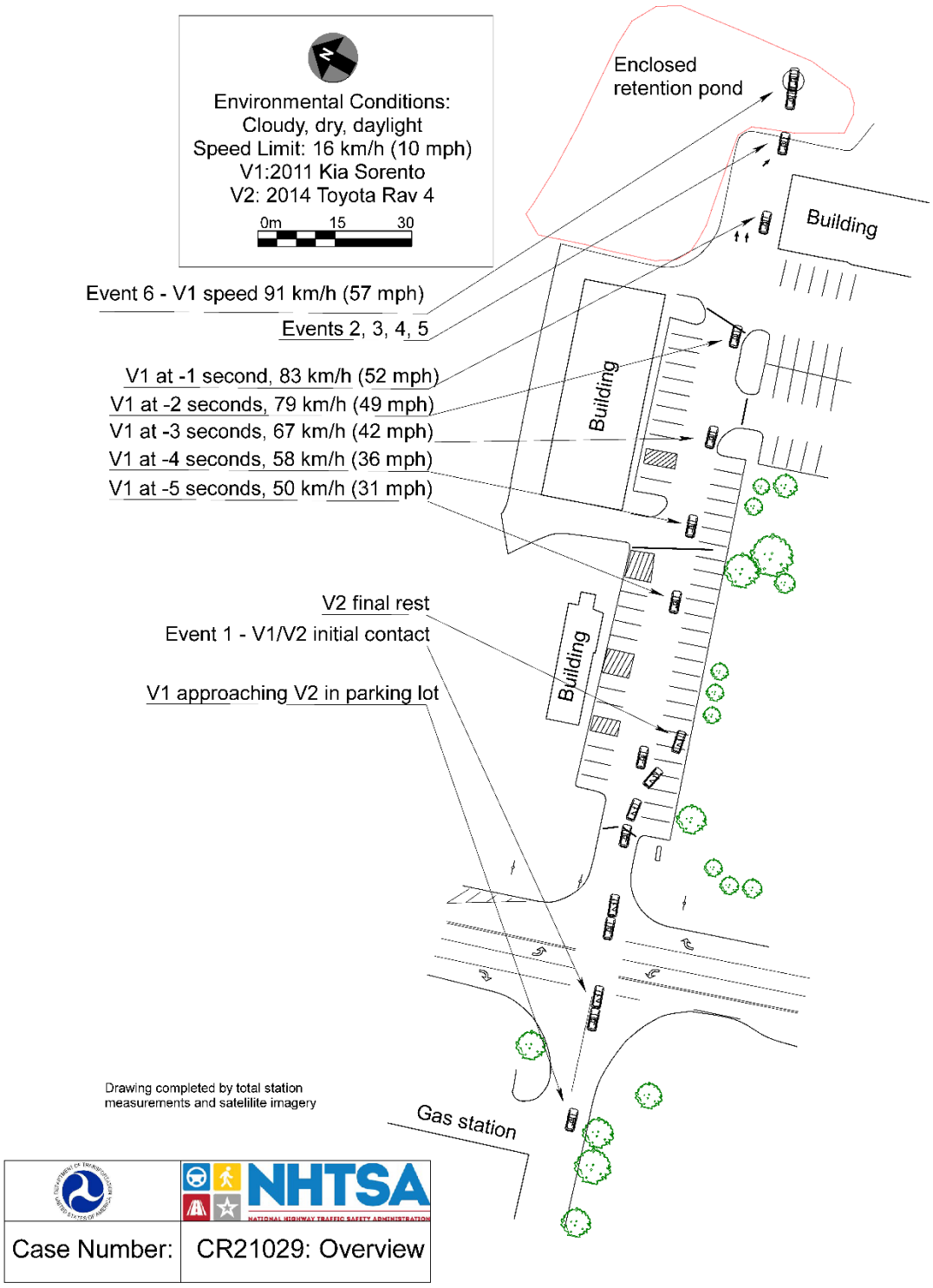
The Toyota's exterior damage consisted of minor impact damage to the rear bumper fascia and the lift gate door with no apparent residual crush (Figure 14). The CDC assigned to the damage pattern was 06BDEW1. During the on-scene police investigation, the Toyota was driven from its controlled final rest position at the top of the grade near the strip mall entrance down to the lower area of the strip mall where the police completed their documentation (as reflected in the above images).

Figure 14. Police image of damage to the rear of the Toyota from impact by the Kia

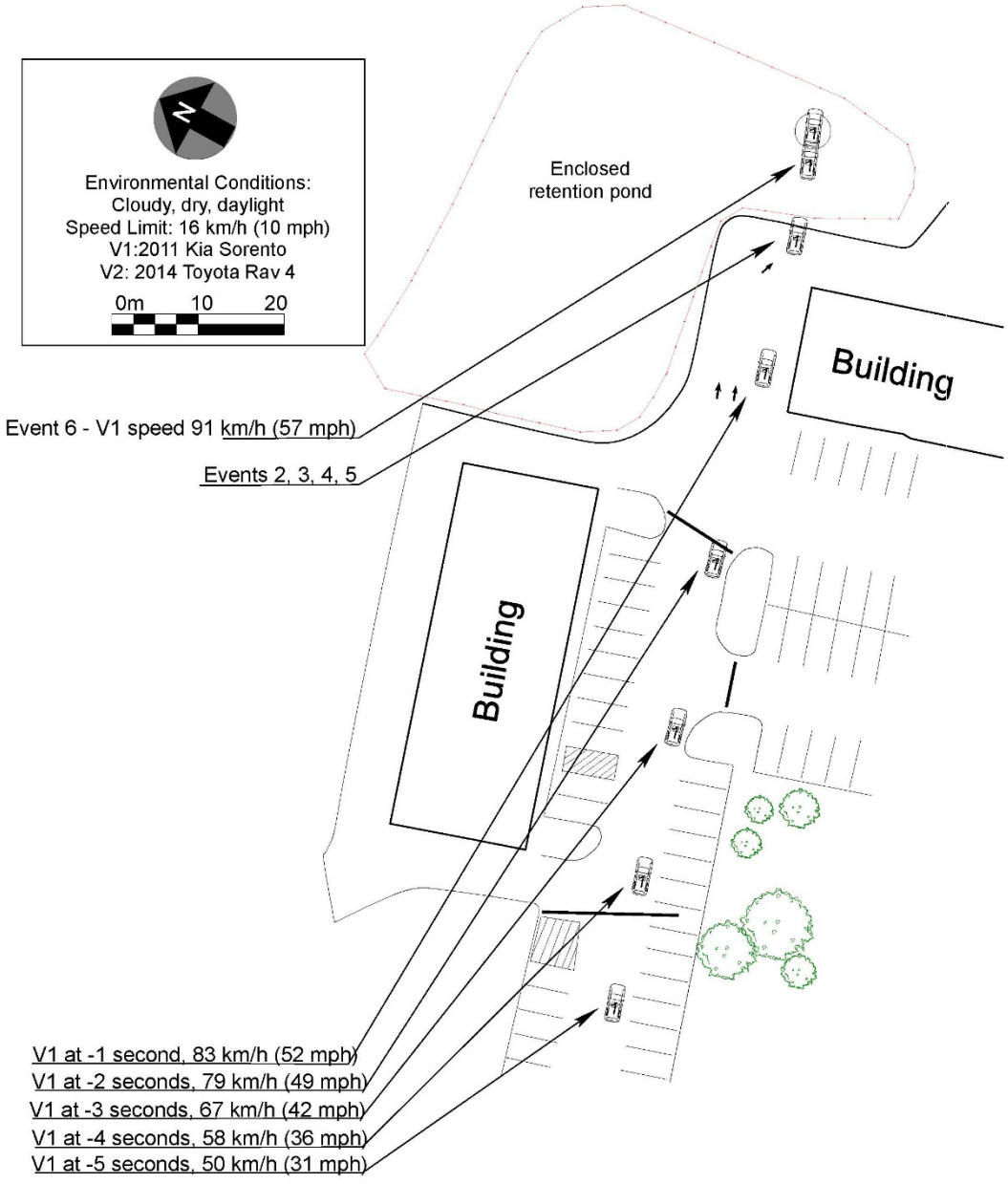
Occupant Data

The 26-year-old female Toyota driver was belted according to the police crash report. She reported to the police that she struck her head on the seatback and B-pillar. She was transported by ambulance to a hospital for evaluation of police-reported possible (C-level) injuries and released.

Crash Diagram



Crash Diagram – Close up



Case Number:	CR21029: Close Up

Appendix A. 2011 Kia Sorento Event Data Recorder Report

The EDR was imaged by the vehicle manufacturer with the GIT Hyundai/Kia scan tool during the joint vehicle inspection. To establish communication with the EDR, the VIN of a 2013 Kia Sorento was substituted for the 2011 model year due to the Federal Motor Vehicle Safety Standard Part 563 regulation. The imaged data was shared with SCI in a PDF file and has been sanitized to remove potential personal identifiable information.

Vehicle Information

KIA SORENTO 2013 AIRBAG SYSTEM	
Vin as Programmed into EMS	

Additional Information

User-entered Vin	5XYKU4A29DG
User name	
Case number	
Crash Date	
Saved-on Date	
EDR Tool Version	E-n-K-01-00-0043
EDR Report Version	EDR0OI-ROI
Tire Size(s)	
Memo	EDR data read throug h DLC using back power at IAA Winder, GA 12/8 2021. Vin year digit changed to D to read EDR.

a Data Limitation

General Information:

Tools for downloading and interpreting the E□Rs in I<ia vehicles have been developed for vehicles produced after September I, 2012. Currently, there is no tool for downloading and accurate interpreting data from the E□Rs in I<ia vehicles produced prior to this date.

The EDR Report requires Adobe Reader Version 9.00 or higher to open.

EDR(Event Data Recorder):

- The EDR function is part of the Airbag Control Unit(ACU).
- ACU can store up to two events.
- Event means a crash or other physical occurrence that causes the trigger threshold to be met or exceeded, or any non-reversible deployable restraint to be deployed, whichever occurs first:

  I. Deployment Event:
  I) the event which is recorded if an airbag is commanded to deploy.
  2) the event is locked and cannot be overwritten.

  2. non-deployment Event:
  I) the event which is recorded, but in which an airbag is not commanded to deploy
  2) the event is not locked and can be overwritten by a subsequent event (Deployment or non- deployment event), for example, Pretensioner(s) only deployment
  3) An example of a non-deployment event is a pretensioner-only deployment with no airbag deployments

- Ignition cycle count will increment by 1 in the following cases

  I. the power mode change from OFF/Accessary to IGn on/Run

  2. EDR data download by tools

- The ACU can record data for all or some of the following events. But, depending on the vehicle's configurations, data for side crash and/or rollover crash(event) may not be recorded.
- If power supply to the ACU is lost during an event, all or part of the data may not be recorded.

Data Limitation

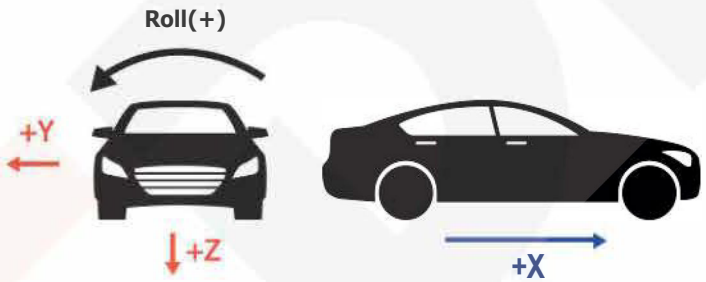
Data Element Sign Convention:

The following table provides an explanation of the sign notation for data elements that may be included in the EDR report. Directional references to sign convention are from the point of view of the driver.

Data element name	Positive sign	note
* Longitudinal acceleration	Forward direction	+X at the figure I
Delta V, longitudinal	Forward direction	+X at the figure I
Lateral acceleration	Left to Right direction	+Y at the figure I
Delta V, lateral	Left to Right direction	+Y at the figure I
normalCvertical) acceleration	Downward direction	+Z at the figure I
Vehicle roll angle	Clockwise about the longitudinal axis	Roll(+) at the figure I
Steering input	Counterclockwise rotation	-

• The forward direction of longitudinal acceleration for front side impact sensor may be different for each vehicle

Figure 1. Sign Conventions



Data Sources:

Many EDR data elements are sourced from other control modules in the vehicle.

1. Most of them can be measured and calculated by the ACU. For example, Delta-V and Rollover angle can be calculated from internal sensors in the ACU (if applicable).

2. The following pre-crash data can be transmitted to the ACU via the vehicle's communication network.
   - Vehicle Speed
   - Engine RPM
   - Engine Throttle
   - Acceleration Pedal
   - Service Brake
   - ABS Activity
   - Stability Control
   - Steering Input Angle

   *note) Depending on the vehicle's configuration and the conditions described above, some items may not be recorded.

3. Pre-crash data is recorded in discrete intervals. Due to different refresh rates within the vehicle's electronics, the data recorded may be asynchronous to each other.

Data Limitation

Data Definitions:

- Data recorded by the ACU and imaged by the EDR tool is displayed relative to Time zero(TO). Time zero(TO) is not typically the time at which the vehicle made contact with another vehicle or object.
- Time zero (TO) means whichever of the following occurs first

  I. For systems with "wake-up" air bag control systems, the time at which the occupant restraint control algorithm is activated; or

  2. For continuously running algorithms,

  I) The first point in the interval where a longitudinal cumulative delta-V of over 0.8 km/h (0.5 mph) is reached within a 20msec time period; or

  2) For vehicles that record "delta-V, lateral," the first point in the interval where a lateral cumulative delta-V of over 0.8 km/h (0.5 mph) is reached within a Smsec time period; or

  3. Deployment of a non-reversible deployable restraint.
- Multi-event crash means the occurrence of 2 events, the first and last of which begin not more than 5 seconds apart. If an event is not part of a multi-event crash, the value of this data element will be "l".
- Service brake, on or off means the status of the device that is installed in or connected to the brake pedal system to detect whether the pedal was pressed. The device can include the brake pedal switch or other driver-operated service brake control,
- Engine RPM means

  I. For vehicles powered by internal combustion engines, the number of revolutions per minute of the main crankshaft of the vehicle's engine, and

  2. For vehicles not entirely powered by internal combustion engines, the number of revolutions per minute of the motor shaft at the point at which it enters the vehicle transmission gearbox.
- Engine Throttle is a measure of the throttle position.
- Accelerator Pedal is a measure of the accelerator pedal value.
- Seat belt status is determined by whether the buckle switch is open or closed.
- Delta-V means the cumulative change in velocity, and is calculated from internal sensors in the ACU
- 'Invalid data' means

  I. The data sources sent invalid data
  2. The data sources did not send data
  3. The data does not be recorded depending on design standard
  4. The data could not be recorded in some conditions such as the loss of power in vehicle
- 'not supported' means : The system is not applied in that vehicle

EDR Information

Part no. (EOL Code) as programmed into ACU	95910-1U000(XM52I
ECU SW Version as programmed into ACU	02(P8.I)
EDR Version as programmed into ACU	

< Event l >

Event Status at Event

Multi-event, number of Event (I or 2)	1 event
Time from Event I to 2 [msec]	0
Completed File Recorded (Yes or no)	YES
Ignition cycle, crash [cycle]	572
Ignition cycle, download [cycle]	invalid data

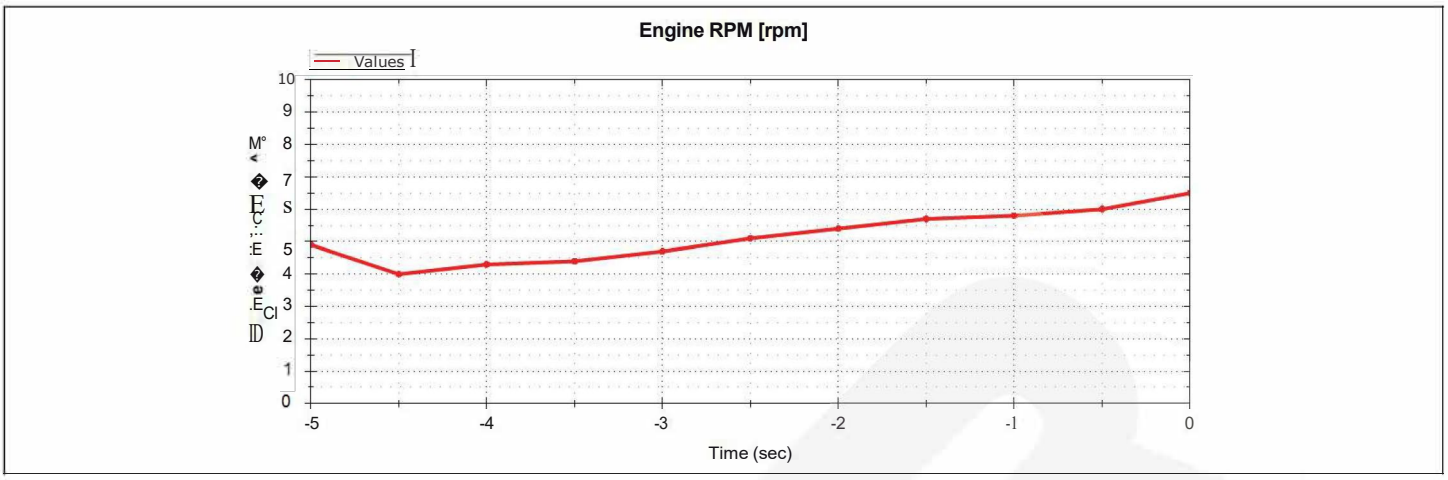
Pre-Crash Information (-5 ,v O sec)

Time (secl	Vehicle Speed [kph)	Engine RPM [rpm)	Engine Throttle [%)	Service Brake [on/off)	ABS Activity [on/off)	Stability Cot [on/off engage l)	Steering Input [degree)
-5.0	50	4900	40	OFF	OFF	on	10
-4.5	54	4000	100	OFF	OFF	on	5
-4.0	58	4300	99	OFF	OFF	on	5
-3.5	63	4400	100	OFF	OFF	on	0
-3.0	67	4700	100	OFF	OFF	on	-5
-2.5	72	5100	100	OFF	OFF	on	-55
-2.0	79	5400	100	OFF	OFF	on	5
-1.5	83	5700	100	OFF	OFF	on	15
-1.0	83	5800	100	OFF	OFF	on	0
-0.5	88	6000	99	OFF	OFF	on	25
0.0	91	6500	100	OFF	OFF	Engaged	85

‹ Event l ›
Vehicle Speed

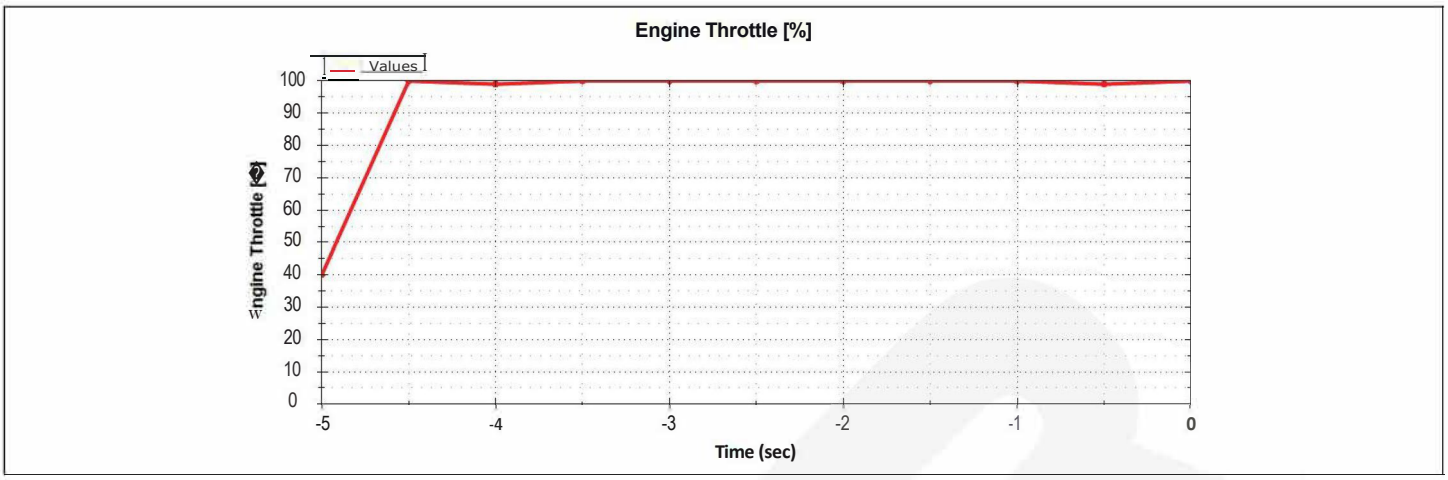
num	Time (sec)	Vehicle Speed [l<ph]
l	-5.0	50
2	-4.5	54
3	-4.0	58
4	-3.5	63
5	-3.0	67
6	-2.5	72
7	-2.0	79
8	-1.5	83
9	-1.0	83
10	-0.5	88
11	0.0	91

‹ Event l ›
Engine RPM



num	Time (sec)	Engine RPM [rpm]
1	-5_0	4900
2	-4.5	4000
3	-4_0	4300
4	-3.5	4400
5	-3.0	4700
6	-2.5	5100
7	-2.0	5400
8	-1.5	5700
9	-1.0	5800
10	-0.5	6000
11	0.0	6500

‹ Event l ›
Engine Throttle



num	Time (sec)	Engine Throttle [%]
I	-5.0	40
2	-4.5	100
3	-4.0	99
4	-3.5	100
5	-3.0	100
6	-2.5	100
7	-2.0	100
8	-1.5	100
9	-1.0	100
10	-0.5	99
11	0.0	100

‹ Event l ›

Service Brake

num	Time (sec)	Service Brake [on/off]
I	-5.0	OFF
2	-4.5	OFF
3	-4.0	OFF
4	-3.5	OFF
5	-3.0	OFF
6	-2.5	OFF
7	-2.0	OFF
8	-1.5	OFF
9	-1.0	OFF
10	-0.5	OFF
11	0.0	OFF

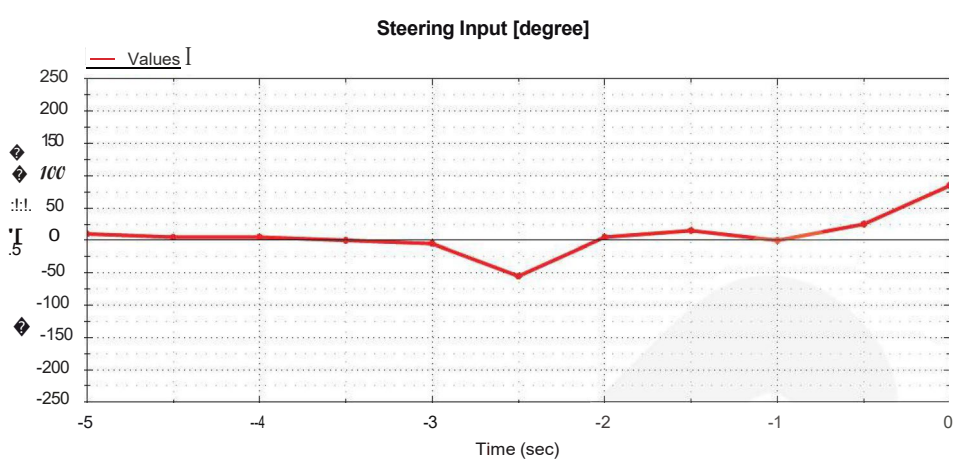
ABS Activity

num	Time (sec)	ABS Activity [on/off]
I	-5.0	OFF
2	-4.5	OFF
3	-4.0	OFF
4	-3.5	OFF
5	-3.0	OFF
6	-2.5	OFF
7	-2.0	OFF
8	-1.5	OFF
9	-1.0	OFF
10	-0.5	OFF
11	0.0	OFF

Stability Control

num	Time (sec)	Stability Control [on/off/engaged]
I	-5.0	on
2	-4.5	on
3	-4.0	on
4	-3.5	on
5	-3.0	on
6	-2.5	on
7	-2.0	on
8	-1.5	on
9	-1.0	on
10	-0.5	on
11	0.0	Engaged

‹ Event l ›
Steering Input



num	Time (sec)	Steering input [degree]
I	-5.0	**10**
2	-4.5	5
3	-4.0	5
4	-3.5	0
5	-3.0	-5
6	-2.5	-55
7	-2.0	5
8	-1.5	15
9	-1.0	0
10	-0.5	25
11	0.0	85

notel Positive value(CCWI, negative value(CWI

‹ Event l ›

System Status at Event

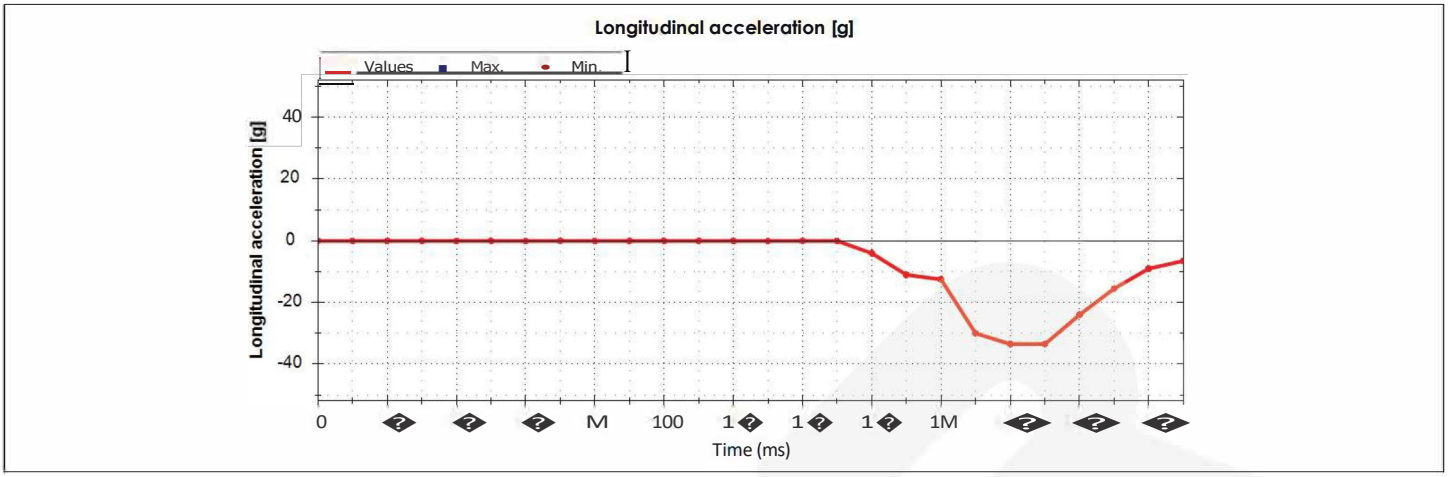
Airbag warning lamp on/off	OFF
Safety seat belt status, driver	on
Safety seat belt status, passenger	on
Seat track position switch foremost status, driver	not Supported
Seat track position switch foremost status, passenger	not Supported
Occupant size classification, driver (5% female or larger)	not Supported
Occupant size classification, passenger (child)	YES

Deployment Command Data at Event

Front airbag deployment time, driver (first stage) [msec]	161
Front airbag deployment time, passenger (first stage) [msec]	no deployment
Front airbag deployment time, driver (second stage) [msec]	165
Front airbag deployment time, passenger (second stage) [msec]	no deployment
Front airbag deployment time, driver (third stage) [msec]	not Supported
Front airbag deployment time, passenger (third stage) [msec]	not Supported
Front airbag disposal deployment, driver (second stage) (Yes or no)	no
Front airbag disposal deployment, passenger (second stage) (Yes or no)	no
Front airbag disposal deployment, driver (third stage) (Yes or no)	no
Front airbag disposal deployment, passenger (third stage) (Yes or no)	no
Front side airbag deployment time, driver [msec]	no deployment
Front side airbag deployment time, passenger [msec]	no deployment
Curtain airbag deployment time, driver [msec]	no deployment
Curtain airbag deployment time, passenger [msec]	no deployment
Seat belt pretensioner deployment time, driver [msec]	161
Seat belt pretensioner deployment time, passenger [msec]	161

‹ Event l ›

Longitudinal crash pulse acceleration Cg, 0 ,.., 250msec)

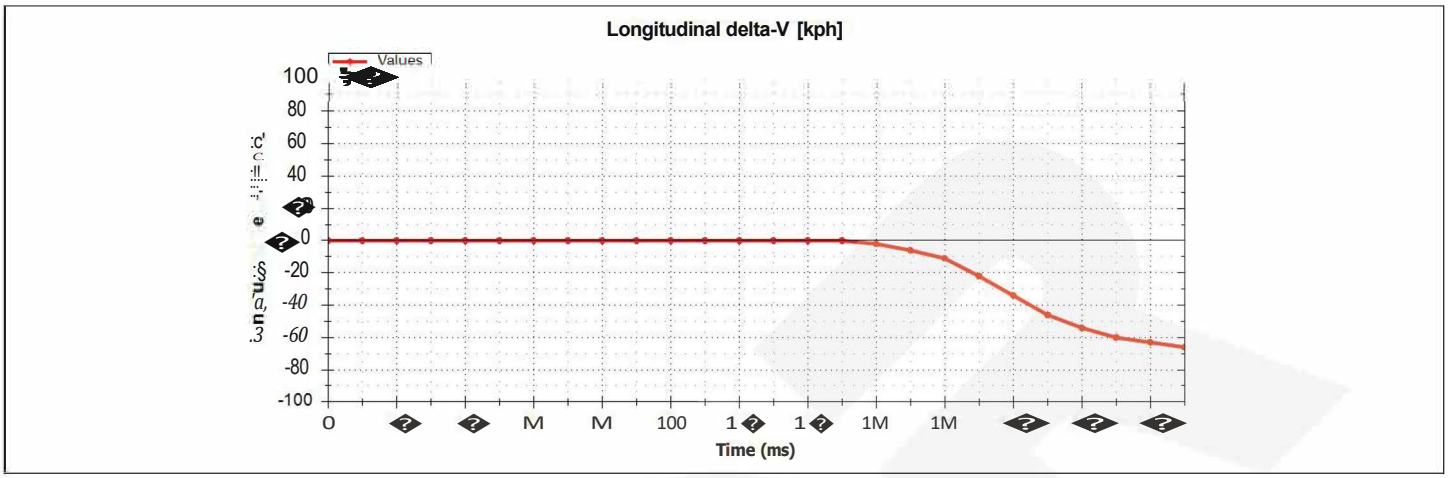


num	Time (ms)	Longitudinal acceleration [g]
I	0.0	0.0
2	10.0	0.0
3	20.0	0.0
4	30.0	0.0
5	40.0	0.0
6	50.0	0.0
7	60.0	0.0
8	70.0	0.0
9	80.0	0.0
10	90.0	0.0
11	100.0	0.0
12	110.0	0.0
13	120.0	0.0
14	130.0	0.0
15	140.0	0.0
16	150.0	0.0
17	160.0	-4.0
18	170.0	-11.0
19	180.0	-12.5
20	190.0	-30.0
21	200.0	-33.5
22	210.0	-33.5
23	220.0	-24.0
24	230.0	-15.5
25	240.0	-9.0
26	250.0	-6.5

‹ Event l ›

Longitudinal crash pulse delta-v (kph, 0 - 250msec)

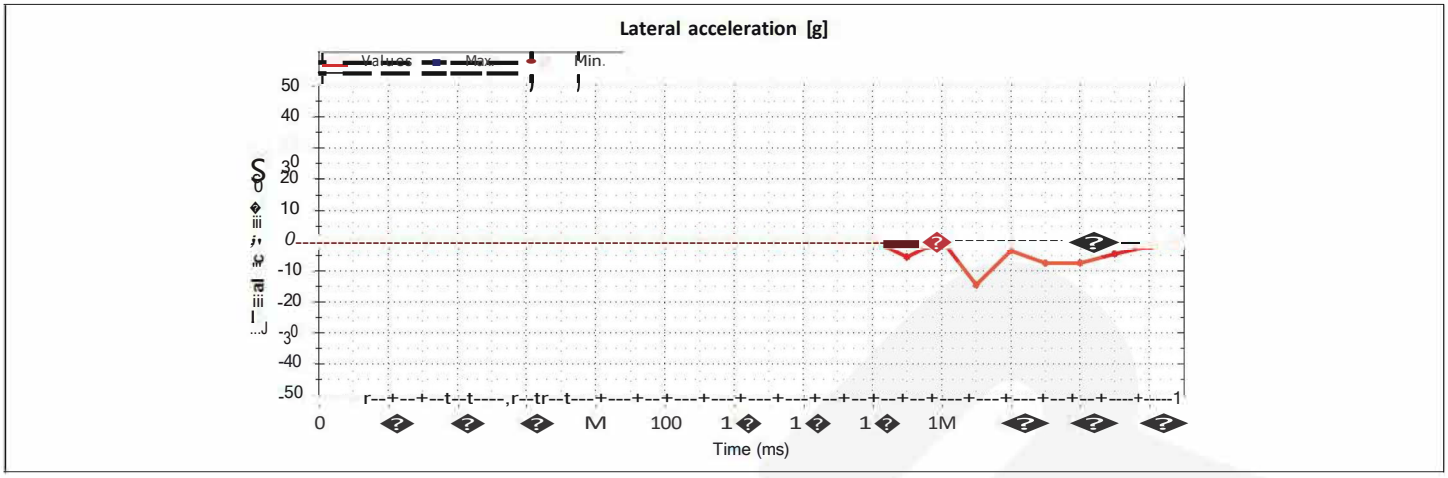
Max. delta-V [kph]	–7/
Time, Max. delta-V [msec]	297.5



num	Time (ms)	Longitudinal delta-V [kph]
l	0.0	0
2	10.0	0
3	20.0	0
4	30.0	0
5	40.0	0
6	50.0	0
7	60.0	0
8	70.0	0
9	80.0	0
10	90.0	0
11	100.0	0
12	110.0	0
13	120.0	0
14	130.0	0
15	140.0	0
16	150.0	0
17	160.0	-2
18	170.0	-6
19	180.0	-11
20	190.0	-22
21	200.0	-34
22	210.0	-46
23	220.0	-54
24	230.0	-60
25	240.0	-63
26	250.0	-66

‹ Event l ›

Lateral crash pulse acceleration Cg, 0 - 250msec)

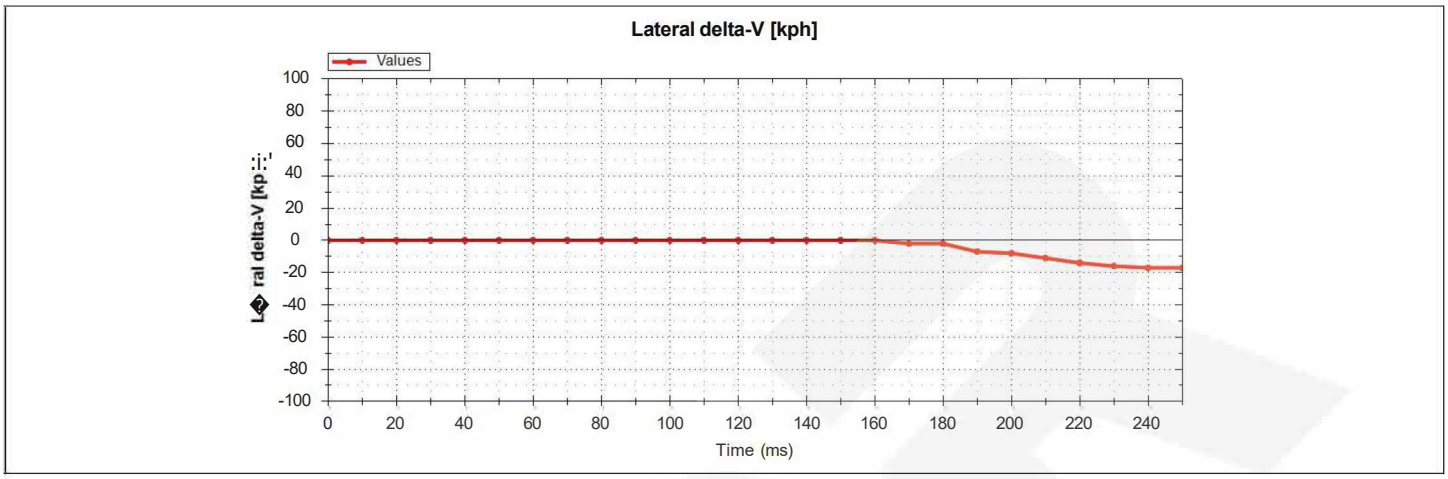


num	Time (ms)	Lateral acceleration [g]
I	0.0	0.0
2	10.0	0.0
3	20.0	0.0
4	30.0	0.0
5	40.0	0.0
6	50.0	0.0
7	60.0	0.0
8	70.0	0.0
9	80.0	0.0
10	90.0	0.0
11	100.0	0.0
12	110.0	0.0
13	120.0	0.0
14	130.0	0.0
15	140.0	0.0
16	150.0	0.0
17	160.0	0.0
18	170.0	-5.5
19	180.0	0.0
20	190.0	-14.5
21	200.0	-3.5
22	210.0	-7.5
23	220.0	-7.5
24	230.0	-4.5
25	240.0	-2.0
26	250.0	0.0

‹ Event l ›

Lateral crash pulse delta-v (kph, 0 - 250msec)

Max. delta-V [kph]	-17
Time, Max. delta-V [msec]	260.0



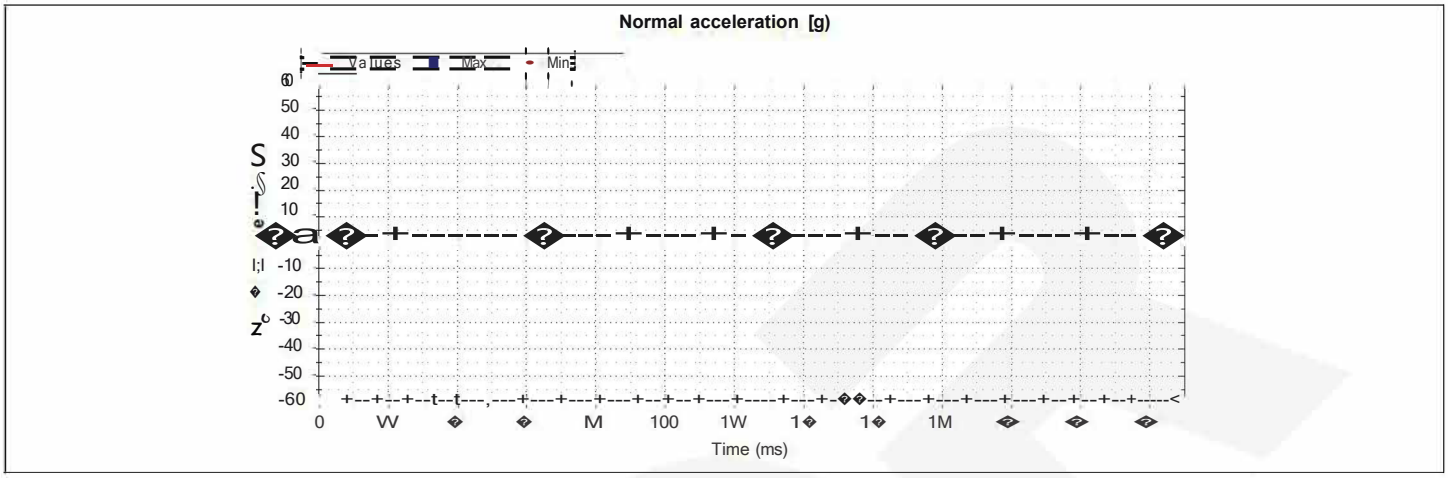
num	Time (ms)	Lateral delta-V [kph]
I	0.0	0
2	10.0	0
3	20.0	0
4	30.0	0
5	40.0	0
6	50.0	0
7	60.0	0
8	70.0	0
9	80.0	0
10	90.0	0
11	100.0	0
12	110.0	0
13	120.0	0
14	130.0	0
15	140.0	0
16	150.0	0
17	160.0	0
18	170.0	-2
19	180.0	-2
20	190.0	-7
21	200.0	-8
22	210.0	-11
23	220.0	-14
24	230.0	-16
25	240.0	-17
26	250.0	-17

‹ Event l ›

Crash pulse Resultant, Time Max. delta-V resultant CO - 300 msec)

Time, Max. delta-V, resultant [msec]	**287.5**

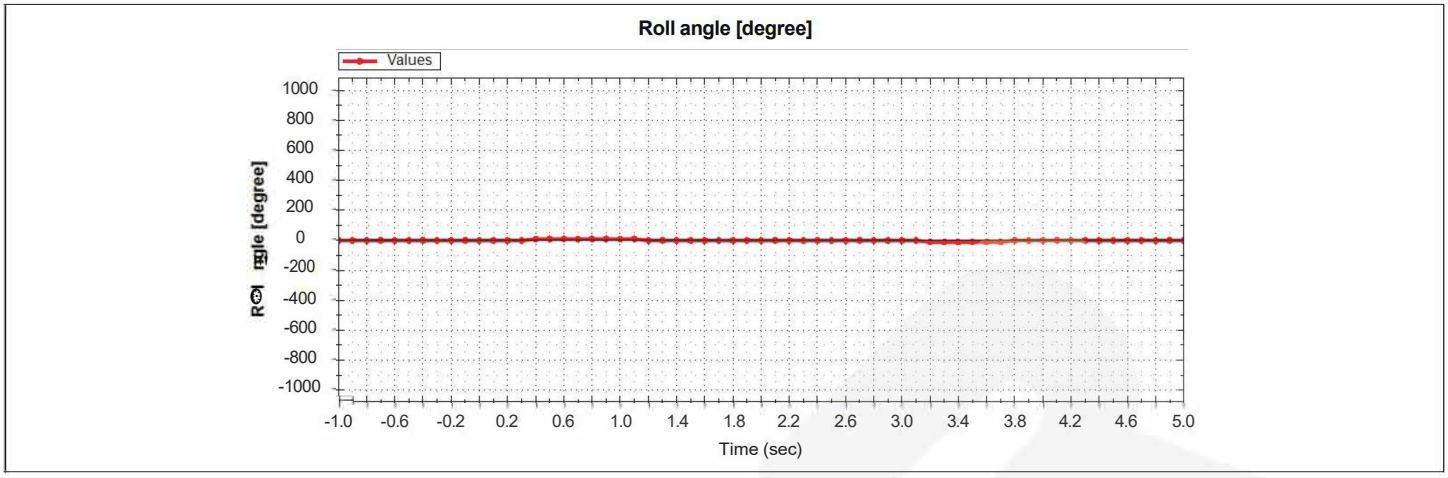
normal acceleration Cg, 0 - 250msec)



num	Time (ms)	normal acceleration [g]
l	**0.0**	not supported
2	**10.0**	not supported
3	**20.0**	not supported
4	**30.0**	not supported
5	**40.0**	not supported
6	**50.0**	not supported
7	**60.0**	not supported
8	**70.0**	not supported
9	**80.0**	not supported
10	**90.0**	not supported
11	**100.0**	not supported
12	**110.0**	not supported
13	**120.0**	not supported
14	**130.0**	not supported
15	**140.0**	not supported
16	**150.0**	not supported
17	**160.0**	not supported
18	**170.0**	not supported
19	**180.0**	not supported
20	**190.0**	not supported
21	**200.0**	not supported
22	**210.0**	not supported
23	**220.0**	not supported
24	**230.0**	not supported
25	**240.0**	not supported
26	**250.0**	not supported

‹ Event l ›

Roll angle (degree, -1 "' 5sec)



num	Time (sec)	Roll angle [degree]
I	-1.0	0
2	-0.9	0
3	-0.8	0
4	-0.7	0
5	-0.6	0
6	-0.5	0
7	-0.4	0
8	-0.3	0
9	-0.2	0
10	-0.l	0
11	0.0	0
12	0.1	0
13	0.2	0
14	0.3	0
15	0.4	10
16	0.5	10
17	0.6	10
18	0.7	10
19	0.8	10
20	0.9	10
21	1.0	10
22	1.1	10
23	1.2	0
24	1.3	0
25	1.4	0
26	1.5	0
27	1.6	0
28	1.7	0
29	1.8	0
30	1.9	0
31	2.0	0

32	2.1	0
33	2.2	0
34	2.3	0
35	2.4	0
36	2.5	0
37	2.6	0
38	2.7	0
39	2.8	0
40	2.9	0
41	3.0	0
42	3.1	0
43	3.2	-10
44	3.3	-10
45	3.4	-10
46	3.5	-10
47	3.6	-10
48	3.	-10
49	3.8	0
50	3.9	0
51	4.0	0
52	4.1	0
53	4.2	0
54	**4.3**	0
55	4.4	0
56	**4.5**	0
57	4.6	0
58	4.7	0
59	4.8	0
60	4.9	0
61	5.0	0

‹ Event 2 ›

There is no recorded event.

DOT HS 813 596
July 2024

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

16304-071924-v3