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**Special Crash Investigations:
On-Site Air Bag Non-Deployment
Crash Investigation;
Vehicle: 2019 Hyundai Tucson;
Location: Massachusetts;
Crash Date: August 2020**

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Special Crash Investigations
On-Site Air Bag Non-Deployment Crash Investigation
Office of Defects Investigation
Case Number: CR20026
Vehicle: 2019 Hyundai Tucson
Location: Massachusetts
Crash Date: August 2020

Background

This report documents the on-site investigation of the non-deployment of the air bag systems in a 2019 Hyundai Tucson (Figure 1). The Hyundai was struck in the left plane by a 2000 Ford F-350 at an angle while crossing an intersection and then struck a utility pole with its right front corner. The Hyundai had supplemental inflatable restraint systems including certified advanced 208-compliant (CAC) frontal, front-seat-mounted side impact, and dual-sensing (side impact and rollover) inflatable curtain (IC) air bags. However, none of the inflatable restraints deployed in the crash, which the vehicle's event data recorder (EDR) measured as a lateral delta V of 9 km/h (5.6 mph). The Hyundai was driven by an unbelted male of unknown age. He was transported by ambulance to a local hospital for evaluation of law-enforcement-reported possible (C-level) injuries and was released within hours of the crash.



Figure 1. Left front oblique view of the 2019 Hyundai Tucson

Notification of this crash was sent by a local towing service operator to a regional Crash Investigation Sampling System (CISS) office, which forwarded the notification to the Special Crash Investigations (SCI) group of the National Highway Traffic Safety Administration. The Office of Defects Investigation requested further research, and the crash was assigned for on-site investigation by the SCI team at Crash Research & Analysis, Inc., in August 2020. The Hyundai's insurance company agreed to cooperate with inspection of the Hyundai, and the on-site investigation took place in August 2020. This included exterior and interior inspection of the Hyundai to measure exterior deformation, interior damage and intrusion, to document any evidence of interior occupant contact, and to examine the manual and supplemental restraint systems. A third-party data collector for the Hyundai's manufacturer participated in the SCI

vehicle inspection and imaged data from its EDR. An electronic file copy of the imaged data was given to the SCI investigator. In addition to the Hyundai inspection, the SCI investigator also documented the crash site using digital photographs and a Nikon total station mapping system.

An in-person visit was made to the last-known address of the Ford's owner, where an exterior photographic inspection of the Ford was conducted on a public roadway. The Hyundai's owner could not be located. Literature was left at the address, but no person has contacted the SCI team as of the date of this report.

Through the course of this SCI investigation, it was apparent that the crash was of insufficient severity to warrant supplemental restraint actuation and deployment. The left plane impact by the Ford was focused in the softer center area of the Hyundai's left front door and did not involve the surrounding structure or frame of the vehicle. Based on the observed damage to the Hyundai and the SCI reconstruction of the crash events, supplemental restraint device actuation/deployment would not be expected. The Hyundai's EDR recorded a lateral delta V of 9 km/h (5.6 mph), and no supplemental restraint device deployment commands were given by the air bag control unit (ACU). No evidence of anomaly or performance malfunction could be identified, as the Hyundai's systems appeared to have operated as designed.

Summary

Crash Site

This crash occurred at the intersection of a one-way street with a two-lane cross street in an urban setting during the afternoon. Reported weather conditions in the locale included mostly cloudy skies, a temperature of 29 °C (84 °F), 67-percent relative humidity, and a southerly wind of 21 km/h (13 mph). The one-way roadway measured 7.2 m (23.6 ft) wide, and was oriented in a southerly direction. The intersecting roadway was oriented east/west and was 9.1 m (29.9 ft) wide. There were no painted lane markings on any of the roadways, and numerous vehicles were parked along the curb in all directions. Traffic was uncontrolled on the southbound one-way roadway but controlled on the intersecting roadway by stop signs and painted stop bars. Figure 2 shows the Hyundai's southbound pre-crash trajectory on the one-way roadway, while Figure 3 shows the Ford's westbound pre-crash trajectory. Speed was regulated by a posted limited of 48 km/h (30 mph). A crash diagram is included at the end of this report.



Figure 2. Southbound view of the Hyundai's pre-crash approach to the crash site



Figure 3. Westbound view of the Ford's pre-crash approach to the crash site

Pre-Crash

The Hyundai was driven by an unknown-aged male. He did not use the available seat belt system as he drove the Hyundai southbound on the one-way urban street. Data imaged from the Hyundai EDR showed the vehicle was traveling at a speed of 35 km/h (22 mph) at 2 seconds prior to the crash, with the driver braking (brakes reported on, minimal deceleration).

The Ford was driven by a male, age unknown. His use of the available manual restraint system is unknown. The Ford traveled west and approached the intersection. According to law enforcement documentation of the crash, the Ford driver reported that he had brought the Ford to a controlled stop at the intersection and did not see any vehicles coming southbound. He further reported that he proceeded to continue westbound and accidentally struck the Hyundai that was traveling south. Based on the law enforcement documentation, the driver of the Ford did not detect the Hyundai prior to impact and made no avoidance attempt.

Data imaged from the Hyundai EDR indicated that its driver saw the Ford entering the intersection and steered right and braked in an attempt to avoid the crash. At 1 second prior to algorithm enable (AE), the driver initiated an increasing right steering input that reached 45 degrees. The vehicle also decelerated to 27 km/h (17 mph) at time zero.

Crash

The first crash event occurred as the front plane, right aspect of the Ford struck the left plane of the Hyundai at an angle in the intersection (Event 1). Directions of force were in the 10 o'clock sector for the Hyundai and the 2 o'clock sector for the Ford. The Hyundai maintained forward momentum and was redirected toward the southwest by the impact and exacerbated by the Hyundai driver's sharp right steering input. The Hyundai approached the southwest intersection quadrant, and its right front corner struck a wooden utility pole (Event 2). It came to final rest on the west edge of the road in the southwest intersection quadrant, with the right front corner of the Hyundai against the utility pole facing southwest. The Ford came to a controlled stop in the intersection.

Post-Crash

The local emergency response system received several calls reporting the crash. Law enforcement, fire department, and EMS personnel responded to the crash scene. Fire department personnel used hydraulic tools to pry open the Hyundai driver's door. The driver was then assisted from the vehicle by EMS personnel and transported by ground ambulance to a local hospital. He was evaluated for law-enforcement-reported possible (C-level) injuries, treated, and released within hours of the crash. A recovery service responded to the crash scene and towed the Hyundai to a local yard. The tow operator identified the non-deployment of the Hyundai's supplemental restraints and reported it to the regional CISS office. The Hyundai was deemed a total loss by its insurer and transferred to a vehicle salvage facility. The driver of the Ford was not injured and drove the Ford from the scene (non-tow).

2019 Hyundai Tucson

Description

The 2019 Hyundai Tucson (Figure 4) was manufactured in Korea during June 2019. It was identified by the VIN KM8J2CA42KUxxxxxx. The electric odometer reading obtained during the SCI inspection was 5,905 km (3,669 mi). The Hyundai was an all-wheel-drive platform, equipped with the SE trim package and powered by a 2.0-liter, inline 4-cylinder, gasoline engine linked to an automatic transmission. Its service brakes were power-assisted, 4-wheel disc with antilock, while the steering was hydraulic-power-assisted rack-and-pinion. Additional features included traction control, stability control, tire pressure monitoring, and a rear-view camera.



Figure 4. Left front oblique view of the 2019 Hyundai Tucson at the time of the SCI vehicle inspection

The gross vehicle weight rating was 2,150 kg (4,740 lb), with gross axle weight ratings of 1,200 kg (2,646 lb) front and 1,150 kg (2,535 lb) rear. The vehicle manufacturer's recommended tire size was P225/60R17, with recommended cold tire pressures of 240 kPa (35 psi) for all four axle positions. At the time of the SCI inspection the Hyundai had Michelin Primacy A/S tires of the vehicle manufacturer's recommended size at all four axle positions. All four tires had 6 mm (7/32 in) of tread. None of the tires were damaged or restricted relative to the crash.

The Hyundai's interior had seating for five occupants (2/3), with front-row bucket seats and a second-row bench seat with split forward-folding seatbacks. All seating positions were cloth-surfaced and featured adjustable head restraints, and were equipped with 3-point lap and shoulder seat belts for manual restraint. Its supplemental restraint systems included front-seat belt retractor pretensioners and eight inflatable supplemental restraints. None of the supplemental restraint systems were commanded to actuate or deploy in this crash.

Vehicle History

A commercially available vehicle history for this specific 2019 Hyundai Tucson indicated it had only one owner over its lifetime. It was purchased new from a manufacturer dealership, then registered and titled in the State of Massachusetts during October of 2019. There were no maintenance records. There was one crash reported by the vehicle history report which, based on the date, was the crash under investigation.

Exterior Damage

This crash involved the left plane and right front corner aspects of the Hyundai. Left plane damage was associated with the impact by the front plane of the Ford, while the front plane damage resulted from the impact to the wooden utility pole. The left plane damage consisted of crush/deformation focused on the driver's door. Direct contact began on the left lower A-pillar 35 cm (13.8 in) rearward of the left front axle position (10 cm (4 in) forward of the left front door edge). It extended 124 cm (49 in) rearward across the left front door and ended 159 cm (62.6 in) rearward of the left front axle position on the B-pillar, 10 cm (4 in) rearward of the seam between the left side doors (Figure 5). The left front door was crushed laterally at mid-door level and jammed shut by the engagement with the Ford's bumper beam. It was forced open post-crash by fire department personnel using hydraulic tools and would not re-close.

A residual crush profile was obtained across the mid-door level using a profile that matched the direct contact, which produced the following resultant measurements: C1 = 0 cm, C2 = 4 cm (1.6 in), C3 = 8 cm (3.1 in), C4 = 8 cm (3.1 in), C5 = 6 cm (2.4 in), and C6 = 3 cm (1.2 in).

Maximum crush measured 8 cm (3.2 in) and was located near the center of the left front door, 103 cm (40.6 in) rearward of the left front axle position. A corresponding collision deformation classification (CDC) of 10LPEW1 was assigned to the Hyundai's left plane damage profile. The damage algorithm of the WinSMASH model was used to calculate the severity of the crash. The total calculated vehicle velocity change (delta V) was 12 km/h (7.5 mph), with specific longitudinal and lateral components of -8 km/h (-5.0 mph) and 9 km/h (5.6 mph). These results seemed reasonable, fit the model, and were similar to the EDR-recorded values.

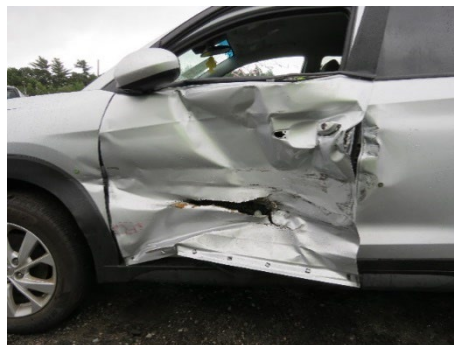


Figure 5. Left plane damage profile to the Hyundai



Figure 6. Minor right front corner damage to the Hyundai

There was cosmetic damage to the right corner of the front bumper fascia that had resulted from the impact with the wooden utility pole. The damage included a fracture to the right headlight assembly, with abrasions to the bumper fascia and right front fender. There was no discernable deformation to the bumper beam or any of the Hyundai's structure (Figure 6). The CDC assigned to the minor front damage profile was 12FREE3. No WinSMASH calculations could be computed due to the lack of residual deformation.

Event Data Recorder

The 2019 Hyundai Tucson had an air bag control unit (ACU) mounted to the floor on the center tunnel, beneath the center console. The ACU monitored the diagnostic functions of the vehicle's restraint systems (air bags and seat belt pretensioners) and controlled the deployment/actuation of those devices dependent upon crash event severity. The ACU also had EDR capabilities to record crash event data for longitudinal (front/rear), lateral (side), and non-horizontal (rollover) crash events. The Hyundai was not supported by the Bosch Crash Data Retrieval software/tool; therefore, the SCI investigator had no way to image any Hyundai data. However, the manufacturer representative who attended the SCI vehicle inspection used a Global Information Technology interface and software and successfully imaged data from the EDR of the Hyundai's ACU. The representative provided an electronic PDF copy of the imaged data to the SCI investigator. A sanitized copy of this data is included at the end of this technical report as Appendix A.

The Hyundai's EDR could store up to two crash events. A crash event was any occurrence that caused a trigger threshold to be achieved or surpassed, or any supplemental restraint system to be actuated/deployed. If an inflatable restraint system was commanded, it was termed as a deployment event. Deployment events became locked to memory and could not be overwritten. If no inflatable restraints were deployed, but an event was still recognized, it was termed as a non-deployment event. Non-deployment events could include pretensioner actuation commands. These types of events were not locked and could be overwritten by subsequent events of greater severity. If power supply to the ACU was lost during or following a crash event, all or part of the data may not be completely recorded to the EDR's memory. The imaged data contained one recognized and completely recorded event, which occurred on ignition cycle 2,590. The data was retrieved on ignition cycle 2,599, a nominal difference compared with the ignition cycle at the time of the crash, which was attributed to the Hyundai's post-crash movement. The imaged data was confirmed to be recorded from the crash under investigation. It included pre-crash data that indicated that the driver steered right and applied the brakes in an attempt to avoid the crash. An asynchronous accelerator pedal input was indicated at time zero, possibly related to driver panic.

Time (sec)	Speed (km/h [mph])	Accel. Pedal (%)	Service Brake	Steering (deg)
-5.0	36 [22.4]	1	On	0
-4.5	35 [21.7]	0	On	0
-4.0	35 [21.7]	0	On	0
-3.5	35 [21.7]	0	On	0
-3.0	35 [21.7]	0	On	0
-2.5	35 [21.7]	0	On	0
-2.0	35 [21.7]	0	On	0
-1.5	35 [21.7]	0	On	0
-1.0	34 [21.1]	0	On	-5

Time (sec)	Speed (km/h [mph])	Accel. Pedal (%)	Service Brake	Steering (deg)
-0.5	34 [21.1]	1	On	-20
0.0	27 [16.8]	29	On	-45

When the event was recorded, the Hyundai's air bag warning lamp was reported as "off." Neither the driver nor the front right passenger seat belt systems were buckled when the event occurred. No actuation or deployment commands were triggered relative to the recorded non-deployment event. The maximum recorded longitudinal delta V of the crash pulse was -10 km/h (-6.2 mph) at 300 milliseconds after AE, and the maximum recorded lateral delta V was 9 km/h (5.6 mph) at 125 milliseconds after AE. Both the longitudinal and the lateral crash pulses were minor in severity over a long time interval.

Interior Damage

Interior inspection of the Hyundai revealed that there had been minor intrusion into the occupant compartment of the vehicle, and the left front glazing was disintegrated. All the Hyundai's doors remained closed during the crash. The left front door was jammed shut by crash damage, but the remaining doors remained operational post-crash. All the Hyundai's glazing, with exception to the left front, did not sustain crash damage or occupant contact.

Although the Hyundai's driver was not belted, there were no discernable occupant contacts identified in the Hyundai at the time of the SCI vehicle inspection. It is likely that the unbelted driver contacted the left front door's interior surfaces with his left flank, but there was no physical evidence identified to support these kinematics.

Minor intrusion into the occupant compartment associated with the crash consisted of the 8 cm (3.1 in) lateral intrusion of the forward and rear lower quadrants of the left front door. The interior fascia panel of the door was found loose in the trunk area of the Hyundai during the SCI inspection; it likely came off of the left front door as a result of the fire department's use of the hydraulic rescue tools. Figure 7 shows the left front door panel at the time of the SCI vehicle inspection.



Figure 7. View of the Hyundai's driver door panel, devoid of discernable contact evidence

Manual Restraint Systems

The Hyundai had 3-point continuous loop lap and shoulder seat belt systems for all five seat positions. The front seat belt systems had adjustable D-rings and used lightweight locking latch plates, while the second-row seat belt systems all featured sliding latch plates. The driver's seat belt retracted onto an emergency locking retractor (ELR), while the four other systems used switchable ELR/automatic locking retractors (ALR). Both front seat belt systems were equipped with retractor pretensioners.

At the time of the SCI vehicle inspection, the driver's seat belt system had been extended from the retractor and tied around the upper aspect of the driver's door frame. It was apparent that this had been done by an individual involved in the Hyundai's post-crash movement, in order to hold the deformed door against the side of the Hyundai and prevent it from swinging open. The SCI investigator untied the belt system and observed that the webbing spooled freely from and back onto the retractor, and the retractor remained functional. The D-ring was adjusted to the full-up position. There was no evidence of loading, and no damage to the driver's seat belt system. The SCI investigator concluded that the driver was not belted at the time of the crash. This conclusion was later supported by the data imaged from the Hyundai's EDR, which indicated that the driver's seat belt system was not buckled when the crash event occurred.

Supplemental Restraint Systems

The Hyundai had devices to provide for the supplemental restraint of its occupants. This included a certified advanced 208-compliant (CAC) frontal air bag system, front-seat-mounted side impact air bags, and dual-sensing (side impact and rollover) IC air bags. The CAC system consisted of driver's and passenger's frontal air bags, front-seat track position sensors, front-seat belt buckle switch sensors, front retractor pretensioners, and a front right occupant classification sensor. The driver's frontal air bag was mounted in the steering wheel hub, while the passenger's frontal air bag was a top-mount design in the right instrument panel. The front-seat-mounted side impact air bags were mounted in the outboard aspect of each front seat, adjacent to the B-pillars, and provided supplemental protection for lateral (side) crash forces. The IC air bags were mounted to the roof side rails and concealed by the vehicle's headliner, designed to provide outboard protection for both seating rows. Labeling molded into the polymer surfaces of the pillar trim panels identified the presence of the IC air bags. The supplemental restraints (air bags and pretensioners) were controlled and monitored by the center tunnel-mounted ACU. None of the supplemental restraint systems actuated or deployed in this crash.

Air Bag Non-Deployment Discussion

This crash was reported to a regional CISS office by the operator of a towing/recovery service, who had towed the Hyundai from the crash scene. The tow operator believed the severity of the crash should have warranted deployment of the Hyundai's side impact air bags. The SCI investigator attempted to conduct an in-person interview of the vehicle's driver/owner, but this person was not available when the SCI investigator conducted the on-site portion of this investigation. As of the date of this report, the driver/owner of the Hyundai has not responded to literature left at his residence by the SCI investigator and could not be located or contacted.

Due to the lack of driver/owner interview, and corresponding unknown demographic information, specific injuries sustained by the driver (if any) relative to the crash remain unknown. However, the SCI investigator confirmed through the vehicle's insurer that the driver was treated and released within hours of the crash.

Through the course of this SCI investigation, it was apparent that the crash was of insufficient severity to warrant/result in supplemental restraint actuation/deployment. The left plane impact by the Ford resulted in minor damage to the door of the Hyundai, and only produced a maximum lateral delta V of 9 km/h (5.6 mph) as recorded by the EDR. The impact was focused in the softer center area of the door, and did not involve the surrounding structure or frame of the vehicle.

Of note, the right front tow hook of the Ford tore the metal skin of the Hyundai's left front door. In the door, as part of the vehicle's sensing and diagnostic equipment, was a peripheral pressure sensor. Based on SCI expertise and confirmed by the Hyundai representative, peripheral pressure sensors are specifically designed to measure and detect rapid changes in atmospheric pressure resulting from deformation, such as the deformation to a door that occurs in a crash. Pressure sensors, in conjunction with had peripheral accelerometers, provide data to the supplemental restraint system's control module. The control module must make a near-instantaneous determination – approximately 5 milliseconds or less - as to whether or not supplemental restraint system actuation/deployment commands are warranted. This decision is based on the analysis of data provided by the peripheral sensors relative to the manufacturer's proprietary algorithms.

The SCI investigator observed, and the Hyundai representative confirmed, that the damage and tear of the Hyundai's door skin could affect the *future* performance of the peripheral pressure sensor. However, in this crash, the tear to the door would have occurred *after* the pressure sensor had already detected the deformation to the door, measured the atmospheric pressure differential, and provided that data to the Hyundai's ACU. Therefore, it is unlikely that the tear to the door affected ACU or its deployment algorithm, which ultimately determined supplemental restraint system actuation/deployment should not have occurred in this crash.

Data imaged from the ACU confirmed that the crash pulse experienced by the Hyundai from the impact by the Ford had a vehicle velocity change (delta V) over an extended time. This correlated to a low-acceleration severity, and therefore, a low-magnitude crash pulse. The ACU appropriately did not command actuation or deployment of any of the Hyundai's supplemental restraint systems in this crash with the Ford. The secondary right front corner impact to the Hyundai with the wooden utility pole involved the soft corner of the vehicle's bumper fascia. There was no structural involvement, and no residual deformation sustained by the Hyundai relative to the utility pole contact. This event did not produce a crash pulse that was detected or recorded by the ACU as a crash event.

Based on the observed damage profiles to the Hyundai and the SCI reconstruction of the crash events, supplemental restraint actuation/deployment would not be expected. No evidence of anomaly or performance malfunction could be identified. The Hyundai's systems appeared to have operated as designed.

NHTSA Recalls and Investigations

A VIN-based query of NHTSA's recall database (www.nhtsa.gov/recalls) for the 2019 Hyundai Tucson as of the September 2022 date of this report indicated that there were no open recalls or investigations pertaining to this specific vehicle.

2019 Hyundai Tucson Occupant

Driver Demographics

Age/sex:	Unknown/male
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat type:	Forward-facing bucket seat with adjustable head restraint
Seat track position:	Between middle and rearmost
Manual restraint usage:	3-point lap and shoulder seat belt with retractor pretensioner available; not used
Usage source:	Vehicle inspection, EDR
Air bags:	Frontal, side impact, and IC air bags available; none deployed
Alcohol/drug involvement:	None reported (no test given)
Egress from vehicle:	Exited vehicle with some assistance
Transport from scene:	Ground ambulance to a local hospital
Type of medical treatment:	Treated and released within hours of the crash

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
N/A	Unknown	N/A	N/A	N/A

Source: non-responsive to in-person literature, demographic information unknown

Driver Kinematics

The male driver occupied the Hyundai alone. He was in the driver's seat, with the track adjusted to a position between middle and rearmost, and with the seatback slightly reclined. Despite the availability of the 3-point lap and shoulder seat belt, the driver was not belted. His lack of seat belt use was determined by the absence of evidence on the seat belt system at the time of the SCI inspection and confirmed by the Hyundai's EDR data.

He drove the Hyundai southbound on the urban one-way roadway. As the Hyundai entered the intersection, the driver saw the Ford enter the intersection. He braked and steered the Hyundai hard right in an attempt to avoid a crash. Despite his attempt, the Hyundai was struck by the Ford in the area of the driver's door. The unbelted driver initiated a left and slightly forward trajectory in response to the 10 o'clock direction of force. His left flank likely contacted and engaged the left door panel, which intruded slightly as a result of the lateral deformation from the impact engagement. Despite the high likelihood of his contact with door panel, the SCI investigator was unable to discern any specific physical evidence of such contact during the SCI vehicle inspection process.

The driver remained left and slightly forward as the Hyundai was redirected toward the southwest intersection quadrant. The secondary impact of the Hyundai's right front corner with the wooden utility pole was of insufficient magnitude to illicit further kinematic response from the driver or induce injury.

The left front door was jammed shut as a result of the damage sustained by the Hyundai from the impact with the Ford. Fire department personnel used hydraulic rescue tools to pry open the driver's door, then EMS personnel assisted the Hyundai's driver from the vehicle. He was transported by ground ambulance to a local hospital for the evaluation and treatment of law enforcement reported possible (C-level) injuries. According to the vehicle's insurer, the driver was treated and released from the hospital within hours of the crash. An in-person attempt by the SCI investigator to interview the driver was unsuccessful. As of the date of this report, the driver has not responded to literature and contact information left at his residence. Absent identifying demographic information, medical record data cannot be requested. Specific injuries sustained by the driver in the crash, if any, remain unknown.

2000 Ford F-350

Description

The 2000 Ford F-350 (Figure 8) was identified by the VIN 1FTSX31L7YExxxxxx. The Ford was located during the on-site portion of the SCI investigation legally parked on the side of the roadway in front of the address of its registered owner. However, the owner was not available, and no access to the locked vehicle's interior was available to the SCI investigator. Therefore, the vehicle's odometer reading remains unknown. The Ford was a 4-wheel drive extended cab pickup, with a single wheel rear axle. It had the Super Duty trim package and powered by a 5.4-liter, 8-cylinder, gasoline engine linked to an automatic transmission.



Figure 8. Left front oblique view of the 2000 Ford F-350 at the time of the SCI inspection

The Ford's gross weight rating was 4,490 kg (9,900 lb), with gross axle weight ratings of 2,358 kg (5,200) front and 3,098 kg (6,830 lb) rear. The vehicle manufacturer's recommended tire size was LT265/75R16, with recommended cold tire pressures of 379 kPa (55 PSI) front and 552 kPa (80 PSI) rear. At the time of the SCI inspection, the Ford had four tires of size LT245/75R16, mounted on OEM steel wheels. The tires were all different makes/models; however, they had a minimum of 2 mm (3/32 in) of tread. None of the tires were damaged or restricted relative to the crash.

The Ford had seating for six occupants (3/3), with a split front bench seat and a folding second-row bench seat. Manual restraint systems included 3-point lap and shoulder seat belts for the four outboard positions, with lap belts for the center positions. Supplemental restraint systems included front seat belt retractor pretensioners and a dual-stage frontal air bag system with passenger's cut-off switch. None of the Ford's supplemental devices actuated or deployed relative to the minor severity crash.

Exterior Damage

The Ford sustained minor damage on its front right corner aspect from the impact with the Hyundai. Direct contact began at the right front bumper corner and extended 90 cm (35.4 in) to the centerline. There were minor scratches and slight denting to the painted surface of the bumper beam, but there was no physical deformation/crush to the beam's contour. Absent

residual crush, the CDC assigned to the Ford for the minor contact damage from the impact with the Hyundai was 02FZLW1.



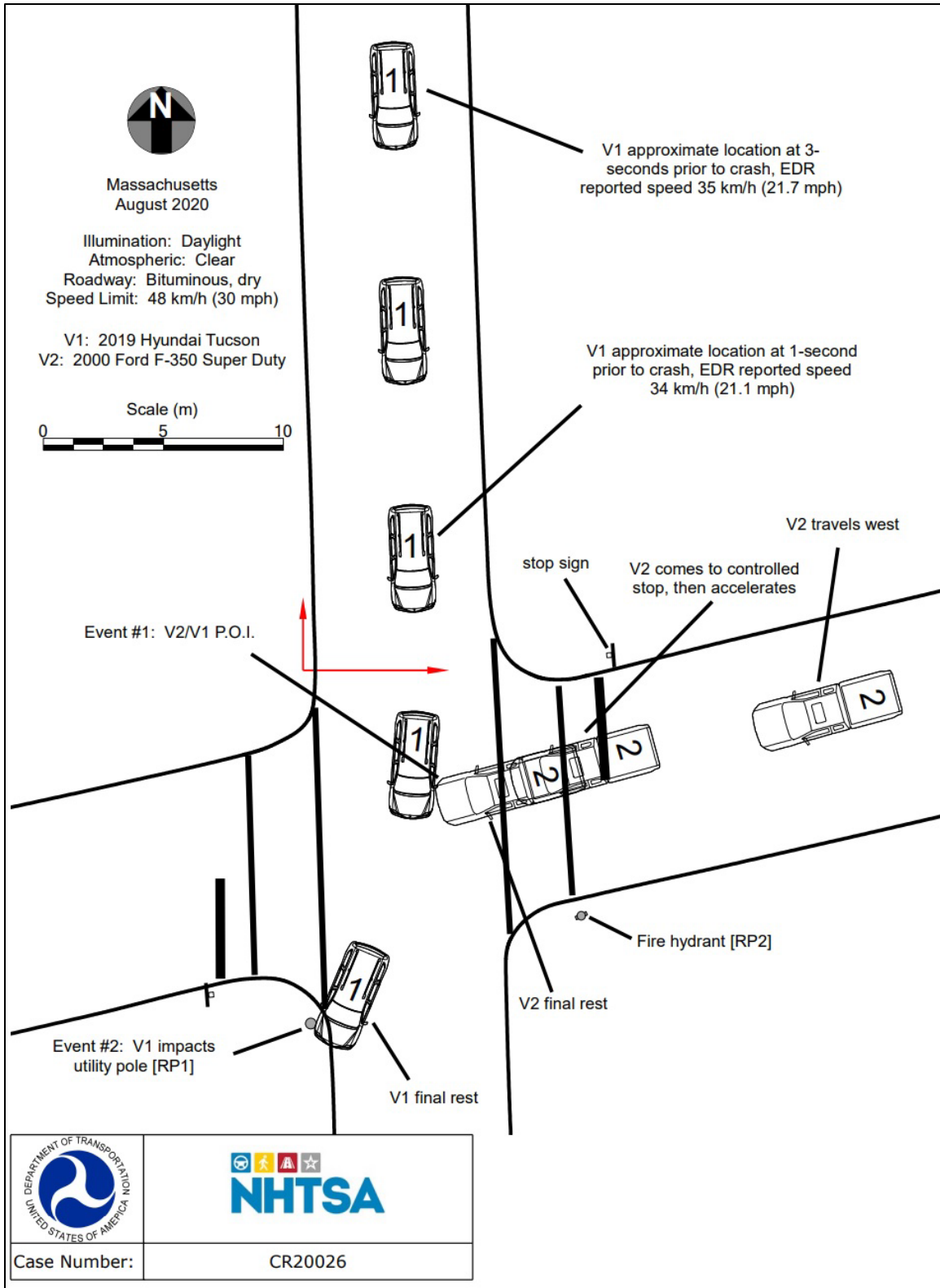
Figure 9. View of the Ford's front plane with minor direct contact discernable on the bumper beam

The damage algorithm of the WinSMASH model was used to calculate the severity of the crash. The total calculated vehicle velocity change (ΔV) of the Ford was 8 km/h (5.0 mph), with specific longitudinal and lateral components of -4 km/h (-2.5 mph) and -7 km/h (-4.4 mph), respectively. These results seemed reasonable and fit the model.

Occupant Data

The Ford was driven by male, age unknown. According to law enforcement documentation of the crash, the driver was belted. No air bags deployed in the Ford. The driver exited the Ford without assistance following the crash and denied injury. He was not medically treated or transported from the crash scene. He drove the Ford from the crash scene.

Crash Diagram



Case Number:

CR20026

Appendix A: 2019 Hyundai Tucson Event Data Recorder Report¹

¹ The EDR report contained in this technical report was imaged using the version of the Global Information Technology tool and software current at the time of the vehicle inspection by a third-party data collection representative of the Hyundai vehicle's manufacturer. A copy of the imaged data was provided to SCI for inclusion in this report. The EDR report contained in the associated Crash Viewer application may differ relative to this report. Hexidecimal data have been sanitized/removed to remove any possible personal identifiable information.



Vehicle Information

HYUNDAI TUCSON(TL) 2019 AIRBAG SYSTEM	
VIN as Programmed into EMS	KM8J2CA42KUxxxxxx

Additional Information

User-entered VIN	KM8J2CA42KUxxxxxx
User Name	
Case Number	
Crash Date	
Saved-on Date	2020-08-17 10:02
EDR Tool Version	E-Π-H-01-00-0035
EDR Report Version	EDR001-R01
Tire Size(s)	
Memo	

▣ Data Limitation

General Information:

Tools for downloading and interpreting the EDRs in Hyundai vehicles have been developed for vehicles produced after September 1, 2012. Currently, there is no tool for downloading and accurate interpreting data from the EDRs in Hyundai 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:
 1. Deployment Event:
 - 1) 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:
 - 1) 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
 1. the power mode change from OFF/Accessory 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.

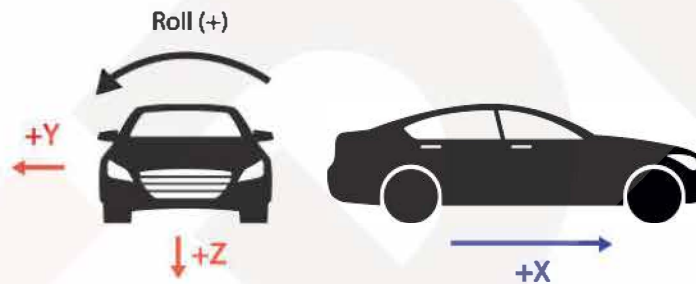
Data Limitation

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 1
Delta V, longitudinal	Forward direction	+X at the figure 1
Lateral acceleration	Left to Right direction	+Y at the figure 1
Delta V, lateral	Left to Right direction	+Y at the figure 1
Normal(vertical) acceleration	Downward direction	+Z at the figure 1
Vehicle roll angle	Clockwise about the longitudinal axis	Roll(+) at the figure 1
Steering input	Counterclockwise rotation	-

Figure 1. Sign Conventions



Data Sources:

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

- 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).
- 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.
- 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(T0). Time zero(T0) is not typically the time at which the vehicle made contact with another vehicle or object.
- Time zero (T0) means whichever of the following occurs first
 1. 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,
 - 1) 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 5msec 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 “1”.
- 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
 1. 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

EDR Information

Part No. (EOL Code) as programmed into ACU	95910-D3950(D396)
ECU SW Version as programmed into ACU	1.00
EDR Version as programmed into ACU	

< Event 1 >

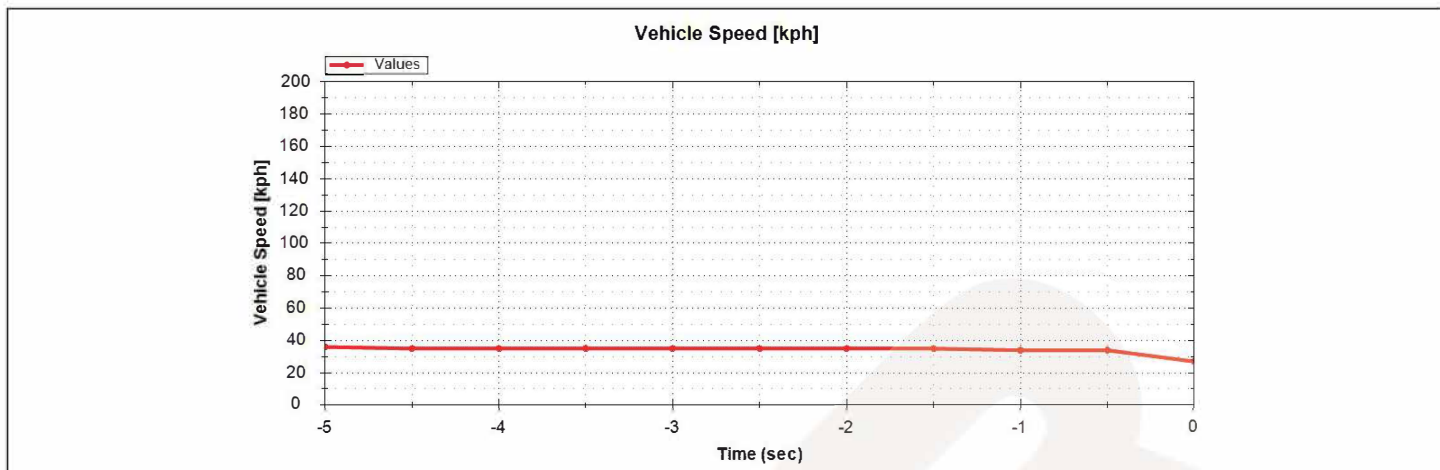
Event Status at Event

Multi-event, Number of Event (1 or 2)	1 event
Time from Event 1 to 2 [msec]	0
Completed File Recorded (Yes or No)	YES
Ignition cycle, crash [cycle]	2590
Ignition cycle, download [cycle]	2599

Pre-Crash Information (-5 ~ 0 sec)

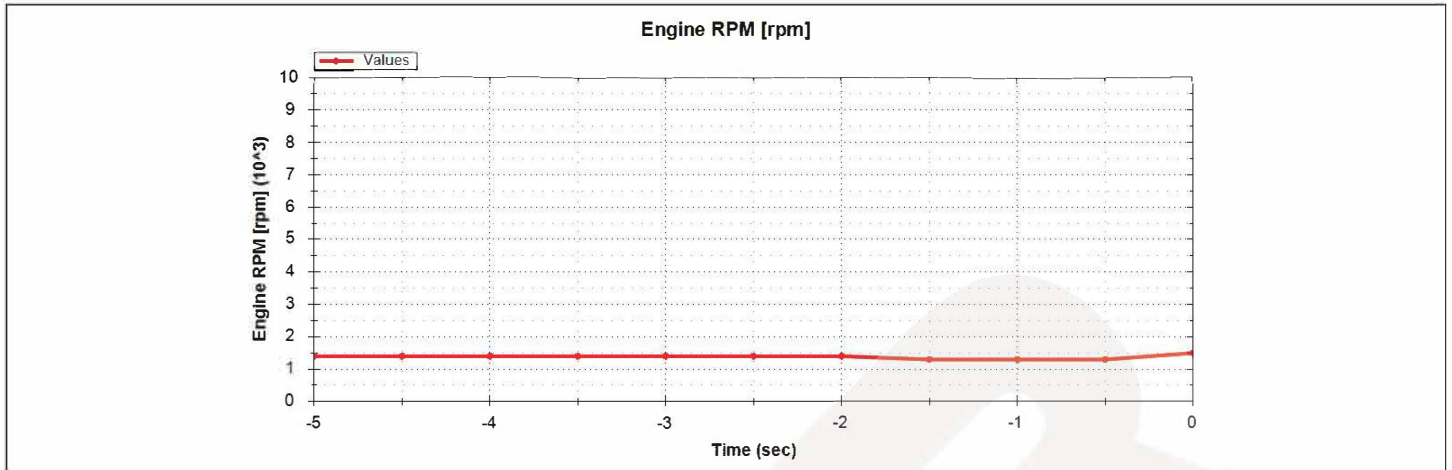
Time (sec)	Vehicle Speed [kph]	Engine RPM [rpm]	Engine Throttle [%]	Acceleration Pedal [%]	Service Brake [on/off]	ABS Activity [on/off]	Stability Control [on/off/engaged]	Steering Input [degree]
-5.0	36	1400	3	1	ON	OFF	ON	0
-4.5	35	1400	3	0	ON	OFF	ON	0
-4.0	35	1400	4	0	ON	OFF	ON	0
-3.5	35	1400	4	0	ON	OFF	ON	0
-3.0	35	1400	3	0	ON	OFF	ON	0
-2.5	35	1400	3	0	ON	OFF	ON	0
-2.0	35	1400	3	0	ON	OFF	ON	0
-1.5	35	1300	3	0	ON	OFF	ON	0
-1.0	34	1300	3	0	ON	OFF	ON	-5
-0.5	34	1300	3	1	ON	OFF	ON	-20
0.0	27	1500	15	29	ON	OFF	ON	-45

< Event 1 > Vehicle Speed



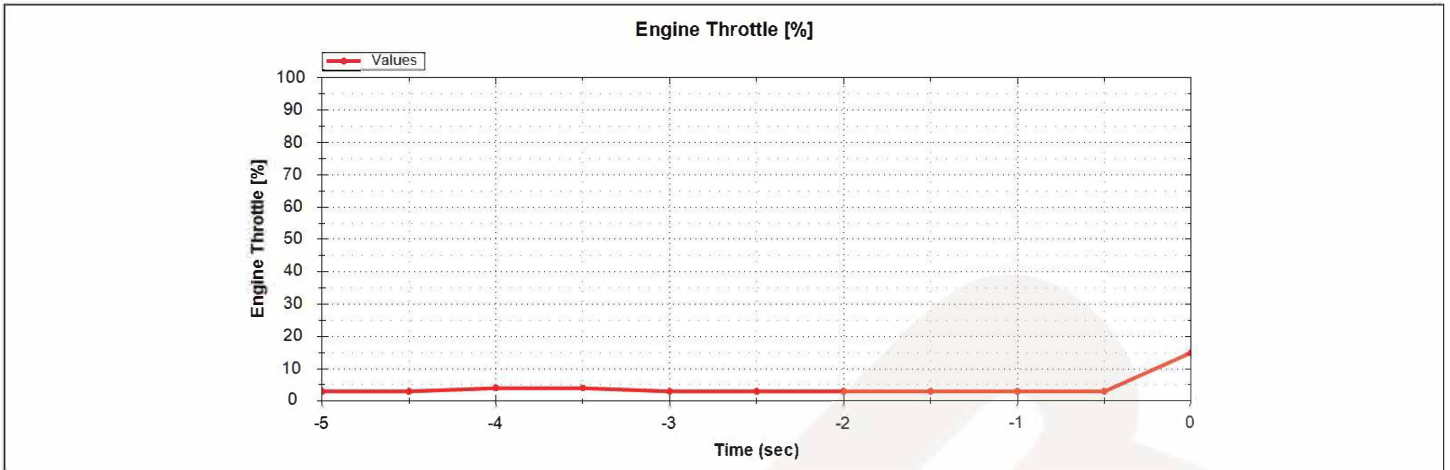
Num	Time (sec)	Vehicle Speed [kph]
1	-5.0	36
2	-4.5	35
3	-4.0	35
4	-3.5	35
5	-3.0	35
6	-2.5	35
7	-2.0	35
8	-1.5	35
9	-1.0	34
10	-0.5	34
11	0.0	27

< Event 1 > Engine RPM



Num	Time (sec)	Engine RPM [rpm]
1	-5.0	1400
2	-4.5	1400
3	-4.0	1400
4	-3.5	1400
5	-3.0	1400
6	-2.5	1400
7	-2.0	1400
8	-1.5	1300
9	-1.0	1300
10	-0.5	1300
11	0.0	1500

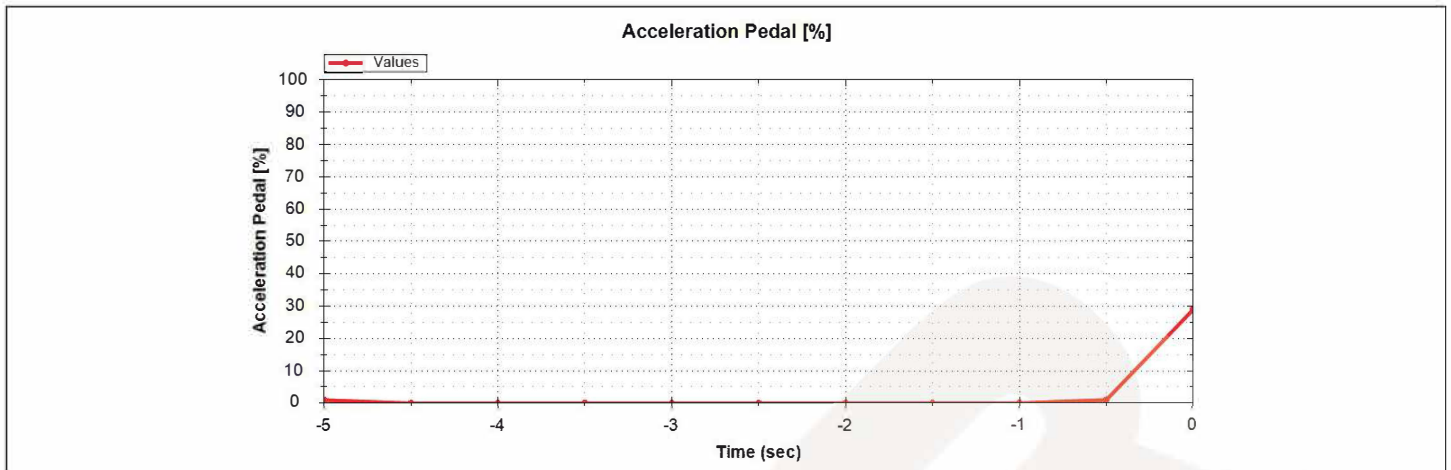
< Event 1 > Engine Throttle



Num	Time (sec)	Engine Throttle [%]
1	-5.0	3
2	-4.5	3
3	-4.0	4
4	-3.5	4
5	-3.0	3
6	-2.5	3
7	-2.0	3
8	-1.5	3
9	-1.0	3
10	-0.5	3
11	0.0	15

< Event 1 >

Acceleration Pedal



Num	Time (sec)	Acceleration Pedal [%]
1	-5.0	0
2	-4.5	0
3	-4.0	0
4	-3.5	0
5	-3.0	0
6	-2.5	0
7	-2.0	0
8	-1.5	0
9	-1.0	0
10	-0.5	1
11	0.0	29

< Event 1 > Service Brake

Num	Time (sec)	Service Brake [on/off]
1	-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	ON

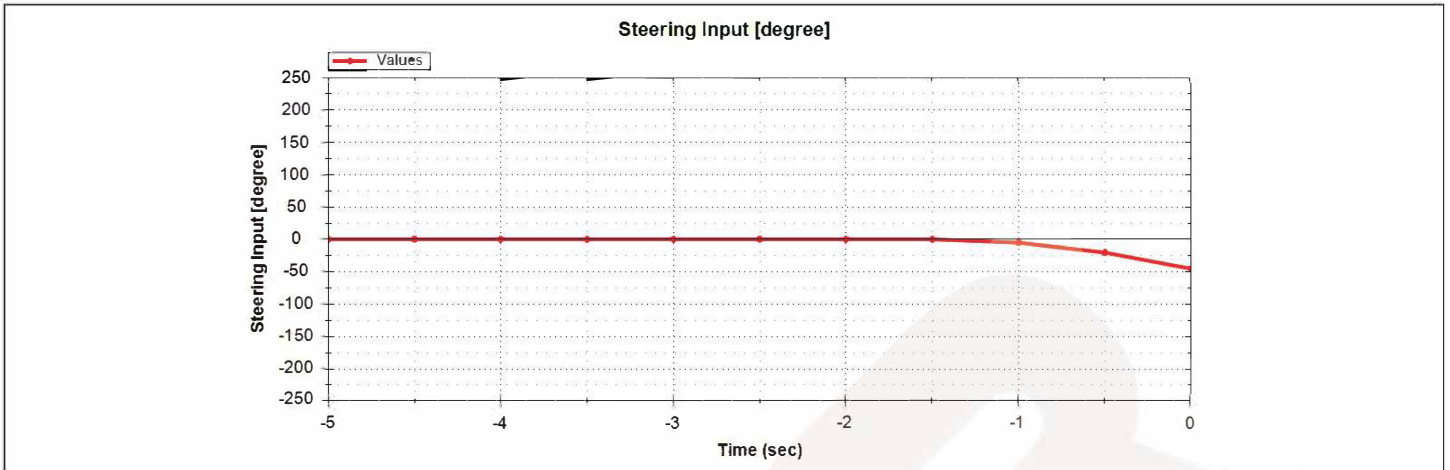
ABS Activity

Num	Time (sec)	ABS Activity [on/off]
1	-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]
1	-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	ON

< Event 1 > Steering Input



Num	Time (sec)	Steering Input [degree]
1	-5.0	0
2	-4.5	0
3	-4.0	0
4	-3.5	0
5	-3.0	0
6	-2.5	0
7	-2.0	0
8	-1.5	0
9	-1.0	0
10	-0.5	-5
11	0.0	-45

Note) Positive value(CCW), Negative value(CW)

< Event 1 >

System Status at Event

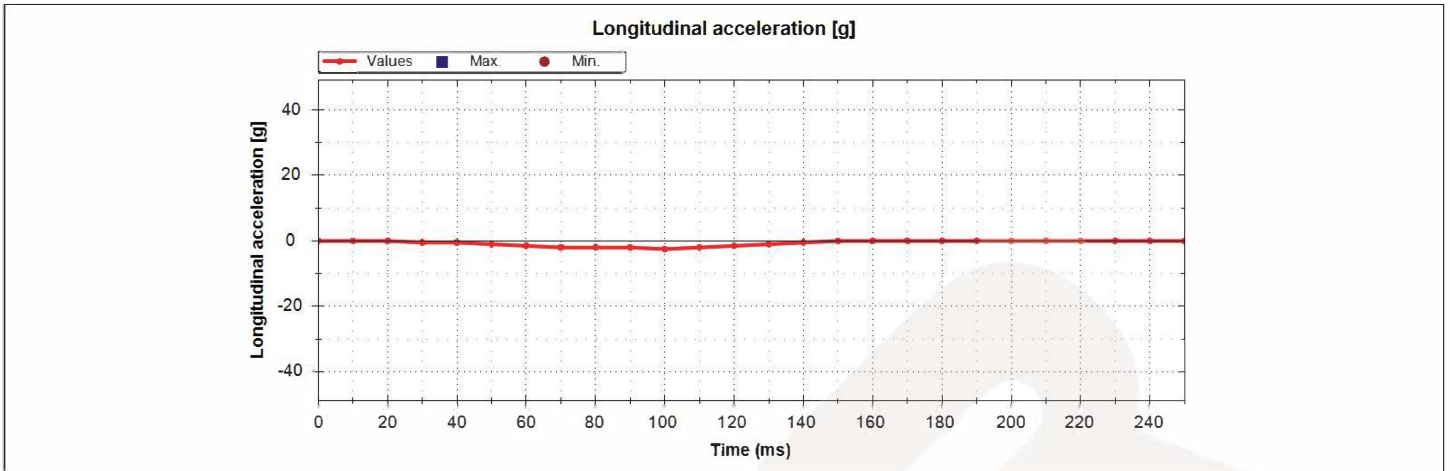
Airbag warning lamp on/off	OFF
Safety seat belt status, driver	OFF
Safety seat belt status, passenger	OFF
Seat track position switch foremost status, driver	Not Supported
Seat track position switch foremost status, passenger	Not Supported
Occupant size classification, driver (5% female or larger)	Not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

Deployment Command Data at Event

Front airbag deployment time, driver (first stage) [msec]	No deployment
Front airbag deployment time, passenger (first stage) [msec]	No deployment
Front airbag deployment time, driver (second stage) [msec]	No deployment
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]	No deployment
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]	No deployment
Seat belt pretensioner deployment time, passenger [msec]	No deployment

< Event 1 >

Longitudinal crash pulse_acceleration (g, 0 ~ 250msec)

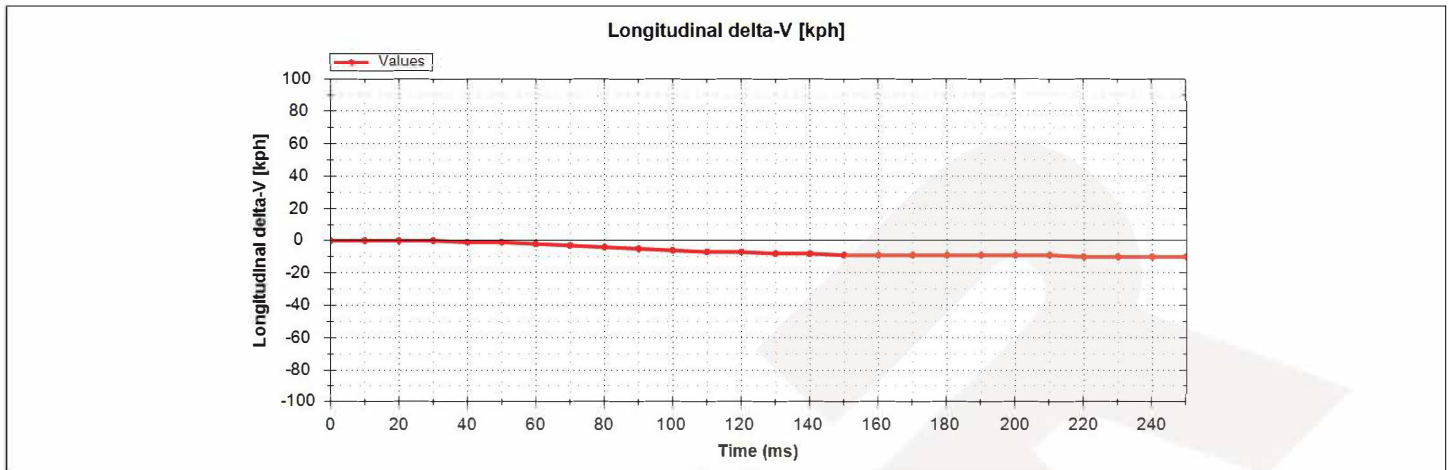


Num	Time (ms)	Longitudinal acceleration [g]
1	0.0	0.0
2	10.0	0.0
3	20.0	0.0
4	30.0	-0.5
5	40.0	-0.5
6	50.0	-1.0
7	60.0	-1.5
8	70.0	-2.0
9	80.0	-2.0
10	90.0	-2.0
11	100.0	-2.5
12	110.0	-2.0
13	120.0	-1.5
14	130.0	-1.0
15	140.0	-0.5
16	150.0	0.0
17	160.0	0.0
18	170.0	0.0
19	180.0	0.0
20	190.0	0.0
21	200.0	0.0
22	210.0	0.0
23	220.0	0.0
24	230.0	0.0
25	240.0	0.0
26	250.0	0.0

< Event 1 >

Longitudinal crash pulse_delta-v (kph, 0 ~ 250msec)

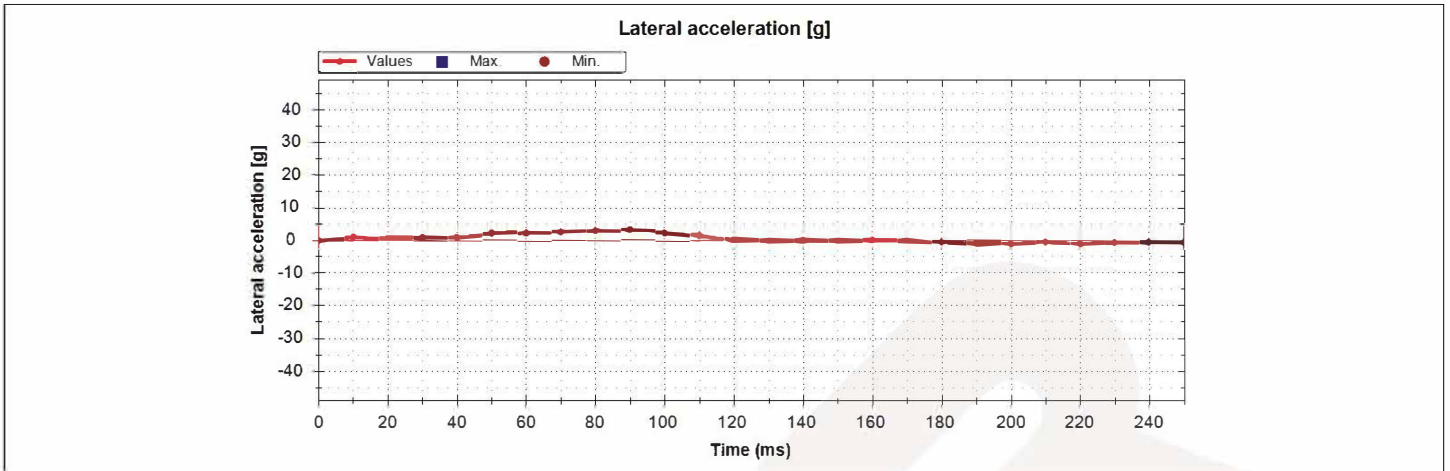
Max. delta-V [kph]	-10
Time, Max. delta-V [msec]	300.0



Num	Time (ms)	Longitudinal delta-V [kph]
1	0.0	0
2	10.0	0
3	20.0	0
4	30.0	0
5	40.0	-1
6	50.0	-1
7	60.0	-2
8	70.0	-3
9	80.0	-4
10	90.0	-5
11	100.0	-6
12	110.0	-7
13	120.0	-7
14	130.0	-8
15	140.0	-8
16	150.0	-9
17	160.0	-9
18	170.0	-9
19	180.0	-9
20	190.0	-9
21	200.0	-9
22	210.0	-9
23	220.0	-10
24	230.0	-10
25	240.0	-10
26	250.0	-10

< Event 1 >

Lateral crash pulse_acceleration (g, 0 ~ 250msec)

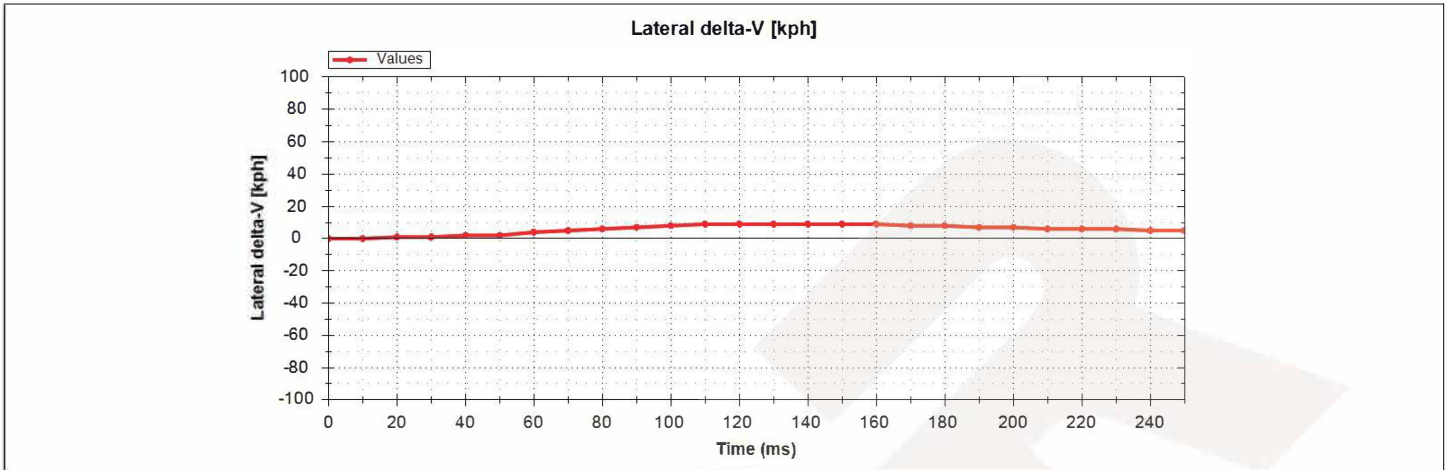


Num	Time (ms)	Lateral acceleration [g]
1	0.0	0.0
2	10.0	1.0
3	20.0	0.5
4	30.0	1.0
5	40.0	1.0
6	50.0	2.0
7	60.0	2.5
8	70.0	2.5
9	80.0	3.0
10	90.0	3.0
11	100.0	2.5
12	110.0	1.5
13	120.0	0.0
14	130.0	0.0
15	140.0	0.0
16	150.0	0.0
17	160.0	0.0
18	170.0	0.0
19	180.0	-0.5
20	190.0	-1.0
21	200.0	-1.0
22	210.0	-0.5
23	220.0	-1.0
24	230.0	-0.5
25	240.0	-0.5
26	250.0	-0.5

< Event 1 >

Lateral crash pulse_delta-v (kph, 0 ~ 250msec)

Max. delta-V [kph]	9
Time, Max. delta-V [msec]	125.0



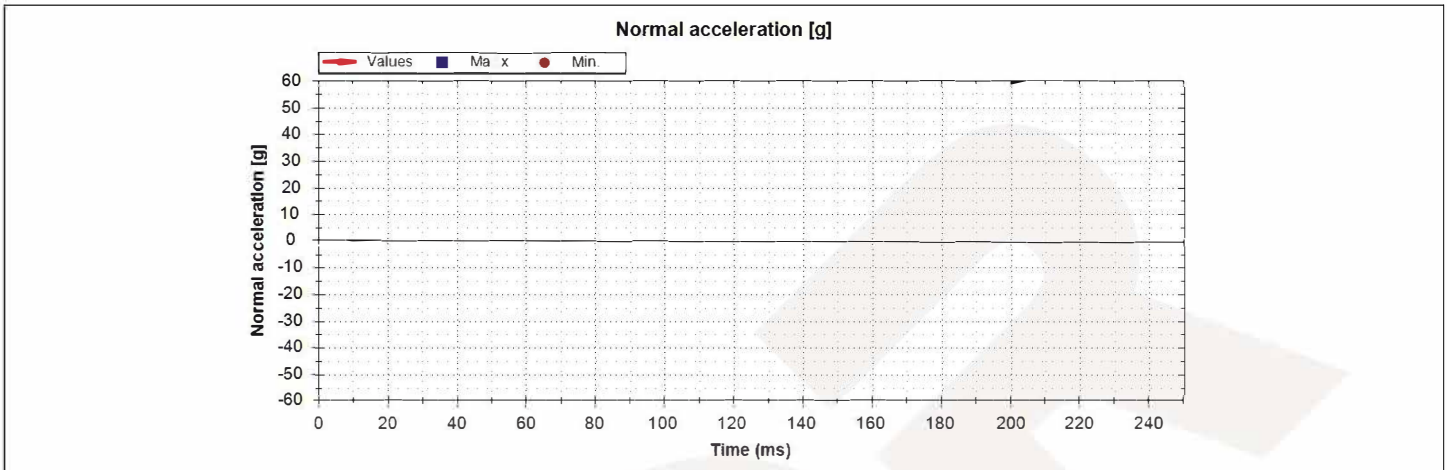
Num	Time (ms)	Lateral delta-V [kph]
1	0.0	0
2	10.0	0
3	20.0	1
4	30.0	1
5	40.0	2
6	50.0	2
7	60.0	4
8	70.0	5
9	80.0	6
10	90.0	7
11	100.0	8
12	110.0	9
13	120.0	9
14	130.0	9
15	140.0	9
16	150.0	9
17	160.0	9
18	170.0	8
19	180.0	8
20	190.0	7
21	200.0	7
22	210.0	6
23	220.0	6
24	230.0	6
25	240.0	5
26	250.0	5

< Event 1 >

Crash pulse Resultant, Time_Max. delta-V resultant (0 ~ 300 msec)

Time, Max. delta-V, resultant [msec]	162.5
--------------------------------------	-------

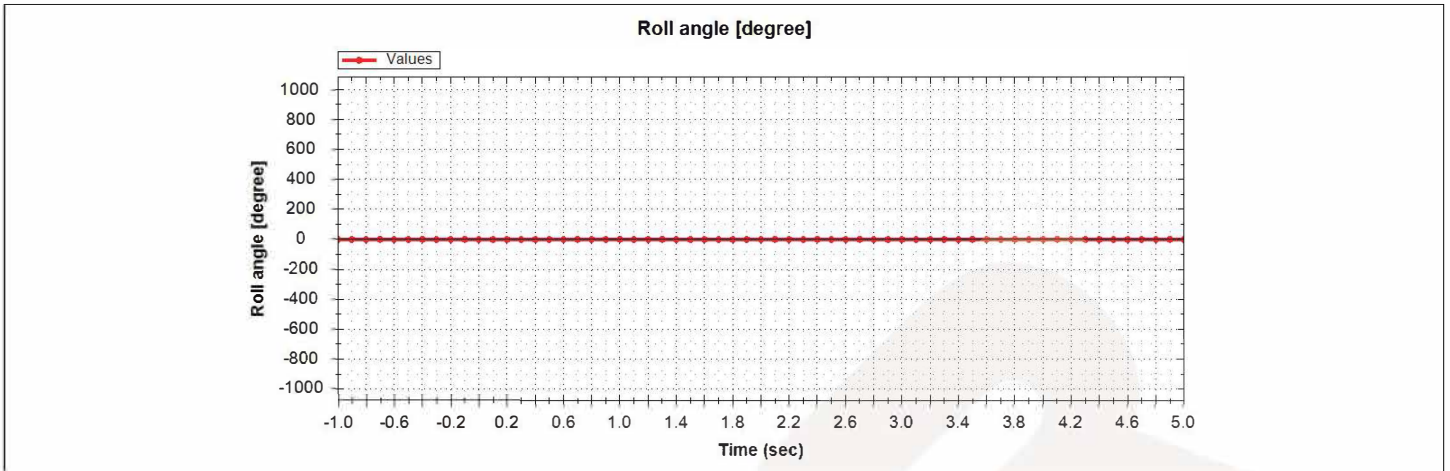
Normal acceleration (g, 0 ~ 250msec)



Num	Time (ms)	Normal acceleration [g]
1	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 1 >

Roll angle (degree, -1 ~ 5sec)



Num	Time (sec)	Roll angle [degree]
1	-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	-0.1	0
11	0.0	0
12	0.1	0
13	0.2	0
14	0.3	0
15	0.4	0
16	0.5	0
17	0.6	0
18	0.7	0
19	0.8	0
20	0.9	0
21	1.0	0
22	1.1	0
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	0
44	3.3	0
45	3.4	0
46	3.5	0
47	3.6	0
48	3.7	0
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 813 384
November 2022



U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

