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

NHTSA

DOT HS 813 489

July 2023

Special Crash Investigations: On-Site Ambulance Crash Investigation; Vehicle: 2017 Ford Transit 250 Type II Ambulance; Location: Alabama; Crash Date: March 2020

DISCLAIMER

This publication is distributed by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration. The United States Government assumes no liability for its contents or use thereof. If trade or manufacturers' names are mentioned, it is only because they are considered essential to the object of the publication and should not be construed as an endorsement. The United States Government does not endorse products or manufacturers.

Suggested APA Citation Format:

Crash Research & Analysis, Inc. (2023, July). *Special Crash Investigations: On-site ambulance crash investigation; Vehicle: 2017 Ford Transit 250 Type II Ambulance; Location: Alabama; Crash Date: March 2020* (Report No. DOT HS 813 489). National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 813 489		

4. Title and Subtitle	5. Report Date
Special Crash Investigations: On-Site Ambulance Crash Investigation; Vehicle: 2017 Ford Transit 250 Type II Ambulance; Location: Alabama; Crash Date: March 2020	July 2023
	6. Performing Organization Code
7. Author	8. Performing Organization Report No.
Crash Research & Analysis, Inc.	CR20010
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Crash Research & Analysis, Inc. PO Box 302 Elma, NY 14059	11. Contract or Grant No. 693JJ919C000004
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
National Highway Traffic Safety Administration 1200 New Jersey Avenue SE Washington, DC 20590	Technical Report
	14. Sponsoring Agency Code

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 published.

16. Abstract

This report documents the on-site investigation of the crash of a 2017 Ford Transit 250 Type II ambulance, which resulted in the fatality of an unbelted 54-year-old male EMT in the patient compartment when the crash occurred. A belted 55-year-old female was driving the ambulance in a non-emergency mode (without warning lights or siren) as it was transporting a 69-year-old female patient to a local hospital. The patient was restrained to a cot by a multi-point harness and was being transported after she had experienced dizzy spells and sustained a minor head laceration from a fall. As the northbound ambulance entered an intersection, it was struck on the left front corner by an eastbound 2016 Hyundai Sonata that was traveling at an impact speed of 117 km/h (72.7 mph) as reported by its event data recorder. The ambulance was redirected to the northeast intersection quadrant and rolled over before coming to rest on its left side in the roadside. The ambulance driver sustained incapacitating (A-level) injuries that included several extremity and rib fractures, as well as a ruptured spleen, and was hospitalized. The patient sustained non-capacitating (B-level) injuries consisting of numerous soft tissue injuries and a hip fracture. The EMT sustained fatal blunt force injuries as a result of the crash.

17. Key Words	18. Distribution Statement
patient, non-emergency mode, EMT, ambulance, wheeled ambulance cot	This document is available to the public from the National Highway Traffic Safety Administration, National Center for Statistics and Analysis, crashstats.nhtsa.dot.gov.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	83	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Table of Contents

Special Crash Investigations
On-Site Ambulance Crash Investigation
Case Number: CR20010
Vehicle: 2017 Ford Transit 250 Type II Ambulance
Location: Alabama
Crash Date: March 2020

Background

This report documents the on-site investigation of the crash of a 2017 Ford Transit 250 Type II ambulance, which resulted in the fatality of an unbelted 54-year-old male EMT in the patient compartment when the crash occurred. A belted 55-year-old female was driving the ambulance (Figure 1) in a non-emergency mode (without warning lights or siren) as it was transporting a 69-year-old female patient to a local hospital. The patient was restrained to the cot by a multi-point harness and was being transported after she had experienced dizzy spells and sustained a minor head laceration from a fall in her home.

Figure 1. Left plane view of the 2017 Ford Transit ambulance at the time of the SCI inspection

As the northbound ambulance entered an intersection, it was struck on the left front corner by an eastbound 2016 Hyundai Sonata traveling at a speed of 117 km/h (72.7 mph) as reported by its event data recorder (EDR). The ambulance was redirected to the northeast intersection quadrant and rolled over before coming to rest on its left side in the roadside. The ambulance driver sustained incapacitating (A-level) injuries that included several extremity and rib fractures, as well as a ruptured spleen, and was hospitalized. The ambulance patient sustained non-capacitating (B-level) injuries consisting of numerous soft tissue injuries and a hip fracture. The EMT in the patient compartment of the ambulance sustained fatal blunt force injuries as a result of the crash.

The crash was identified by the National Highway Traffic Safety Administration through news media reports in March 2020. Notification was forwarded to the Special Crash Investigations (SCI) group and assigned for on-site investigation by the SCI team at Crash Research & Analysis

on the same day. The SCI team initiated contact with the investigating law enforcement agency and established cooperation to conduct an on-site investigation. The on-site portion of this investigation took place during March 2020 and included the exterior and interior inspections of the ambulance to measure exterior deformation, interior damage and intrusion, document interior occupant contact evidence, and examine the manual and supplemental restraint systems. The specialty equipment and features of the ambulance were also inspected and documented.

An exterior inspection of the Hyundai was conducted, and the crash site was photographed and documented. On-site activities concluded with in-person interviews of the ambulance agency's managerial staff to gather information specific to their operating procedures, policies, and personnel involved in this crash. The Ford and Hyundai were both equipped with EDRs. The EDRs were removed from each vehicle and retained as evidence by the investigating law enforcement agency. The SCI investigator was not permitted to image any data from either vehicle. Electronic (PDF) copies of the imaged data from the Ford and Hyundai were later given to the SCI investigator by the law enforcement agency.

Summary

Crash Site

The crash occurred at the intersection of a divided roadway with a multi-lane roadway in a suburban setting at night. Illumination conditions were dark, with overhead artificial lighting. At the time of the crash the National Weather Service reported fair skies, a temperature of 4 ºC (39 ºF), 82 percent relative humidity, and calm winds. The police crash report (PCR) listed the environmental conditions as dark, clear, and dry. The northbound portion of the divided roadway consisted of six travel lanes, including two 3.7 m (12.1 ft) wide designated left turn lanes, three 3.5 m (11.5 ft) wide straight through lanes, and one 5.0 m (16.4 ft) wide right turn lane. All lanes were clearly delineated by painted markings and retroreflective markers. Speed on the divided north/south roadway was regulated by a posted limit of 89 km/h (55 mph). The ambulance traveled north in the rightmost straight through lane (Figure 2).

Figure 2. North-facing view of the roadway for the ambulance's pre-crash travel trajectory

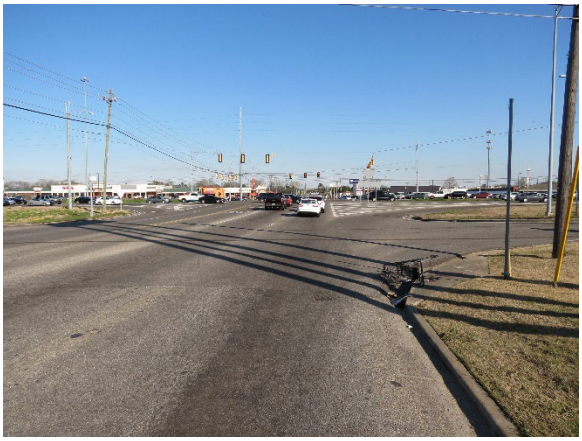


Figure 3. East-facing view of the roadway and pre-crash approach for the Hyundai

The crossing roadway consisted of four lanes in the eastbound direction: one 3.7 m (12.1 ft) wide left turn lane, two 3.7 m (12.1 ft) wide straight through lanes, and one 6.0 m (19.7 ft) wide right turn lane. All lanes were delineated by painted markings. Raised concrete curbs bordered the corner of the intersection. The Hyundai traveled east toward and through the intersection in the right through lane (Figure 3). Speed on the east/west roadway was regulated by a posted limit of 72 km/h (45 mph). The surrounding suburban environment consisted of grassy roadsides and numerous commercial properties. A crash diagram is included at the end of this report.

Ambulance Agency, Crew, and Transport Description

The private ambulance agency was a multi-tiered medical transport service not associated with any particular medical treatment center. It was capable of providing all levels of EMS care, from basic life support (BLS) to advanced life support (ALS) critical care. The agency was a privately-held, for-profit enterprise with an all-career staff who performed public emergency response, inter-facility transfers, private requests, and specialty transports. It operated its own dispatch, operations, and fleet facilities, and conducted transports using a fleet of Type II and Type III ambulances.

The agency was among the largest of its kind in the United States, and employed career professionals who consisted of administrative staff, support personnel, dispatchers, and emergency medical technicians (EMTs) of varying levels of care. The 55-year-old driver had been employed by the agency since November 2009, while the 54-year-old EMT had been with the company since June 2002. Both employees were credentialed as a paramedic by the State of Alabama. The driver's certification was first obtained in 2008, and was valid until March 2022. The EMT's certification had begun in 1988, and was valid until March 2020 (recertification pending).

The agency maintained its equipment and reportedly operated in compliance with all regulations of Alabama. The ambulance agency required its employees who operated vehicles to complete emergency vehicle operations (EVOC) training. This training was facilitated and provided through State-sanctioned courses, and had to be renewed/recertified every 2 years. The driver had last refreshed her EVOC training in April 2019.

The agency operated several different shift schedules for its EMS personnel, most of which had a 24-hour duration that was followed by a 48-hour time-off period. The driver's schedule followed this 24-hour format. She had begun her shift at 0700 hours on the day preceding the crash, and would have completed her shift later in the morning on the day the crash occurred. That is, she was more than 17 hours, but less than 24 hours, into her shift when the crash occurred. She had been off-duty for the 48-hour period preceding the start of her shift. The EMT also was scheduled on 24-hour shift rotation, which normally began at 0900 hours. However, on the particular day of the crash, the EMT was assisting a co-worker and covering a portion of his shift. That is, his on-duty time had begun at 2100 hours on the day preceding the crash. He was more than 3 hours into a 12-hour cover shift when the crash occurred. He had been off-duty for 36 hours preceding the start of his back-half cover shift.

The ambulance agency said it enforced a written policy concerning belt use. The policy stated that employees and all occupants in any of the agency's fleet vehicles must be belted whenever the vehicle was in operation. This included that all patients must be restrained completely by the

available multi-point harness system, with the added notation that use of the system was required "as long as [it] does not interfere with patient care."

Pre-Crash

The following pre-crash specifics were substantiated from the evidence gathered during the SCI investigation from statements made by the ambulance agency's managerial staff during interviews, and a review of the law enforcement documentation of the crash. Prior to the crash, the involved ambulance was requested to respond to an emergency 9-1-1 call from a local residence for a person who had fallen. The 69-year-old female had been having dizzy spells during the preceding hours and fell after standing up from a lounge chair. When she had fallen, she also sustained a minor laceration to her head. The family called the emergency response system to have her evaluated and transported to a local hospital.

The ambulance and crew were dispatched to the location. On arrival they evaluated the patient, placed her in a Fowler's position (anatomical position of comfort with legs outstretched and back reclined approximately 45 to 60 degrees) on the wheeled ambulance cot, and loaded her into the patient compartment of the ambulance. According to dispatch logs, the ambulance and crew were only on-scene at the residence for 9 minutes. They then initiated a non-emergency transport (no warning lights or siren in operation) to a local hospital. The destination was 11.4 km (7.1 miles) away, requiring a travel time of approximately 13 minutes under normal traffic conditions.

The 55-year-old female EMT drove the ambulance. She was restrained by the available 3-point lap and shoulder seat belt system, with the driver's seat adjusted to a middle track position and the seatback slightly reclined. The 54-year-old male EMT was in the patient compartment of the ambulance to attend to the patient. He was positioned unbelted on the left-facing bench seat adjacent to the patient. The ambulance company reported that its policy was the use of restraints is required, so long as it does not interfere with the administration of patient care. The EMT's responsibility was to monitor and attend to the care of the patient, performing duties during travel such as obtaining vital signs, administering care, providing lifesaving intervention if/when necessary, documenting the patient's condition, documenting any treatments rendered, obtaining and documenting pertinent historical information concerning the patient and her present condition, and notifying the hospital of their pending arrival, and providing them with a patient report.

The ambulance traveled north on the divided multi-lane roadway. It approached the intersection traveling in the right through lane. Overhead electronic three-phase traffic signals in the area were cycled to a steady green phase for north/south through traffic. Steady red signal phases controlled crossing traffic on the intersecting multi-lane roadway, as well as left-turning north/south traffic. Data from the ambulance's EDR revealed that the ambulance traveled at speeds from 71 to 77 km/h (44 to 48 mph) over the 5-second pre-crash interval.

Surveillance video (traffic camera) footage obtained by the investigating law enforcement agency and shown to the SCI investigator revealed that the electronic signal maintained the steady green phase for north/south through traffic for nearly 40 seconds prior to the crash. This confirmed that the ambulance approached and entered the intersection while maintaining a consistent speed and proceeding on its northbound travel trajectory through the intersection. The ambulance's driver actively depressed the accelerator pedal to maintain the vehicle's speed, which notably was below the 89 km (55 mph) posted speed limit.

The 2016 Hyundai Sonata traveled eastbound on the multi-lane intersecting roadway, driven by a belted 27-year-old male. It was adjacent to and a short distance behind an unknown make/model white sedan. The white sedan was in the left through lane, while the Hyundai was in the right through lane. Both vehicles entered the intersection from the west, despite the long-duration steady red phase of the electronic traffic signal. In the surveillance footage, the vehicles appeared to be traveling at high speeds. Data imaged from the Hyundai's EDR revealed that the vehicle was traveling at speeds from 114 to 130 km/h (71 to 81 mph). Over the final 1.5-seconds prior to impact, the Hyundai's accelerator pedal was depressed (70% at 0.5-second interval) and its speed was 115 km/h (71.5 mph). This notably was well in excess of the 72 km/h (45 mph) posted speed limit.

As the white sedan crossed over the northbound lanes, its right side was briefly illuminated by the ambulance's headlights. In an apparent reaction by the ambulance's driver to the surprise presence of the white sedan, the ambulance's brake lights illuminated (EDR data indicated that the ambulance's driver initiated braking at between the 0.5-second and time-zero interval). Simultaneously, the Hyundai began to cross over the northbound lanes and rapidly approached the travel path of the northbound ambulance.

Crash

The crash occurred as the ambulance's left plane/forward aspect was struck by the front plane of the Hyundai in a near right-angle configuration (Event 1). Figure 4 is a screenshot of the video from the traffic camera provided by the investigating law enforcement agency, showing the ambulance and Hyundai immediately prior to impact. The steady green phase of the electronic signal for the ambulance's travel trajectory is apparent, and the ambulance's brake lights are illuminated in response to the driver applying the brakes after observing the white sedan (out of frame to the right) pass through the intersection immediately in front of it. Directions of force were within the 10 o'clock sector for the ambulance and the 1 o'clock sector for the Hyundai.

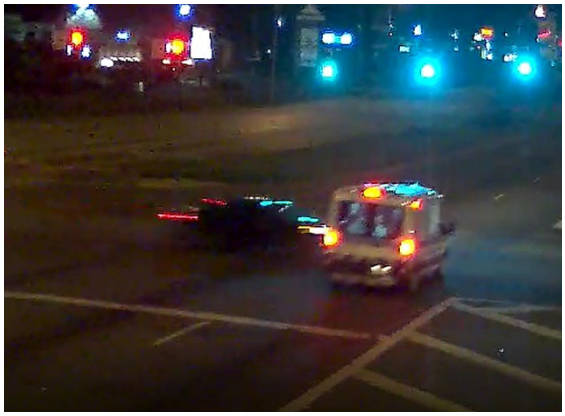


Figure 4. North-looking screenshot of the traffic camera's surveillance video provided by the investigating law enforcement agency showing the ambulance and the Hyundai when the crash occurred

Impact forces initiated a rapid clockwise rotation to the ambulance and a rapid counterclockwise rotation to the Hyundai as both vehicles were redirected to the northeast. The second crash event then occurred as the right plane/rear aspect of the Hyundai side-slapped the left plane of the ambulance. The higher profile and center of mass of the ambulance coupled with location of initial impact initiated the dynamics of a left roll about the ambulance's longitudinal axis.

The ambulance maintained its momentum along a redirected trajectory and traversed across the intersection while it rotated clockwise and continued to roll left. The ambulance then fell onto its left plane (Event 3) and departed the roadway into the northeast roadside. It slid through the grassy roadside and came to final rest facing southwest, toward the intersection. At rest (Figure 5), the ambulance's center of mass was located 8 m (26.2 ft) from the northeast curb and 42 m (137.8 ft) from the point of impact.

Figure 5. Northeast-looking image of the ambulance at final rest (on-scene law enforcement image)

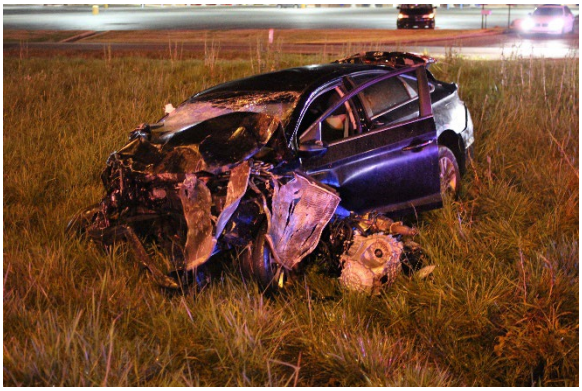


Figure 6. Northeast-looking image of the Hyundai at final rest (on-scene law enforcement image)

The Hyundai also maintained a redirected trajectory to the northeast. It struck the concrete curb with its undercarriage (Event 4) and departed the northeast intersection quadrant. This engagement broke off and pulled from the ground a large section of the concrete curb, which vaulted the Hyundai into the grass roadside. It maintained its counterclockwise rotation and tripped into a right side-leading rollover sequence (Event 5). The Hyundai completed four quarter-turns (one complete revolution) and came to rest on its wheels, facing west. At rest

(Figure 6), the Hyundai's center of mass was located 23.5 m (77.1 ft) from the curb and 57 m (187.0 ft) northeast from the initial point of impact.

Post-Crash

There were several witnesses to the crash who contacted the local emergency response system. Local fire department, law enforcement, and EMS personnel responded to the crash site, and passersby stopped to offer assistance. The Hyundai driver exited the vehicle without assistance. Visible in the surveillance video, he initially went over to the back of the ambulance (which was out of the field of view), but then fled from the scene in the white sedan that he had been following prior to the arrival of emergency personnel/law enforcement.

Arriving emergency responders observed the EMT unresponsive and lying partially on the ground and partially on the opened right rear loading door. Official records and reports of the crash suggest that he was ejected (wholly or partially) from the ambulance as it slid to final rest. However, it is more likely that the EMT was pulled from the vehicle by the Hyundai's driver and/or other passersby, as his kinematics do not support the dynamics that would have been required for him to be ejected during the latter stages of the crash. Regardless, arriving emergency responders initiated lifesaving efforts and the EMT was transported by ambulance to a local hospital. He was ultimately pronounced deceased shortly after his arrival.

The ambulance driver was assisted from the vehicle and transported to a local hospital for the treatment of reported incapacitating (A-level) injuries. She was hospitalized for the treatment of extremity and rib fractures and a ruptured spleen. The patient, who remained belted to the wheeled ambulance cot, was removed from the vehicle by emergency responders and transported by another ambulance to a local hospital. Separate from her pre-crash ailments, the patient sustained non-incapacitating (B-level) injuries that included numerous soft tissue injuries and a hip fracture. A local service recovered the ambulance and Hyundai from the crash scene and transferred them to a secure facility, where they were held on law enforcement impound.

2017 Ford Transit 250

Description

The 2017 Ford Transit 250 was manufactured in August 2017, identified by the Vehicle Identification Number (VIN) 1FDYR2CM6HKxxxxxx. It was a rear-wheel-drive platform with a 3.7-liter, V-6 gasoline engine linked to a 6-speed automatic transmission. The ambulance had power-assisted front and rear ventilated disc brakes with antilock. The vehicle manufacturer's recommended tire size was P235/65R16, with recommended cold tire pressures of 360 kPa (52 PSI) front and 490 kPa (71 PSI) rear. Figure 7 shows the ambulance at the time of the SCI inspection, while Figure 8 shows a similar Ford Transit ambulance for exemplar purposes.

Figure 7. Left front oblique view of the 2017 Ford Transit Type II ambulance

Figure 8. Left front oblique view of an exemplar Ford Transit ambulance of the same agency

At the time of the crash, the ambulance had Firestone Transforce CV tires of the recommended size, with matching tire identification numbers (TINs) of "E2B0 CV2 xx19." All tires had tread depths of 6 mm (8/32 in) or greater. The left front tire was flat, restricted, and displaced rearward by the impact damage. However, there was no damage or restriction to the left rear, right rear, or right front tires.

The ambulance cab had cloth-surfaced bucket seats with adjustable head restraints and folding inboard armrests. Both front-row seats featured manual track and seatback recline adjustments. The driver's seat was adjusted to a middle track position, while the front right seat was fully rearward at the time of the SCI vehicle inspection. The driver's head restraint was adjusted fully downward. Customized emergency lighting switches and radio communication equipment were mounted to the center instrument stack. Safety equipment consisted of 3-point lap and shoulder seat belt systems with retractor pretensioners for both of the cab's seat positions. Supplemental restraint was provided by dual-stage frontal, outboard seat-mounted side impact, and roof side rail-mounted inflatable curtain (IC) air bags.

Type II Ambulance Patient Compartment

The ambulance was completed as a Type II during secondary manufacturing in December 2017 by American Emergency Vehicles (AEV).[1] During that time, the interior cargo area was transformed into a patient compartment equipped as a mobile emergency medical care unit. In addition to the completion of the patient compartment, secondary manufacturing also included the installation of emergency services operations equipment. This included emergency warning lights, sirens, and radio communications, which were installed in the ambulance's cab and about the exterior of the vehicle. The patient compartment was configured for the seating of up to five total occupants, which consisted of a rear-facing captain's chair at the forward aspect, a three-occupant left-facing bench seat on the right side, and a rear-facing wheeled ambulance cot. An opening to the cab of the ambulance was located adjacent to the captain's chair position. There were cabinets and a counter area mounted to the left wall of the interior. Entry/egress was achieved through double rear doors and a single right door. Figure 9 shows a forward-facing interior view of the ambulance's patient compartment. Interior cabinets were constructed of plywood and aluminum components of varying thicknesses, bonded together using a variety of glue, wooden pegs, and metallic screws. Surfaces were covered with a laminate finish and/or vinyl-covered foam padding, and all cabinets were outfitted with clear polymer sliding doors. Aluminum corner bead and plastic were used for edge trim. Fiberglass and foam insulation provided thermal and acoustic protection from the environment.

Figure 9. Forward-facing view of the ambulance's patient compartment at the time of the SCI inspection

[1] American Emergency Vehicles, Jefferson, NC.

The patient compartment was occupied by the EMT and patient at the time of the crash. The EMT was seated unbelted on the left-facing bench seat, while the patient was positioned on the ambulance cot and belted by the integral multi-point harness system.

Vehicle Weight/Payload

The chassis was placarded by its manufacturer with a gross vehicle weight rating (GVWR) of 4,082 kg (9,000 lb). This was distributed as gross axle weight ratings (GAWR) of 1,873 kg (4,130 lb) front and 2,502 kg (5,515 lb) rear. According to title data, the vehicle's curb weight was 2,268 kg (5,000 lb). A placard stated that the combined weight of the ambulance's occupants and payload should not exceed 939 kg (2,070 lb). During the SCI vehicle inspection, the SCI investigator estimated the weight of the equipment and supplies to be approximately 386 kg (850 lb). Based on the vehicle's placarded GVWR and other available weight information, it was the SCI investigator's assessment that the ambulance was operating in its usable payload capacity and weight rating at the time of the crash.

Exterior Damage

Damage to the ambulance from the multiple event crash was located on the front and left side planes. The cab of the ambulance sustained severe damage, biased to the left front aspect, as a result of the severe side impact crash with the Hyundai. Direct contact damage began at the left front corner and extended rearward to immediately rearward of the left A-pillar on the forward aspect of the left front door. This distance measured 128 cm (50.4 in) wide. The left front axle position, located in the damage pattern, was displaced inward and rearward 23 cm (9.1 in) (Figure 10). A residual crush profile documented to the damage pattern produced the following resultant measurements: C1 = 42 cm (16.5 in), C2 = 48 cm (18.9 in), C3 = 75 cm (29.5 in), C4 = 85 cm (33.5 in), C5 = 80 cm (31.5 in), and C6 = 66 cm (26.0 in). Maximum crush of 85 cm (33.5 in) was observed 40 cm (15.7 in) forward of the deformed left front axle position. The Collision Deformation Classification[2] (CDC) assigned to the ambulance for the Event 1 damage pattern was 10LYEW4 (Figure 11).

Figure 10. Overhead perspective view of the Event 1 damage profile to the ambulance

[2] SAE J224_202205 – SAE Recommended Practice describing vehicle collision damage in an alphanumeric format.

Figure 11. View of the deformation to the ambulance's left front from the impact by the Hyundai

The WinSMASH model damage algorithm was used to calculate the severity (delta V) reconstruction of the crash. The calculated total delta V of the ambulance for the Event 1 impact by the Hyundai was 31 km/h (19.3 mph). Longitudinal and lateral components of the calculated delta V were -20 km/h (-12.4 mph) and 23 km/h (14.3 mph), respectively. These results were underestimated and considered borderline due an impact not applicable to the WinSMASH program. Additionally, the results were significantly below the delta V values in the EDR report.

Damage from the Event 2 side-slap was located on the ambulance's left plane, beginning in the middle aspect of the left plane and extending above the left rear axle position. The direct contact damage pattern measured 133 cm (52.4 in) wide, and was vertically located above the beltline. A residual crush profile documented to the damage pattern produced the following resultant measurements: C1 = 6 cm (2.4 in), C2 = 13 cm (5.1 in), C3 = 17 cm (6.7 in), C4 = 16 cm (6.3 in), C5 = 13 cm (5.1 in), and C6 = 12 cm (4.7 in). Maximum crush of 17 cm (6.7 in) was observed 32 cm (12.6 in) forward of the left rear axle position at the beltline. The CDC assigned to the ambulance for the side slap damage profile was 09LZHW2.

Figure 12. Left plane view of the ambulance and the side slap profile above the left rear axle position

Figure 12 shows the side slap damage profile to the ambulance as documented during the SCI vehicle inspection. Note that the Event 3 rollover damage overlapped both the Event 1 (Hyundai impact) and Event 2 (side slap) damage profiles. The damage with missing vehicle algorithm of the WinSMASH model was used to calculate the severity (delta V) reconstruction of the crash. The calculated total delta V of the ambulance for the Event 2 side slap impact with the Hyundai was 7 km/h (4.3 mph). Longitudinal and lateral components of the calculated delta V were 0 km/h (0 mph) and 7 km/h (4.3 mph), respectively. These results were borderline and underestimated the severity of the impact.

Rollover damage was observed to the left plane of the ambulance, consisting of abrasions and deformation from contacting and then sliding across the ground. The lower half of the left front door appeared to have pulled away from the vehicle and then been deformed/folded over as the vehicle slid. Significant dirt/debris was embedded in the lower half of the door and along the sill. No crush measurements relative to the rollover were obtainable due to the distribution of the direct contact across the entire left plane and overlapping nature of the damage with respect to the Event 1 and Event 2 impact damage profiles. The CDC assigned to the ambulance for the rollover damage was 00LDAO2. No WinSMASH calculations were conducted for the rollover event due to the lack of deformation measurements and non-horizontal nature of the forces which were beyond the scope of the WinSMASH program.

Event Data Recorder

The ambulance chassis had a restraint control module (RCM) mounted to the center tunnel beneath the center instrument panel. The RCM monitored and measured vehicle acceleration in axes and had event data recorder capabilities to record data for longitudinal, lateral, and rollover crash pulses. The Ford was being held on law enforcement impound at the time of the SCI inspection, and the SCI investigator was not permitted to image any data from the Ford during the inspection. However, the law enforcement agency imaged the Ford's RCM data via a direct to module connection using the Bosch Crash Data Retrieval (CDR) tool and software version 19.0. An electronic (PDF) file of the imaged data, reported using the same CDR software version, was provided by the investigating law enforcement agency to SCI. During the SCI analysis it was observed that the content on Pages 8-10 and 17-19 of the PDF was missing for undetermined reasons. The supplied data file is included at the end of this report as Appendix A.

The EDR component of the RCM could record "non-deployment," "air bag deployment," or "non air bag deployment" event types. By definition, non-deployment events were those in which the recording trigger threshold was met or exceeded, but no supplemental restraint devices (pretensioners or air bags) were actuated or deployed. Air bag deployment events were those in which frontal, seat-mounted, or IC air bags were commanded to deploy. Similar to non-deployment event types, a non-air bag deployment event exceeded the recording threshold and actuated pretensioners or deployed knee air bags, but did not deploy frontal, seat-mounted, or IC air bags. Non-deployment and non-air bag deployment events could be overwritten by subsequent events, whereas deployment events became locked and could not be overwritten. The RCM had the capacity to store up to two events, which were reported as "First Record" and "Second Record."

At algorithm enable (AE) and recognition of an event, the EDR had the capacity to record up to 250 milliseconds of longitudinal and lateral delta V data in 10 millisecond intervals. Roll angle data was recorded in 0.1-second intervals for one second prior and 5 seconds after AE.

Associated to each event was a 5-second pre-crash buffer that recorded numerous vehicle operational parameters (vehicle speed [mph], accelerator pedal position [%], service brake [on/off], and other data).

The Ford's data were imaged when the ignition cycle counter read 5,242. Two recorded events were recovered, both of which had occurred on ignition cycle 5,238.

First Record

At the time of the first record, there were no faults (diagnostic trouble codes) indicated and no warning lights were illuminated. The driver's seat belt status was reported "buckled," and all warning lights/maintenance telltales were "off." This record was locked and was associated to SCI crash Events 1, 2 and 3.

The maximum recorded longitudinal vehicle velocity change of the recorded event was -42.56 km/h (-26.44 mph), which was reported at 300 milliseconds after AE. The maximum recorded lateral vehicle velocity change was 61.57 km/h (38.26 mph), reported 300 milliseconds after AE. Because the 300-millisecond interval was the last available recording interval, it is likely that the crash pulse had not yet achieved its maximum values. The delta V values were an indicator of the approximate severity of the initial impact (Event 1) and the side slap (Event 2). The roll angle data reached a reported maximum value of -82.35 degrees at the 1.0-second interval after AE, indicative of the one-quarter turn rollover event (Event 3). The data limitations indicated a positive rollover polarity was to the right (relative to the seated driver), hence the recorded negative roll polarity was in agreement with the SCI crash reconstruction.

Pre-crash buffer data associated with the first record included a steady state operation of the ambulance with a recorded brake application at AE, which was consistent with the SCI crash reconstruction:

Time	Vehicle Speed km/h (mph)	Accelerator Pedal (%-full)	Service Brake	Engine rpm	ABS activity
-5.0	71 (44)	27.5	Off	2,176	Non-engaged
-4.5	71 (44)	26.6	Off	1,828	Non-engaged
-4.0	72 (45)	36.8	Off	1,972	Non-engaged
-3.5	73 (45)	38.0	Off	2,276	Non-engaged
-3.0	74 (46)	35.7	Off	2,282	Non-engaged
-2.5	75 (47)	34.6	Off	2,292	Non-engaged
-2.0	76 (47)	32.6	Off	2,276	Non-engaged
-1.5	76 (47)	30.9	Off	2,146	Non-engaged
-1.0	77 (48)	30.4	Off	2,080	Non-engaged
-0.5	77 (48)	0.0	Off	1,966	Non-engaged
0.0	74 (46)	0.0	On	1,504	Non-engaged

The first record was a deployment event that produced the following commands:

Device	Time (milliseconds)
Pretensioner (retractor), driver	15.5
Pretensioner (retractor), right front	15.5
Outboard side (seat-mounted) air bag, left	15.5
Inflatable curtain (IC), left	15.5
Inflatable curtain (IC), right	15.5

Device	Time (milliseconds)
Frontal air bag, driver	32.0
Frontal air bag, right front	32.0
Outboard side (seat-mounted) air bag, right	85.0

Second Record

The second record recorded by the Ford's RCM was an unlocked event that occurred 2.6 seconds after the first record. This record was most-likely related to the vehicle's travel to final rest in the northeast intersection quadrant. DTCs consistent with the crash event were recorded.

Interior Damage

The left front door was jammed shut by the overlapping damage sustained from the impact by the Hyundai and the rollover. The right front door and right loading door remained closed and were operational post-crash. The rear loading doors were opened at the time of the SCI inspection and deformed in a manner that they would not re-latch. Law enforcement documentation of the crash indicated that the rear loading doors were open when the first officers arrived at the crash scene. The SCI investigation was unable to determine if the doors came open during the crash or were opened post-crash by witnesses.

The left front glazing was disintegrated and the windshield was fractured its full height and width by the impact forces of the crash. The right front and right rear glazing remained intact and were not contacted by an occupants during the crash. The fixed glazing of the rear loading doors were both disintegrated at the time of the SCI inspection. It could not be determined if they were damaged during or after the crash.

Figure 13. View of the driver's position and the left side intrusions, including displacement of the steering wheel

There was major damage to the interior of the ambulance's cab, related to the severe lateral intrusion of frontal components biased to the left side of the interior. The left front door, left A-pillar, and floor were compressed by the damage pattern and laterally intruded. The floor area at the driver's position was completely collapsed, such that the foot controls were captured between folds in the collapsed floor and displaced beneath the center stack. The driver's left boot remained in the vehicle, captured in the collapsed floor adjacent to the intruded left lower A-

pillar. Components surrounding the left front position, including the instrument panel and steering wheel, were shifted right toward the center aspect of the vehicle. In its intruded and displaced state, the steering wheel was in alignment with the right aspect of the driver's seat. Figure 13 shows the driver's position at the time of the SCI inspection, with the lateral intrusions and right shift of the steering wheel apparent. As discernable in the image, the left aspect of the driver's seat was deformed by the intrusion of the left front door.

A summary of the intrusions documented during the SCI vehicle inspection is as follows:

Component	Intruded Magnitude	Direction
Left front door, FUQ	27 cm (10.6 in)	Lateral
Left front door, FLQ	38 cm (15.0 in)	Lateral
Left front door, RUQ	12 cm (4.7 in)	Lateral
Left front door, RLQ	22 cm (8.7 in)	Lateral
Left B-pillar	10 cm (3.9 in)	Lateral
Left lower A-pillar (kick panel)	32 cm (12.6 in)	Lateral
Floor/toe pan	29 cm (11.4 in)	Lateral
Left instrument panel	22 cm (8.7 in)	Lateral
Left instrument panel	10 cm (3.9 in)	Vertical

Several areas of occupant contact were documented during the SCI inspection. This included contacts attributed to the driver and documented in the ambulance's cab. The left door's rear upper, forward upper, and forward lower quadrants all had deformation consistent with occupant contact/loading from the driver's left flank, left thigh, and left lower leg. The capture of the driver's left boot between the left lower A-pillar and floor substantiated further contact.

In addition to the contact evidence from the driver, the SCI investigator observed contact evidence in the patient compartment attributable to the EMT (left-facing bench seat occupant). A distinct scuff/discoloration to the vinyl surface of the seat cushion evidenced his initial response to the crash forces. This scuff (Figure 14) was located on the forward aspect of the left-facing bench seat and was attributable to the EMT's buttocks. There also was a distinct impression/transfer on the laminate surface of the patient compartment wall/bulkhead, located directly above the rear-facing captain's chair seat position. This contact was an imprint of the EMT's face/head (Figure 15).

Figure 14. Contact evidence on the bench seat from the EMT's posterior

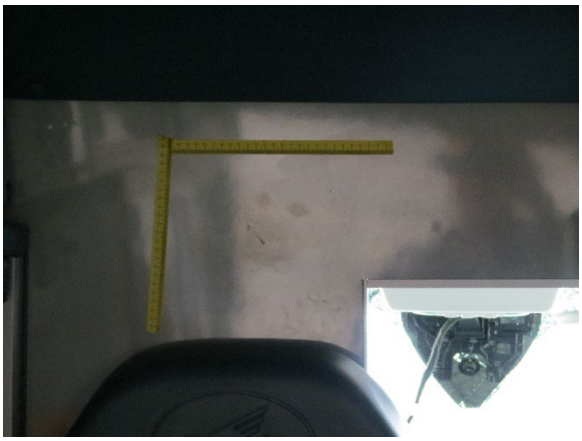


Figure 15. Contact evidence on the front wall of the patient compartment from the EMT's face

The occupant contact in the vehicle was documented as follows:

Component	Evidence	Occupant	Body Region	Confidence
Left front door, FLQ	Deformed	Driver	Left lower leg	Certain
Left front door, FUQ	Deformed	Driver	Left leg	Certain
Left front door, RUQ	Deformed	Driver	Left flank	Certain
Left panel forward of A-pillar	Deformed	Driver	Left ankle	Certain
Deployed left seat-mounted air bag	Scuffed	Driver	Left flank	Certain
Deployed driver's frontal air bag	Blood	Driver	Head/face	Probable
Deployed left IC air bag	Blood	Driver	Head	Certain
Left-facing bench seat cushion	Scuffed	EMT	Buttocks	Certain
Bulkhead above Captain's Chair	Imprint	EMT	Head/face	Certain

Manual Restraint Systems

The cab of the ambulance had 3-point lap and shoulder seat belt systems for the driver and front right passenger positions. Both systems consisted of continuous loop webbing with a lightweight locking latch plate, an adjustable D-ring, and retractor pretensioners. The front-row D-rings were both adjusted to their respective full-down positions at the time of the SCI inspection. The retractor pretensioners were actuated as a result of the crash. The driver's seat belt webbing was extended from the retractor in a used position at the time of the SCI inspection. Webbing was gathered into the forward aspect of the D-ring as well as the latch plate (Figure 16), and there was accompanying loading evidence discernable on the webbing. It was apparent to the SCI investigator that the driver was belted.

The patient compartment had multi-point harness systems for each of the EMS crewmember seat positions (captain's chair and both left-facing bench seat positions). These systems used retractors, wall mounted D-rings, and a center chest buckle. There was no loading evidence on any of the systems; none were in use at the time of the crash. Figure 17 shows the multi-point harness systems of the left-facing seat positions on the bench seat.

Figure 16. View of the driver's seat belt webbing gathered in the latch plate

Figure 17. Multi-point harness systems available for bench seat occupants of the ambulance

Supplemental Restraint Systems

The ambulance had a dual-stage frontal air bag system, front outboard seat-mounted side-impact air bags, and IC air bags, which provided supplemental protection for both the driver and front right passenger positions. The driver's frontal air bag was mounted in the hub of the four-spoke steering wheel and concealed by an H-configuration cover flap. The passenger's frontal air bag was mounted in the mid-upper aspect of the right instrument panel and also concealed by H-configuration cover flaps. An air bag cut-off switch for the passenger's frontal air bag was located in the right instrument panel, concealed in the storage compartment. The switch was not activated at the time of the crash; therefore, there was no suppression of the passenger's frontal air bag. Of the six available air bags, all deployed as a result of the crash.

The driver's frontal air bag deployed from the module without damage. It was internally tethered, with a pair of 3 cm (1.2 in) diameter vents on the back side of the bag at the 11 and 1 o'clock positions. The air bag itself was 66 cm (26.0 in) in overall diameter in its deflated state, with a vertically-oriented 9x26 cm (3.5x10.2 in) rectangular center stitch pattern (Figure 18). A small area of blood evidence, believed to be from the driver, was observed on the left aspect of

the air bag's face. It was apparent that the driver had contacted the deployed driver's frontal air bag with her face/head during the crash sequence.

Figure 18. Deployed driver's frontal air bag in the ambulance at the time of the SCI inspection

The passenger's frontal air bag had deployed from the top aspect of the instrument panel through the cover flaps without damage. It was a large air bag that provided coverage over the majority of the right instrument panel, with two vents on its outboard side. The passenger's frontal air bag was not damaged or contacted relative to the crash.

The outboard seat-mounted side impact air bags deployed from the forward aspect of the front-row seats through their respective outboard seams. In their deflated states, the air bags measured 72 cm (28.3 in) in overall height and were 26 cm (10.2 in) in overall maximum width. They had a 5 cm (2.0 in) vent on their leading aspect. The driver's seat-mounted air bag became partially captured between the left seatback, B-pillar, and intruded left front door during the crash sequence. Minor blood evidence was observed on the interior aspect, and it was apparent that the driver had contacted and loaded the deployed seat-mounted air bag with her left flank during the crash. The right seat-mounted air bag was not damaged or contacted relative to the crash.

The IC air bags had deployed through the edges of the headliner without damage. They measured 126 cm (49.6 in) in overall length and were a maximum of 80 cm (31.5 in) in overall height. A pair of fabric tethers secured the forward aspect of each IC air bag to the A-pillar. In their deployed states, the IC air bags provided full-height coverage from the roof side rail to well below the belt line. The outer aspect of the left IC air bag was covered in mud/dirt residue. There was significant blood evidence and mud/dirt observed on the interior aspect of the left IC air bag, largely attributable to post-crash movement of the driver as the vehicle laid on its left plane. However, the driver would have contacted the air bag during the crash while it was inflated with her head, as well as her left shoulder. The right IC air bag had been partially cut by emergency responders post-crash; there was no crash-related damage or occupant contact to the right IC air bag. Figure 19 shows the left front seat-mounted air bag at the time of the SCI inspection, while Figure 20 shows the deployed left IC air bag.

Figure 19. View of the deployed driver's seat-mounted side impact air bag at the time of the SCI inspection

Figure 20. View of the deployed left IC air bag in the ambulance at the time of the SCI inspection

Wheeled Ambulance Cot

The wheeled ambulance cot installed in the ambulance was a Performance Pro XT Model 6086, manufactured by Stryker. Its serial number was S/N: 15063xxxx, indicative that it was manufactured in June 2015. The Stryker cot (Figure 21) was constructed of a tubular aluminum frame with circumferential weld joints and steel hardware fasteners. The X-frame supporting the mattress platform featured manual lower/lift, with nine height positions between a minimum of 35 cm (13.8 in) and a maximum of 107 cm (42.1 in).

The backrest articulated from zero (flat) to 73° of angular adjustment via a manually controlled gas-pressure cylinder. In a similar fashion, the leg portion featured 15° of positive angular adjustment. Overall dimensions of the cot were 58 cm (23.0 in) wide and 203 cm (80.0 in) long. A placard on the cot declared that the load capacity limit of the cot was 318 kg (700 lb).

The Stryker cot had a multi-point harness system for manual restraint of its occupant (patient). It consisted of a lateral lower extremity strap, a lateral lap/thigh strap, and an upper torso harness which incorporated two shoulder straps that buckled into a lateral chest strap. All of the straps were constructed of fixed-length webbing that included either locking latch plates or sewn buckles. The wheeled ambulance cot was occupied by the 69-year-old female patient at the time

of the crash. Based on ambulance agency policy, the transporting status of the ambulance, crew statements, and on-scene emergency responder observations, the patient was securely restrained using the complete harness system at the time of the crash.

Figure 21. View of the Stryker Performance Pro wheeled ambulance cot at the time of the SCI inspection

Figure 22. Forward-facing view of the Performance-LOAD fastener during the SCI inspection

Cot Fastening System

The Stryker ambulance cot was secured in place and positioned in the floor of the patient compartment via a Stryker Model 6392 Performance-LOAD manual fastener system. It was manufactured in 2017 and identified by the S/N 201700110xxxx. The system consisted of two components, including a bracket/assembly that attached to the cot and a continuous bracket that mounted to the floor of the patient compartment. The bracket/assembly that attached to the cot had a single bolt head located toward the head-end of the cot, as well as a large bracket located at the foot-end of the cot. The continuous bracket that mounted to the patient compartment floor (Figure 22) measured 178 cm (70 in) long, was 23 cm (9 in) wide at the rear (foot end), and was 48 cm (119 in) wide at the front (head end). Manufacturer specifications indicated that the complete system weighed a total of 28.5 kg (63 lb). The floor-mounted bracket guided the cot into the patient compartment of the ambulance, then captured the exposed head-end bolt in a

forward latch (Figure 23) and captured the foot-end bracket in a rear latch. Combined, this secured the cot longitudinally to the floor and restricted the multi-directional movement of the cot during vehicle operation.

Figure 23. Head-end view of the cot fastener system in the ambulance's patient compartment

Cot and Fastener Damage

There was no discernable damage sustained by structure, components, or attachment points of either the wheeled ambulance cot or the floor-mounted bracket of the cot fastener system relative to the crash.

The cot remained secured in the fastener system through the duration of the impact sequence with the Hyundai and the rollover. Arriving emergency response personnel observed that the patient remained restrained by the multi-point harness system and was still positioned on the cot, and the cot was still secured in the fastener system, in the overturned ambulance at final rest following the crash.

2017 Ford Transit 250 Occupants

Driver Demographics

Age/sex:	55 years/female
Height:	150 cm (59 in)
Weight:	Unknown
Eyewear:	None
Seat type:	Forward-facing bucket seat with adjustable head restraint
Seat track position:	Middle
Manual restraint usage:	3-point lap and shoulder seat belt
Usage source:	Vehicle inspection, EDR
Air bags:	Frontal, outboard seat-mounted side impact, and IC air bags available; all deployed
Alcohol/drug involvement:	None
Egress from vehicle:	Assisted from the vehicle by emergency responders
Transport from scene:	Ambulance to a local hospital
Type of medical treatment:	Hospitalized

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Bilateral serious lung contusion, NFS	441410.3	ICS #1: Tandem IPC - Initial: Left air bag – Left seatback outboard; Secondary: Left door panel – Left rear upper quadrant ICS #2: Isolated IPC - Interior – Shoulder portion of belt restraint	Possible Probable Possible
2	Spleen laceration, NFS	544220.2	Isolated IPC - Left door panel – Left rear upper quadrant	Probable
3	Right humerus fracture, NFS	751100.2	Isolated IPC - Front – Steering wheel (combination of rim and hub/spoke)	Possible
4	Left humerus fracture, NFS	751100.2	Tandem IPC - Initial: Left air bag – Left roof side rail Secondary: Left door panel – Left rear upper quadrant	Possible Probable
5	Left leg fractures, multiple, NFS	852002.2	Isolated IPC - Left side – Left side panel forward of A-pillar	Probable
6	Right leg fractures, multiple, NFS	852002.2	Isolated IPC - Floor – Floor (including toe pan)	Probable

Source: Online blog concerning the driver's treatment; several hospital record requests denied.

Driver Kinematics

The driver was seated in the front left seat with the seat track adjusted to a middle track position. The seatback was slightly reclined and the head restraint was flush to the top of the seat back (fully downward). The driver used the available 3-point lap and shoulder seat belt system for manual restraint, determined by the post-crash condition of the system at the time of the SCI vehicle inspection and confirmed by the data imaged from the Ford's EDR by the investigating law enforcement agency. The driver's specific posture remains unknown. She drove the ambulance in a non-emergency mode (without emergency warning lights or siren) northbound on the divided roadway. As she approached the intersection, she maintained the ambulance's trajectory to proceed through the intersection in response to the steady green phase of the electronic signal.

The driver became alerted by the flash of white created by the ambulance's headlights as they illuminated the side plane of the white sedan that crossed abruptly in front of the ambulance. She responded by initiating a braking maneuver, but did not detect the approaching Hyundai.

At impact by the Hyundai, the ambulance's driver initiated a forward and leftward trajectory. Her body loaded the seat belt system, evidenced by the loading abrasions on the system as observed during the SCI vehicle inspection. Her face and head contacted the left aspect of the deployed driver's frontal air bag, while her left shoulder and left aspect of her head likely contacted the deployed left IC air bag. Her left flank loaded the side impact air bag and door. The driver's left leg loaded the left side panel and left lower A-pillar as they simultaneously intruded. The driver's loading of the left side components was likely exacerbated by the secondary left side impact with the Hyundai (side slap).

Her contacts with the left door, left lower A-pillar, and floor, and subsequent loading as they intruded/deformed, resulted in several fractures to her left arm and lower extremities. Her right arm fracture likely resulted from contact with the steering wheel. The driver remained belted, but forward and leftward, as the ambulance rotated clockwise and rolled onto its left plane. She remained in contact with the left side components as the ambulance slid to final rest.

Arriving emergency response personnel assisted the driver from the overturned vehicle. She was transported by ambulance to a regional hospital, where she was hospitalized in intensive care for 38 days. She was then transferred to the hospital's general floor for an unknown duration. Her total days of hospitalization are unknown due to a lack of cooperation by the treating medical facility.

Patient Demographics

Age/sex:	69 years/female
Height:	Unknown
Weight:	Unknown
Eyewear:	Unknown
Seat type:	Wheeled ambulance cot (rear-facing)
Seat track position:	Not adjustable
Manual restraint usage:	Multi-point harness system
Usage source:	Vehicle inspection; official records
Air bags:	None available
Alcohol/drug involvement:	None

Egress from vehicle: Removed from vehicle by emergency responders
Transport from scene: Ambulance to a local hospital
Type of medical treatment: Unknown

Patient Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Hip fracture, NFS [suspected to be the right hip in consideration of the crash dynamics]	856200.2	Isolated IPC - Left side – Other left side object (specify): Left wall of patient compartment	Possible
2	Numerous soft tissue injuries, NFS	910000.1	Unknown due to lack of specificity	Unknown

Source: Ambulance agency interview; several hospital record requests denied.

Patient Kinematics

The patient was being transported to a local hospital by the involved ambulance and crew after she had experienced dizzy spells and sustained a minor head laceration from a fall. She was in a Fowler position on the wheeled ambulance cot, and restrained by its multi-point harness system. The harness system included lateral leg, thigh, and chest straps, with shoulder harness. The patient's manual restraint status was reported by the investigating law enforcement agency and corroborated by her outcome and final rest position. Historical wear on the harness system masked any minor loading evidence.

At impact with by the Hyundai, the patient initiated a rearward trajectory (with respect to her orientation) toward the impact forces. Her posterior loaded the inclined back support of the mattress platform, and the use of the multi-point harness system and shoulder straps prevented her vertical displacement from the wheeled ambulance cot. The patient remained on the wheeled ambulance cot as the vehicle experienced the secondary impact (side slap) and rolled left. She likely contacted the left wall cabinetry during the crash during the rollover, which may have been the source of the unspecified hip fracture. She was reported to have remained belted by the multi-point harness system.

The wheeled ambulance cot remained secured by the cot fastener system for the duration of the impact sequence. Arriving emergency response personnel located the patient belted to the cot in the ambulance and assisted her from the vehicle. The cot remained secured in the overturned ambulance. The patient was transported by another ambulance to a local hospital. Due to a lack of cooperation by the treating facility, the source of her injury information came from the interview with the ambulance agency. Her outcome and the treatment course for her pre-crash ailments also remains unknown.

EMT Demographics

Age/sex: 54 years/male
Height: 175 cm (69 in)
Weight: 107 kg (236 lb)
Eyewear: None

Seat type:	Left-facing bench with separate back cushions
Seat track position:	Not adjustable
Manual restraint usage:	Multi-point harness system available; not used
Usage source:	Vehicle inspection
Air bags:	None available
Alcohol/drug involvement:	None
Egress from vehicle:	Unknown
Transport from scene:	Ambulance to a local hospital
Type of medical treatment:	Pronounced deceased after arrival at hospital

EMT Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Crushed chest – anterior wall free-floating	400999.9	Isolated IPC Interior – Other interior objects (specify): Forward wall of patient compartment/bulkhead	Certain
2	Hypermobility of neck	600999.9	Isolated IPC Interior – Other interior objects (specify): Forward wall of patient compartment/bulkhead	Certain
3	Left wrist fracture, NFS	751900.2	Isolated IPC Interior – Other interior objects (specify): Forward wall of patient compartment/bulkhead	Probable
4	Extensive abrasion of right hand, NFS	710202.1	Isolated IPC Interior – Other interior objects (specify): Forward wall of patient compartment/bulkhead	Probable

Source: medical examination records (external)

EMT Kinematics

The EMT was seated in the ambulance's patient compartment on the left-facing bench seat. Although two multi-point harness systems were available for his manual restraint, he was not belted. His lack of manual restraint use was apparent by the evidence documented as part of this SCI investigation. The parent company policy was that the use of restraints is required, so long as it does not interfere with the administration of patient care.

The EMT was in the patient compartment to monitor and attend to the care of the patient who was being transported to a local hospital. The activities that the EMT would have been responsible for during the transport would have included: monitoring the patient, obtaining vital signs, administering care, documenting the patient's condition and any courses of treatment,

obtaining and documenting pertinent information concerning the patient and her current condition, and notifying the hospital of their pending arrival and providing them with a patient report.

At impact by the Hyundai, the EMT initiated a trajectory toward the left front of the ambulance in response to the direction of the impact force. This trajectory was rightward and slightly forward with respect to his seating orientation. The EMT loaded the seat cushion of the bench seat as he was displaced, evidenced by abrasions to the vinyl surface of the bench as documented during the SCI vehicle inspection. He separated from the bench seat and continued toward the applied force. He then contacted the bulkhead/front wall of the patient compartment with his face/head. This contact was evidenced by an impression of his face on the laminate surface as documented by the SCI vehicle inspection. He loaded the bulkhead with his head and face, while his anterior chest/thorax likely contacted the seatback of the captain's chair and wall. There was no evidence on the captain's chair to support these kinematics. The EMT remained displaced against the bulkhead as the ambulance began to roll to the left and rotate clockwise in response to the dynamics of the crash.

The EMT's trajectory toward the left side of the ambulance was exacerbated by the secondary impact with the Hyundai (left side slap). His left flank likely contacted the left wall cabinetry, though there was no documented contact evidence to support these kinematics. He would have remained toward the left of the interior as the ambulance maintained its clockwise rotation and fell onto its left side. As the ambulance continued its rotation while sliding toward its documented final rest position, it is possible that the EMT was directed toward the rear of the vehicle.

There were conflicting reports and evidence surrounding the final rest position of the EMT. Law enforcement documentation of the crash suggested that he was ejected, either wholly or partially, through the rear loading doors as the ambulance slid to final rest.

However, the dynamics of the crash did not include a rearward force to the ambulance, other than that of friction on its left plane as it slid to rest, that could have elicited a substantial rearward trajectory to the male with respect to the ambulance. Yet, the first arriving emergency response personnel found the EMT at the rear of the ambulance, with the rear loading doors opened, and him lying partially on the opened rear left door and partially on the ground.

Surveillance video recordings of the crash and the surrounding environment were not at the correct angle to provide a clear view of the rear aspect of the ambulance during the final stages of the crash or as it was positioned at final rest. The video did show the Hyundai driver going toward the back of the ambulance, but he had fled from the scene by the time emergency responders arrived at the scene. Based on the SCI investigation, it is more likely that either the Hyundai's driver or other passersby opened the rear loading doors and pulled the EMT partially out of the vehicle.

The EMT sustained significant injuries as a result of the crash and was unresponsive when emergency responders arrived at the crash scene. He was immobilized on a long spine board and lifesaving efforts were initiated. The EMT was transported by ambulance to the closest hospital, where he was pronounced deceased shortly after arrival.

2016 Hyundai Sonata

Description

The 2016 Hyundai Sonata (Figure 24) was manufactured during February 2016 and was identified by the VIN 5NPE24AF3GHxxxxxx. It was a four-door, front-wheel-drive sedan powered by a 2.4-liter inline 4-cylinder gasoline engine linked to an automatic transmission. The GVWR was 2,040 kg (4,497 lb), with a front GAWR of 1,160 kg (2,557 lb) and rear GAWR of 1,140 kg (2,513 lb) rear. The vehicle manufacturer's recommended tire size was P205/65R16, with recommended cold tire pressures of 235 kPa (34 PSI) front and rear. At the time of the SCI inspection, the Hyundai had Kumho Solus TA31 tires of the recommended size at all four axle positions. The front tires both had 3 mm (4/32 in) of tread, while the rears both had 6 mm (8/32 in) of tread. The left front, left rear, and right rear tires all had matching TINs: Y0ER YAY1 4515. The right front TIN was not visible. Only the left front tire remained inflated, the others were all flat. The right front tire was debeaded and the axle assembly was sheared from the vehicle.

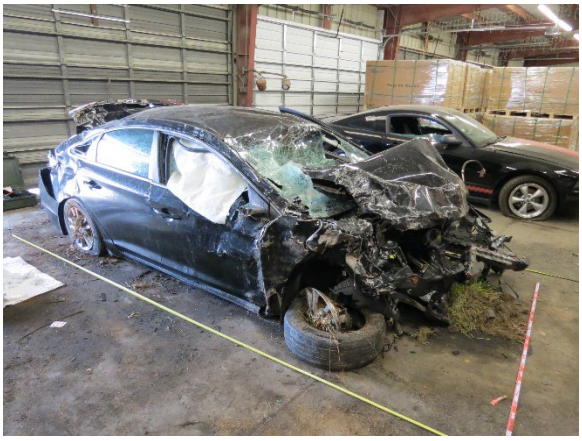


Figure 24. Right front oblique view of the Hyundai at the time of the SCI inspection

Exterior Damage

Severe damage was apparent to the front plane of the Hyundai associative to the events of the crash. Longitudinal deformation to the front plane of the Hyundai relative to the frontal impact with the ambulance (Event 1) was apparent. Minor deformation was discernable to the rear right aspect of the Hyundai from the side-slap (Event 2). The entire engine assembly had separated from the vehicle during the crash sequence, likely as a result of the impact to the concrete curb (Event 4). Finally, minor rollover damage was discernable on all planes (Event 5).

The Event 1 direct damage width, as well as the direct and induced damage width (Field-L) both measured 113 cm (44.5 in) across the width of the deformed front bumper beam. The bumper beam extension on the left frame rail was bent, and the right frame rail was deformed. A residual crush profile documented to the deformed bumper beam produced the following resultant measurements: C1 = 21 cm (8.3 in), C2 = 33 cm (13.0 in), C3 = 46 cm (18.1 in), C4 = 58 cm (22.8 in), C5 = 58 cm (22.8 in), and C6 = 48 cm (18.9 in).

Maximum crush to the vehicle measured 58 cm (23.2 in) and was located 30 cm (11.8 in) left of the right front bumper corner. Associative to the severe frontal impact, the right wheelbase was reduced by approximately 18 cm (7.1 in). The CDC assigned to the event 1 damage pattern of the Hyundai was 01FDEW3. The front plane damage profile spanned the entire end width of the Hyundai (Figure 25). The damage algorithm of the WinSMASH model was used to calculate the severity (delta V) reconstruction of the crash. The calculated total delta V of the Hyundai for the Event 1 impact with the ambulance was 60 km/h (37.3 mph). Longitudinal and lateral components of the calculated delta V were -46 km/h (-29.6 mph) and -39 km/h (-24.2 mph), respectively. These results were underestimated compared to the EDR-reported delta V values.

Figure 25. View of the severe front plane damage profile from the Event 1 impact with the ambulance

Damage related to the secondary side slap impact was located on the right plane of the Hyundai with a non-horizontal nature wrapping toward the top plane. Damage began at the C-pillar and extended 110 cm (43.3 in) to the back plane. The damage consisted of the disintegration of the small glazing panel between the C-pillar and D-pillar, the likely disintegration of the backlight glazing, disintegration of the right taillight, minor deformation to the C- and D-pillars, deformation to the right rear fender, and deformation to the trunk. In the surveillance video, the trunk lid was seen popping open as a result of the deformation and forces associated with the side slap event.

Figure 26. View of the right plane damage from the side slap (Event 2) and rollover (Event 5)

Due to the location of the impact and the overlapping rollover damage, no specific crush measurements of the pattern were obtained. Figure 26 shows the Hyundai's side slap damage profile. The CDC assigned to the Hyundai was 03RBHW3. The missing vehicle algorithm of the WinSMASH model was used to calculate the severity (delta V) of the impact. The calculated total delta V of the Hyundai for the Event 2 side slap impact with the ambulance was 13 km/h (8.1 mph). Longitudinal and lateral components of the calculated delta V were 2 km/h (1.2 mph) and -13 km/h (-8.1 mph), respectively. These borderline results seemed reasonable.

Damage associated with the impact to the curb (Event 4) was observed to the front plane and undercarriage of the Hyundai. The left front tire/wheel was displaced rearward 21 cm (8.3 in) and the entire engine assembly was pulled from the Hyundai during the engagement with the curb. The engagement of the engine and left front axle position of the Hyundai with the curb instigated counterclockwise rotation to the vehicle. No crush measurements relative to this impact could be obtained. The CDC assigned to the Hyundai for the front plane/undercarriage impact was 12FYLW3. No WinSMASH calculations for the curb strike (Event 4) could be computed due to the lack of residual crush and impact type that was beyond the scope of the program.

Rollover damage to the Hyundai (Event 5) was discernable on all planes, with various areas of dirt and vegetation debris captured in the body. The most significant rollover damage was observed to the top plane, consisting of minor deformation and crush of less than 3 cm (1.2 in) to the roof. The CDC assigned to the Hyundai for the rollover event was 00TDDO1. It was a right side-leading rollover, instigated by the tripping forces of the right side tires/wheels engaging the grass/soil surface of the roadside. No WinSMASH calculations could be computed relative to the rollover, as the dynamics of the rollover were beyond the scope of the program.

Event Data Recorder

The 2016 Hyundai Sonata had an air bag control unit (ACU) that was 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 safety 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 CDR software/tool; therefore, the SCI investigator had no means by which to image any data from the Hyundai. However, the investigating law enforcement agency later provided to SCI an electronic (PDF) copy of the data that they imaged from the Hyundai's ACU. A sanitized copy of this data is included at the end of this technical report as Appendix B.

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 9,397. The data were retrieved on ignition cycle 9,398. The imaged data were confirmed to be recorded from the crash under investigation. It was accompanied by pre-crash data that indicated that the driver was accelerating the Hyundai and operating it at excessive speed, with no attempt to avoid the crash. The recorded pre-crash data were as follows.

Time (sec)	Speed (km/h [mph])	Accel. Pedal (%)	Service Brake	Steering (deg)
-5.0	130 (81)	0	On	0
-4.5	123 (76)	0	On	-5
-4.0	120 (75)	0	On	0
-3.5	116 (72)	0	On	-5
-3.0	114 (71)	40	Off	-5
-2.5	116 (72)	0	Off	5
-2.0	115 (71)	0	Off	0
-1.5	115 (71)	44	Off	0
-1.0	115 (71)	66	Off	0
-0.5	115 (71)	71	Off	0
0.0	117 (73)	55	Off	0

The recorded event was a deployment event that produced the following commands:

Device	Time (milliseconds)
Pretensioner, driver	7
Frontal air bag, driver, 1st stage	17
Frontal air bag, driver, 2nd stage	22
Side (seat-mounted) air bag, right	22
Inflatable curtain (IC), right	22

When the event was recorded, the Hyundai's air bag warning lamp was off. The driver's seat belt system was buckled when the event occurred. The maximum recorded longitudinal delta V of the crash pulse was -66 km/h (-41 mph) at 112.5 milliseconds after AE, and the maximum recorded lateral delta V was -62 km/h (-39 mph) at 295 milliseconds after AE. It was apparent that no subsequent events were recorded due to the loss of vehicle power associated with the disintegration of the vehicle's battery relative to the Event 1 impact damage.

Occupant Data

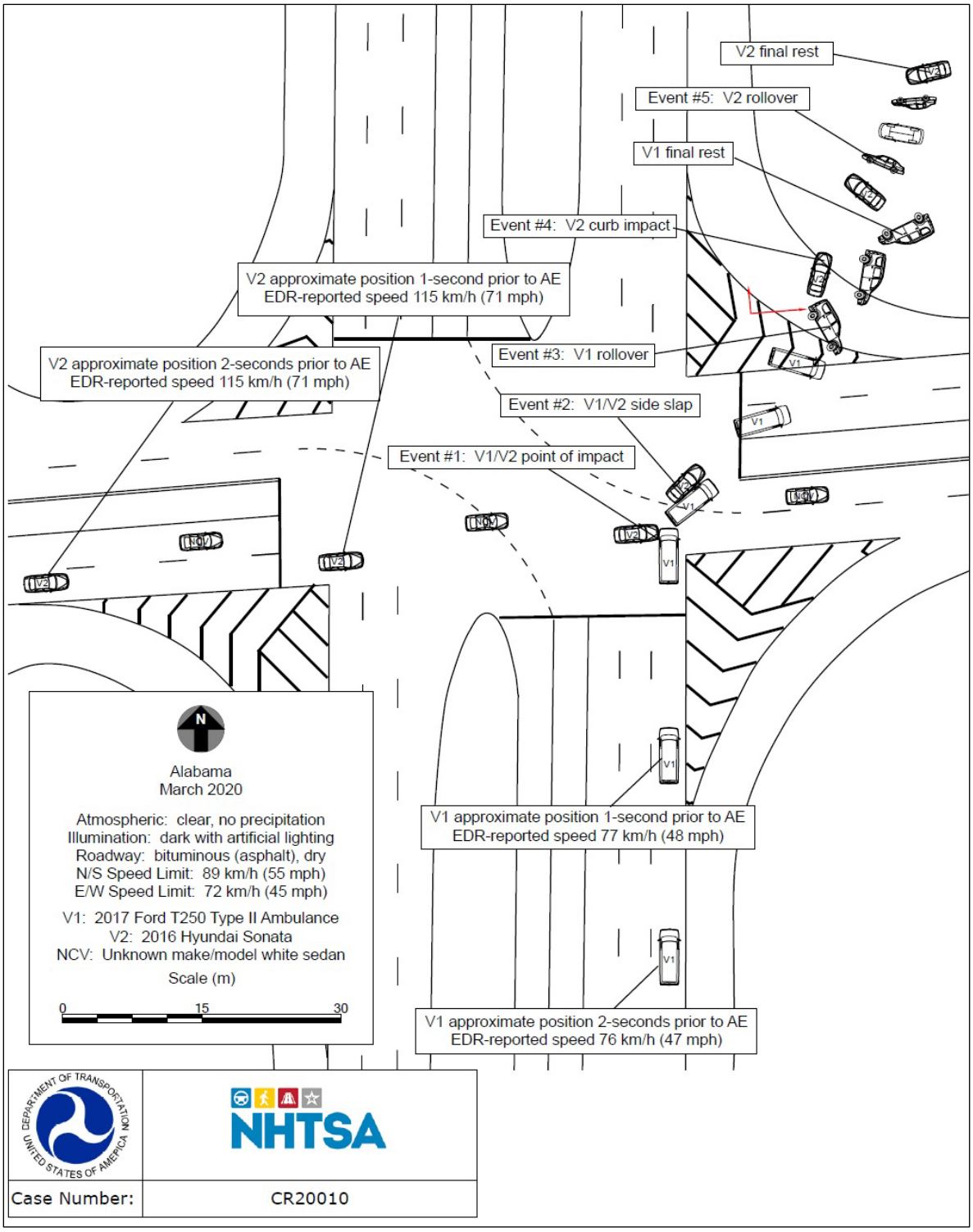
The Hyundai was driven by a belted 27-year-old male. When the crash occurred, the Hyundai was traveling at high speeds adjacent to and slightly behind a white sedan of an unknown make and model. The Hyundai driver accelerated the vehicle through the intersection against the steady red phase of the electronic signal.

According to the data imaged from the Hyundai's EDR and the traffic surveillance camera video, the Hyundai's driver made no attempt to avoid the crash. Several supplemental safety devices, including the driver's seat belt pretensioner and frontal air bag, deployed as a result of the multiple event crash.

The driver remained belted in the Hyundai when the vehicle rolled to final rest on its wheels (upright). He exited the vehicle without assistance and was observed in the video walking toward the back of the overturned ambulance. After a short time delay out of view, the Hyundai driver was then observed getting into the white sedan he had initially been traveling next to and fled from the crash scene. He sought medical care at a local hospital for reported non-incapacitating (B-level) injuries. The Hyundai driver was later arrested, criminally charged, and convicted of several counts.

.

Crash Diagram



Appendix A: 2017 Ford Transit Event Data Recorder Report[3]

[3] The EDR report contained in this technical report was imaged by the investigating law enforcement agency using the version of the Bosch CDR software current at the time of their investigation. The data was later provided to SCI as an electronic (PDF) file. During the SCI analysis it was observed that the content on Pages 8-10 and 17-19 appeared to be missing. The report was then sanitized by SCI to remove the production sequence in the vehicle identification number, as well as the hexadecimal data on Pages 21-27.

IMPORTANT NOTICE: Robert Bosch LLC and the manufacturers whose vehicles are accessible using the CDR System urge end users to use the latest production release of the Crash Data Retrieval system software when viewing, printing or exporting any retrieved data from within the CDR program. Using the latest version of the CDR software is the best way to ensure that retrieved data has been translated using the most current information provided by the manufacturers of the vehicles supported by this product.

CDR File Information

User Entered VIN	1FDYR2CM6HKxxxxxx
User	
Case Number	
EDR Data Imaging Date	03/27/2020
Crash Date	
Filename	
Saved on	Friday, March 27 2020 at 16:16:36
Imaged with CDR version	Crash Data Retrieval Tool 19.0
Imaged with Software Licensed to (Company Name)	
Reported with CDR version	Crash Data Retrieval Tool 19.0
Reported with Software Licensed to (Company Name)	
EDR Device Type	Airbag Control Module
ACM Adapter Detected During Download	Yes
Event(s) recovered	locked frontal event locked side event locked rollover event

Comments

Data Limitations

Data Imaging:

CAUTION: When imaging data directly from the RCM on a bench top, make sure the RCM is placed on a flat surface without any movement (static) while connected to and powered by the CDR interface. Not following the above guideline for bench top imaging could risk inducing new events to be recorded in the RCM and possibly overwriting a Non airbag deployment.

Note that the RCM Adapter Detected during Download parameter equal to " Yes" indicates that the EDR data was collected directly from the RCM. When equal to "No", it indicates that the EDR data was collected through the OBD II from the vehicle.

Restraints Control Module (RCM) Recorded Crash Event(s):

The RCM can store up to two crash events. Event types are categorized as follow:

1. Non deployment trigger event is an event in which EDR recording trigger threshold is met or exceeded (minimum of 5 mph (8kph) Accumulated Delta Velocity within 150ms interval), but no device(s) have deployed. The data from such event can be overwritten by subsequent events.

2. Airbag deployment event is an event in which frontal, side or curtain airbags have deployed. Note that such event cannot be overwritten or cleared from the Restraints Control Module (RCM). Once the RCM has deployed any airbag device(s), the RCM must be replaced.

3. Some RCM may also categorize Non airbag deployment event. This type is an event in which non airbag devices such as pretentioners, knee bolster etc… have deployed. Note that such event can be overwritten given a subsequent "deployment" event.

"Time zero" or Event Beginning of any event (First Record or Second Record) is defined as the first Algorithm wake up during that event. So all the Pre-Crash, At Event, Delta V Data, deployment times etc… are relative to "Time zero".

It is possible that conditions in a crash may result in an incomplete event data record.

EDR Data Elements Overview/Interpretation in CDR Report:

Under CDR File Information Section

- Event(s) recovered indicates if an event was detected and recorded by RCM. If no event is detected, it will indicate "none". If a trigger or non airbag deployment event is detected, it will indicate "unlocked event". If an airbag deployment is detected, it will indicate "locked frontal event", or "locked side event", or "locked rollover event".

Under System Status at Event Section

- Complete file recorded indicates if data from the recorded event has been fully written to the RCM memory.
- If the RCM detected a peripheral crash sensor was lost during an event, the crash sensor would be identified as well as the time it was lost during that event relative to Time zero. If no loss of a peripheral crash sensor, nothing would be displayed. Note in some vehicles, loss of a peripheral crash sensor may lead to the loss of another peripheral crash sensor due to shared communication.

Under Deployment Data Section

- If the RCM commanded a deployment during an event, the deployment device(s) would be identified as well as the time the RCM commanded its deployment relative to Time zero. If no device was commanded to deploy by the RCM, nothing (no deployment device(s)) would be displayed.

Under Pre-Crash Data -5 to 0 sec

- Steering Wheel Angle if Applicable: positive value indicates left turn, and negative value would indicate right turn.
- Stability Control Lateral Acceleration if Applicable: Lateral Acceleration (Y-direction) is the acceleration along the lateral axis of the vehicle, reported as positive when accelerating to the left.
- Stability Control Longitudinal Acceleration if Applicable**:** Longitudinal Acceleration (X-direction) is the acceleration along the longitudinal axis of the vehicle, reported as positive when accelerating in a forward direction.
- Stability Control Yaw Rate if Applicable: The Yaw Axis is the vertical axis of the vehicle, generally perpendicular to the plane of the road. A positive Yaw Rate is counter-clockwise when observing the vehicle from above.
- Stability Control Roll Rate if Applicable: The Roll Axis is the longitudinal axis of the vehicle, generally aligned with the primary axis of motion of the vehicle. A positive Roll Rate is counter-clockwise when observing the vehicle from the front.

Under Longitudinal Crash Pulse

- Delta-V, longitudinal: SAE J211 sign convention, negative value generally indicates a front crash and positive value generally indicates a rear crash. Longitudinal delta-V reflects the change in forward velocity that the sensing system experienced from Time zero. It is not the speed the vehicle was traveling before the event. Note that the vehicle speed is recorded separately. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle longitudinal delta-V.

Under Lateral Crash Pulse

- Delta-V, lateral: SAE J211 sign convention, Positive value generally indicates a driver side crash and negative value generally indicates a passenger side crash.

Under Rollover Sensor Data (if Applicable)

- Vehicle roll angle if applicable: The Roll Axis is the longitudinal axis of the vehicle, generally aligned with the primary axis of motion of the vehicle. A positive Roll Angle is counter-clockwise when observing the vehicle from the front.

Data Sources:

The Restraints Control Module (RCM) contains all recorded data on any event. Data collected from the RCM comes from multiple sources:

1. Internal to the RCM such as internal sensors for delta Velocity data, rollover angle data if applicable, etc… which are measured, calculated and stored internally.

2. External to the RCM but with a direct connection such as buckle switches, peripheral crash sensors, seat track switch(s) etc… which are measured, calculated and stored internally.

3. External Modules to the RCM such as Powertrain Control Module, Brake Control Module, etc… Theses modules communicate to the RCM via Vehicle Communication Network. The RCM stores the received data internally.

System Status at Time of Retrieval

VIN As Programmed into RCM at Factory	1FDYR2CM6HKxxxxxx
Current VIN from PCM	1FDYR2CM6HKxxxxxx
Ignition Cycle, Download (First Record)	5,242
Ignition Cycle, Download (Second Record)	5,242
Restraints Control Module Part Number	CK4T-14B321-CG
Restraints Control Module Serial Number	7039227130250000
Restraints Control Module Software Part Number (Version)	BK2T-14C028-BA
Driver Side/Center Frontal Restraints Sensor Serial Number	00022A6A
Driver, Row 1, Side Restraint Sensor 1 Serial Number	00000080
Driver, Row 2, Side Restraint Sensor 2 Serial Number	00022A62
Passenger Frontal Restraints Sensor Serial Number	00000000
Passenger, Row 1, Side Restraint Sensor 1 Serial Number	00000048
Passenger, Row 2, Side Restraint Sensor 2 Serial Number	00182A6C

System Status at Event (First Record)

Recording Status	Record Locked
Complete File Recorded (Yes, No)	Yes
Multi-Event, Number of Events	1
Time From Event 1 to 2 (msec)	N/A
Lifetime Operating Timer at Event Time Zero (sec)	11,681,430
Key-On Timer at Event Time Zero (sec)	1,305
Vehicle Voltage at Time Zero (V)	14.175
Energy Reserve Mode Entered During Event (Yes, No)	Yes
Time Driver Side/Center Frontal Restraints Sensor Lost Relative to Time Zero (msec)	81.0
Time Row 1 Driver Side Restraint Sensor Lost Relative to Time zero (msec)	30.5

Faults Present at Start of Event (First Record)

No Faults Recorded

Deployment Data (First Record)

Frontal Airbag Deployment, Time to First Stage Deployment, Driver (msec)	32.0
Side Curtain Airbag Deployment, Time to Deploy, Driver Side (msec)	15.5
Side (Thorax) Air Bag Deployment, Time to Deploy, Driver (msec)	15.5
Pretensioner (Retractor) Deployment, Time to Fire, Driver (msec)	15.5
Frontal Airbag Deployment, Time to First Stage Deployment, Front Passenger (msec)	32.0
Side Curtain Airbag Deployment, Time to Deploy, Passenger Right Side (msec)	15.5
Side (Thorax) Airbag Deployment, Time to Deploy, Right Front Passenger (msec)	85.0
Pretensioner (Retractor) Deployment, Time to Fire, Right Front Passenger (msec)	15.5
Maximum Delta-V, Longitudinal (MPH [km/h])	-26.44 [-42.56]
Time, Maximum Delta-V Longitudinal (msec)	300
Maximum Delta-V, Lateral (MPH [km/h])	38.26 [61.57]
Time, Maximum Delta-V Lateral (msec)	300
Driver Row 2, Side Sensor, Discriminating Deployment	Yes
Driver Row 2, Side Sensor, Safing	Yes
RCM, Side Driver (Lateral), Safing	Yes
RCM Side Passenger (Lateral), Safing	Yes
Driver or Center, Front Satellite Sensor, Discriminating Deployment	Yes
Driver or Center, Front Satellite Sensor, Safing	Yes
Passenger, Front Satellite Sensor, Discriminating Deployment	Yes
RCM Front (Longitudinal), Discriminating Deployment	Yes
RCM Front (Longitudinal), Safing	Yes
RCM, Rollover, Discriminating Deployment	Yes
RCM, Vertical, Safing	Yes
Longitudinal Delta-V Time Zero Offset (msec)	7.5 ms
Lateral Delta-V Time Zero Offset (msec)	7.5 ms
Roll Angle Time Zero Offset (msec)	87.5 ms

Pre-Crash Data -1 sec (First Record)

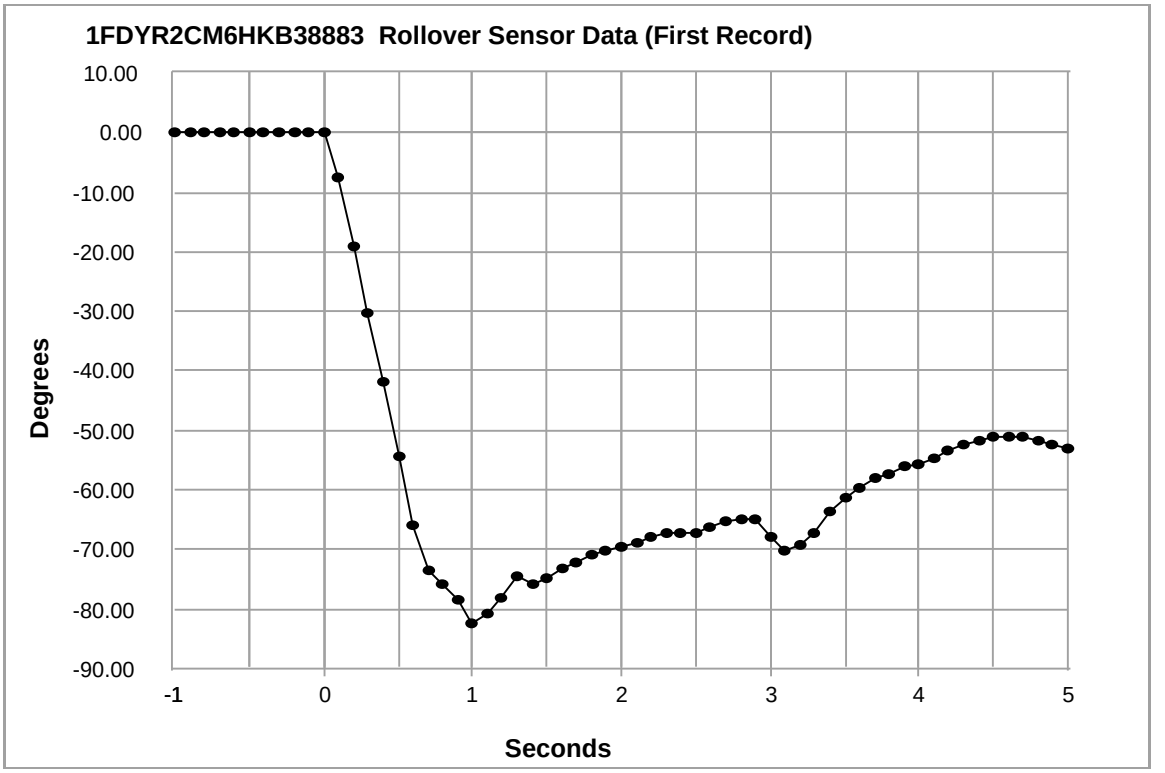
Ignition Cycle, Crash	5,238
Frontal Air Bag Warning Lamp, On/Off	Off
Frontal Air Bag Suppression Switch Status, Front Passenger	Not Active
Safety Belt Status, Driver	Buckled
Brake Telltale	Off
ABS Telltale	Off
ESC/TC Telltale	Off
ESC/TC Off Telltale	Default
Powertrain Wrench Telltale	Off
Powertrain Malfunction Indicator Lamp (MIL) Telltale	Off

Pre-Crash Data -5 to 0 sec [2 samples/sec] (First Record, table 1 of 2)

Times (sec)	Speed, Vehicle Indicated (MPH [km/h])	Speed, Vehicle Indicated Quality Factor	Accelerator Pedal, % Full	Accelerator Pedal Quality Factor	Service Brake, On/Off	Engine RPM	ABS Activity (Engaged, Non-Engaged)	Brake Powertrain Torque Request
- 5.0	44 [71]	OK	27.5	Ok	Off	2,176	non-engaged	No
- 4.5	44 [71]	OK	26.6	Ok	Off	1,828	non-engaged	No
- 4.0	45 [72]	OK	36.8	Ok	Off	1,972	non-engaged	No
- 3.5	45 [73]	OK	38.0	Ok	Off	2,276	non-engaged	No
- 3.0	46 [74]	OK	35.7	Ok	Off	2,282	non-engaged	No
- 2.5	47 [75]	OK	34.6	Ok	Off	2,292	non-engaged	No
- 2.0	47 [76]	OK	32.6	Ok	Off	2,276	non-engaged	No
- 1.5	47 [76]	OK	30.9	Ok	Off	2,146	non-engaged	No
- 1.0	48 [77]	OK	30.4	Ok	Off	2,080	non-engaged	No
- 0.5	48 [77]	OK	0.0	Ok	Off	1,966	non-engaged	No
0.0	46 [74]	OK	0.0	Ok	On	1,504	non-engaged	No

Pre-Crash Data -5 to 0 sec [2 samples/sec] (First Record, table 2 of 2)

Times (sec)	Driver Gear Selection	Traction Control via Brakes	Wheel Torque (Nm)	Speed Control Telltale
- 5.0	Drive	non-engaged	592	Off
- 4.5	Drive	non-engaged	636	Off
- 4.0	Drive	non-engaged	720	Off
- 3.5	Drive	non-engaged	896	Off
- 3.0	Drive	non-engaged	912	Off
- 2.5	Drive	non-engaged	904	Off
- 2.0	Drive	non-engaged	860	Off
- 1.5	Drive	non-engaged	740	Off
- 1.0	Drive	non-engaged	728	Off
- 0.5	Drive	non-engaged	84	Off
0.0	Drive	non-engaged	4	Off



Rollover Sensor Data (First Record)

Time (sec)	Vehicle Roll Angle (deg)
-1.0	0.1
-0.9	0.17
-0.8	0.17
-0.7	0.17
-0.6	0.15
-0.5	0.12
-0.4	0.11
-0.3	0.1
-0.2	0.1
-0.1	0.1
0.0	0.02
0.1	-7.59
0.2	-19.13
0.3	-30.3
0.4	-41.68
0.5	-54.39
0.6	-65.87
0.7	-73.53
0.8	-75.83
0.9	-78.53
1.0	-82.35

Time (sec)	Vehicle Roll Angle (deg)
1.1	-80.65
1.2	-78.11
1.3	-74.47
1.4	-75.97
1.5	-74.87
1.6	-73.15
1.7	-72.12
1.8	-70.73
1.9	-70.04
2.0	-69.5
2.1	-68.85
2.2	-67.99
2.3	-67.39
2.4	-67.21
2.5	-67.19
2.6	-66.24
2.7	-65.33
2.8	-65.03
2.9	-64.88
3.0	-67.83
3.1	-70.07

Time (sec)	Vehicle Roll Angle (deg)
3.2	-69.17
3.3	-67.08
3.4	-63.75
3.5	-61.19
3.6	-59.8
3.7	-57.98
3.8	-57.34
3.9	-56.09
4.0	-55.7
4.1	-54.75
4.2	-53.53
4.3	-52.27
4.4	-51.62
4.5	-51.16
4.6	-51.03
4.7	-51.18
4.8	-51.8
4.9	-52.48
5.0	-52.89

System Status at Event (Second Record)

Recording Status	Record Unlocked
Complete File Recorded (Yes, No)	Yes
Multi-Event, Number of Events	2
Time From Event 1 to 2 (msec)	2,600
Lifetime Operating Timer at Event Time Zero (sec)	11,681,435
Key-On Timer at Event Time Zero (sec)	1,310
Vehicle Voltage at Time Zero (V)	13.446
Energy Reserve Mode Entered During Event (Yes, No)	No
Time Driver Side/Center Frontal Restraints Sensor Lost Relative to Time Zero (msec)	Data lost prior to event
Time Row 1 Driver Side Restraint Sensor Lost Relative to Time zero (msec)	Data lost prior to event
Time Row 2 Passenger Side Restraint Sensor Lost Relative to Time Zero (msec)	Data lost prior to event

Faults Present at Start of Event (Second Record)

U3000-49
B1413-93
B1414-93
B1193-00

Deployment Data (Second Record)

Maximum Delta-V, Longitudinal (MPH [km/h])	-8.86 [-14.26]
Time, Maximum Delta-V Longitudinal (msec)	300
Maximum Delta-V, Lateral (MPH [km/h])	3.40 [5.48]
Time, Maximum Delta-V Lateral (msec)	300
Driver Row 2, Side Sensor, Discriminating Deployment	Yes
Driver Row 2, Side Sensor, Safing	Yes
RCM, Side Driver (Lateral), Safing	Yes
RCM Side Passenger (Lateral), Safing	Yes
Longitudinal Delta-V Time Zero Offset (msec)	6.0 ms
Lateral Delta-V Time Zero Offset (msec)	6.0 ms
Roll Angle Time Zero Offset (msec)	66.0 ms

Pre-Crash Data -1 sec (Second Record)

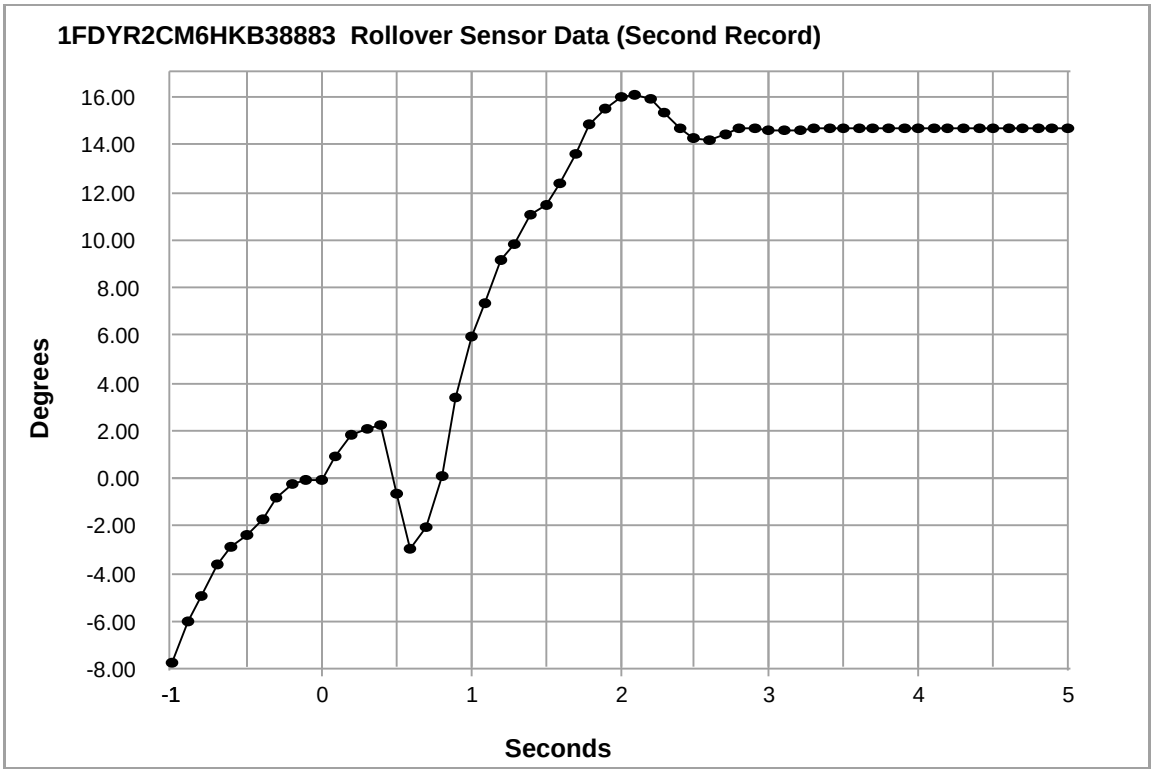
Ignition Cycle, Crash	5,238
Frontal Air Bag Warning Lamp, On/Off	On
Frontal Air Bag Suppression Switch Status, Front Passenger	Not Active
Safety Belt Status, Driver	Buckled
Brake Telltale	Off
ABS Telltale	Off
ESC/TC Telltale	Off
ESC/TC Off Telltale	Default
Powertrain Wrench Telltale	Off
Powertrain Malfunction Indicator Lamp (MIL) Telltale	Off

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Second Record, table 1 of 2)

Times (sec)	Speed, Vehicle Indicated (MPH [km/h])	Speed, Vehicle Indicated Quality Factor	Accelerator Pedal, % Full	Accelerator Pedal Quality Factor	Service Brake, On/Off	Engine RPM	ABS Activity (Engaged, Non-Engaged)	Brake Powertrain Torque Request
- 5.0	47 [75]	OK	34.6	Ok	Off	2,292	non-engaged	No
- 4.5	47 [76]	OK	32.6	Ok	Off	2,276	non-engaged	No
- 4.0	47 [76]	OK	30.9	Ok	Off	2,146	non-engaged	No
- 3.5	48 [77]	OK	30.4	Ok	Off	2,080	non-engaged	No
- 3.0	48 [77]	OK	0.0	Ok	Off	1,966	non-engaged	No
- 2.5	46 [74]	OK	0.0	Ok	On	1,504	non-engaged	No
- 2.0	45 [73]	OK	0.0	Ok	On	1,452	non-engaged	No
- 1.5	0 [0]	OK	0.0	Ok	On	1,452	non-engaged	No
- 1.0	0 [0]	OK	0.0	Ok	On	1,452	non-engaged	No
- 0.5	0 [0]	OK	0.0	Ok	On	1,452	non-engaged	No
0.0	0 [0]	OK	0.0	Ok	On	1,452	non-engaged	No

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Second Record, table 2 of 2)

Times (sec)	Driver Gear Selection	Traction Control via Brakes	Wheel Torque (Nm)	Speed Control Telltale
- 5.0	Drive	non-engaged	904	Off
- 4.5	Drive	non-engaged	860	Off
- 4.0	Drive	non-engaged	740	Off
- 3.5	Drive	non-engaged	728	Off
- 3.0	Drive	non-engaged	84	Off
- 2.5	Drive	non-engaged	4	Off
- 2.0	Drive	non-engaged	-28	Off
- 1.5	Drive	non-engaged	-28	Off
- 1.0	Drive	non-engaged	-28	Off
- 0.5	Drive	non-engaged	-28	Off
0.0	Drive	non-engaged	-28	Off



Rollover Sensor Data (Second Record)

Time (sec)	Vehicle Roll Angle (deg)
-1.0	-7.74
-0.9	-6.01
-0.8	-4.98
-0.7	-3.59
-0.6	-2.9
-0.5	-2.36
-0.4	-1.72
-0.3	-0.85
-0.2	-0.25
-0.1	-0.07
0.0	-0.05
0.1	0.89
0.2	1.8
0.3	2.1
0.4	2.26
0.5	-0.69
0.6	-2.93
0.7	-2.03
0.8	0.05
0.9	3.39
1.0	5.95

Time (sec)	Vehicle Roll Angle (deg)
1.1	7.34
1.2	9.16
1.3	9.79
1.4	11.05
1.5	11.43
1.6	12.38
1.7	13.61
1.8	14.87
1.9	15.52
2.0	15.98
2.1	16.1
2.2	15.95
2.3	15.33
2.4	14.66
2.5	14.25
2.6	14.18
2.7	14.43
2.8	14.7
2.9	14.72
3.0	14.64
3.1	14.62

Time (sec)	Vehicle Roll Angle (deg)
3.2	14.63
3.3	14.65
3.4	14.65
3.5	14.65
3.6	14.65
3.7	14.65
3.8	14.65
3.9	14.65
4.0	14.65
4.1	14.65
4.2	14.65
4.3	14.65
4.4	14.65
4.5	14.65
4.6	14.65
4.7	14.65
4.8	14.65
4.9	14.65
5.0	14.65

Hexadecimal Data

Data that the vehicle manufacturer has specified for data retrieval is shown in the hexadecimal data section of the CDR report. The hexadecimal data section of the CDR report may contain data that is not translated by the CDR program. The control module contains additional data that is not retrievable by the CDR system.

Disclaimer of Liability

The users of the CDR product and reviewers of the CDR reports and exported data shall ensure that data and information supplied is applicable to the vehicle, vehicle's system(s) and the vehicle ECU. Robert Bosch LLC and all its directors, officers, employees and members shall not be liable for damages arising out of or related to incorrect, incomplete or misinterpreted software and/or data. Robert Bosch LLC expressly excludes all liability for incidental, consequential, special or punitive damages arising from or related to the CDR data, CDR software or use thereof.

Appendix B: 2016 Hyundai Sonata Event Data Recorder Report[4]

[4] The EDR report contained in this technical report was imaged by a third party for the investigating law enforcement agency using the version of the Global Information Technology tool and software current at the time of their inspection. An electronic (PDF) copy of the imaged data was provided to SCI, which was then sanitized for inclusion in this report.

Vehicle Information

HYUNDAI | SONATA(LFA) | 2016 | AIRBAG SYSTEM	
VIN as Programmed into EMS	

Additional Information

User-entered VIN	5NPE24AF3GHxxxxxx
User Name	
Case Number	
Crash Date	
Saved-on Date	2020-03-18 09:00
EDR Tool Version	E-N-H-01-00-0031
EDR Report Version	EDR001-R01
Tire Size(s)	205/65R16
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/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.

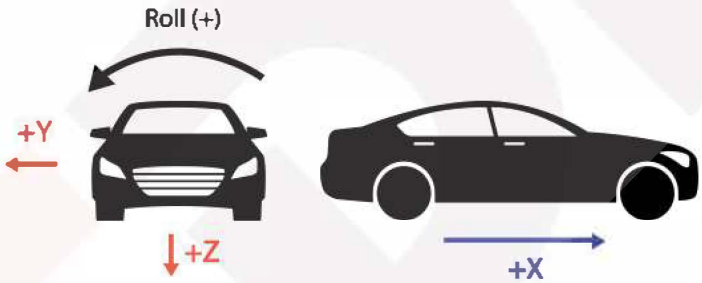
Data Limitation

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 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.

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(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-C2000(C204)
ECU SW Version as programmed into ACU	LF151301
EDR Version as programmed into ACU	

< Event 1 >

Event Status at Event

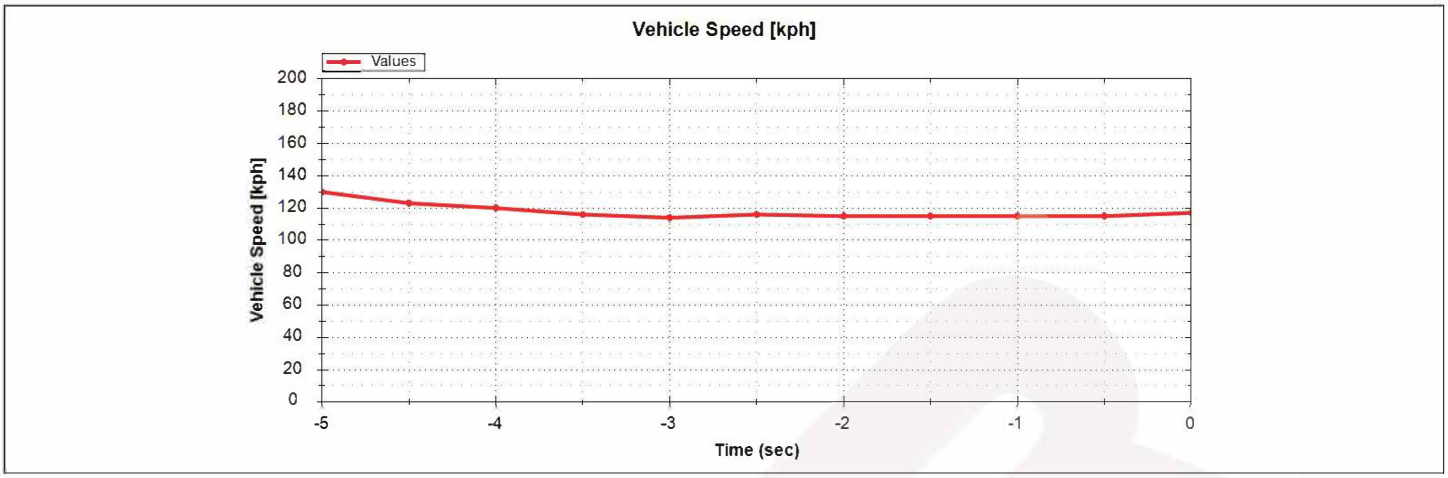
Multi-event, Number of Event (1 or 2)	1 event
Time from Event 1 to 2 [msec]	0
Completed File Recorded (Yes or No)	YES
Ignition cycle, crash [cycle]	9397
Ignition cycle, download [cycle]	9398

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	130	2300	0	0	ON	OFF	ON	0
-4.5	123	2000	0	0	ON	OFF	ON	-5
-4.0	120	1700	0	0	ON	OFF	ON	0
-3.5	116	1500	0	0	ON	OFF	ON	-5
-3.0	114	1800	20	40	OFF	OFF	ON	-5
-2.5	116	2300	0	0	OFF	OFF	ON	5
-2.0	115	2100	0	0	OFF	OFF	ON	0
-1.5	115	2100	30	44	OFF	OFF	ON	0
-1.0	115	2400	48	66	OFF	OFF	ON	0
-0.5	115	3800	70	71	OFF	OFF	ON	0
0.0	117	4100	73	55	OFF	OFF	ON	0

< Event 1 >

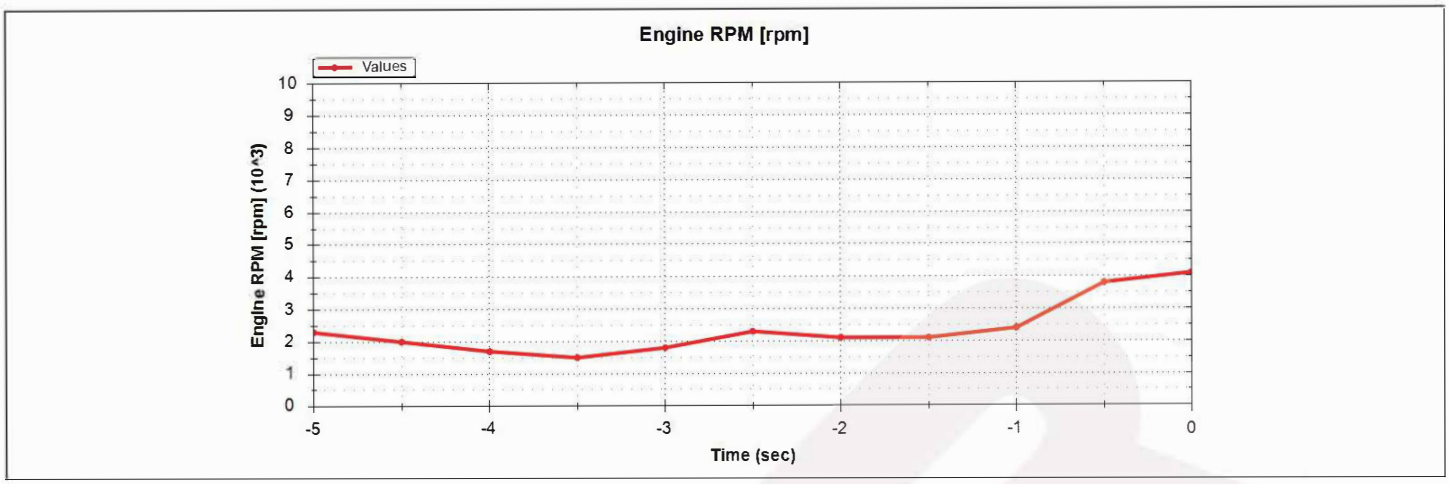
Vehicle Speed



Num	Time (sec)	Vehicle Speed [kph]
1	-5.0	130
2	-4.5	123
3	-4.0	120
4	-3.5	116
5	-3.0	114
6	-2.5	116
7	-2.0	115
8	-1.5	115
9	-1.0	115
10	-0.5	115
11	0.0	117

< Event 1 >

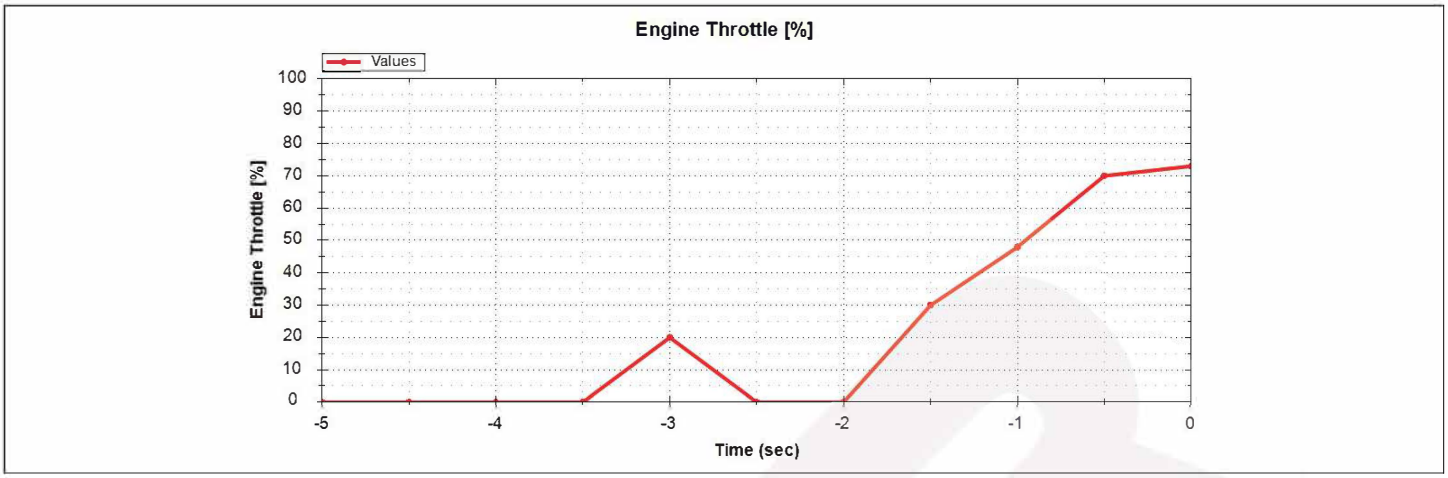
Engine RPM



Num	Time (sec)	Engine RPM [rpm]
1	-5.0	2300
2	-4.5	2000
3	-4.0	1700
4	-3.5	1500
5	-3.0	1800
6	-2.5	2300
7	-2.0	2100
8	-1.5	2100
9	-1.0	2400
10	-0.5	3800
11	0.0	4100

< Event 1 >

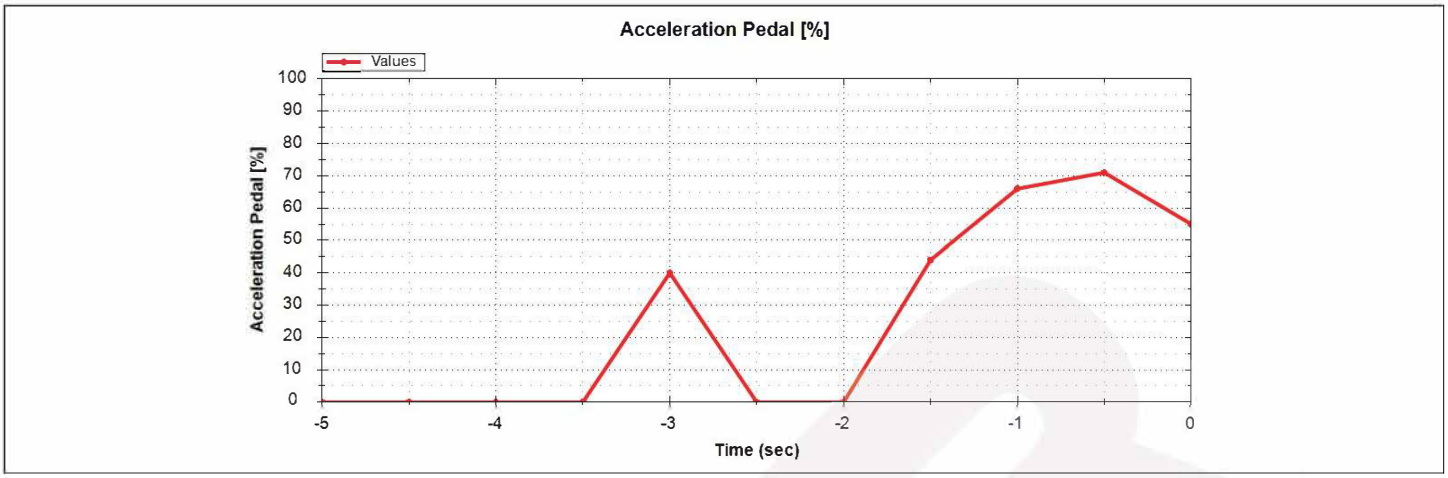
Engine Throttle



Num	Time (sec)	Engine Throttle [%]
1	-5.0	0
2	-4.5	0
3	-4.0	0
4	-3.5	0
5	-3.0	20
6	-2.5	0
7	-2.0	0
8	-1.5	30
9	-1.0	48
10	-0.5	70
11	0.0	73

< 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	40
6	-2.5	0
7	-2.0	0
8	-1.5	44
9	-1.0	66
10	-0.5	71
11	0.0	55

< 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	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

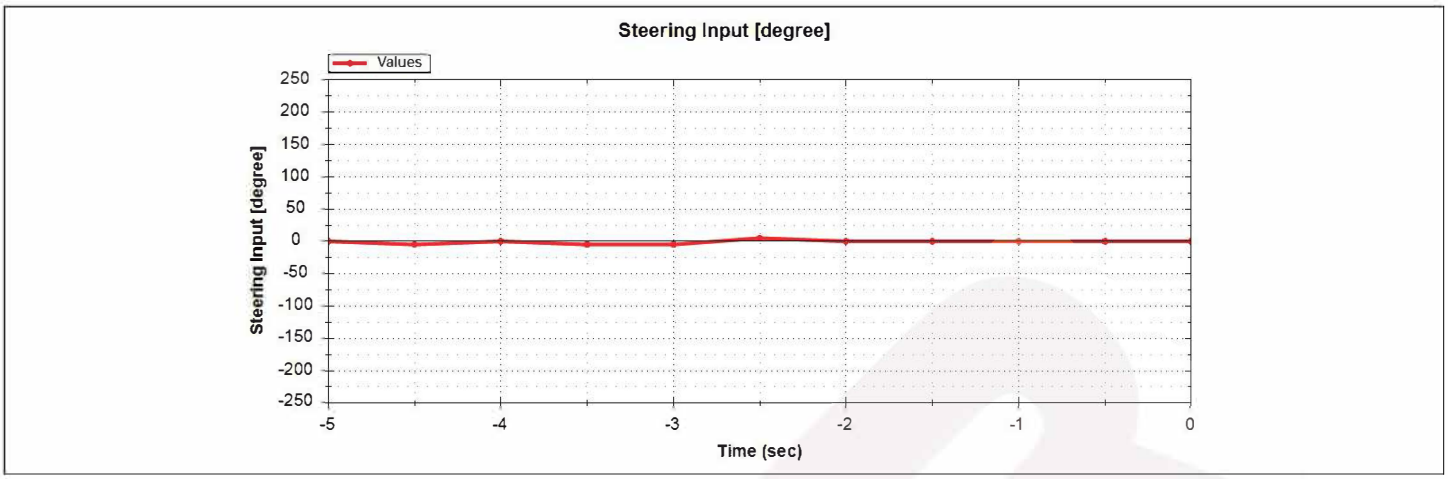
Num	Time (sec)	ABS Activity [on/off]
1	-5.0	OFF
2	-4.5	OFF
3	-4.0	OFF
4	-3.5	OFF
5	-3.0	OFF
6	-2.5	OFF
7	-2.0	OFF
8	-1.5	OFF
9	-1.0	OFF
10	-0.5	OFF
11	0.0	OFF

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	-5
3	-4.0	0
4	-3.5	-5
5	-3.0	-5
6	-2.5	5
7	-2.0	0
8	-1.5	0
9	-1.0	0
10	-0.5	0
11	0.0	0

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

< Event 1 >

System Status at Event

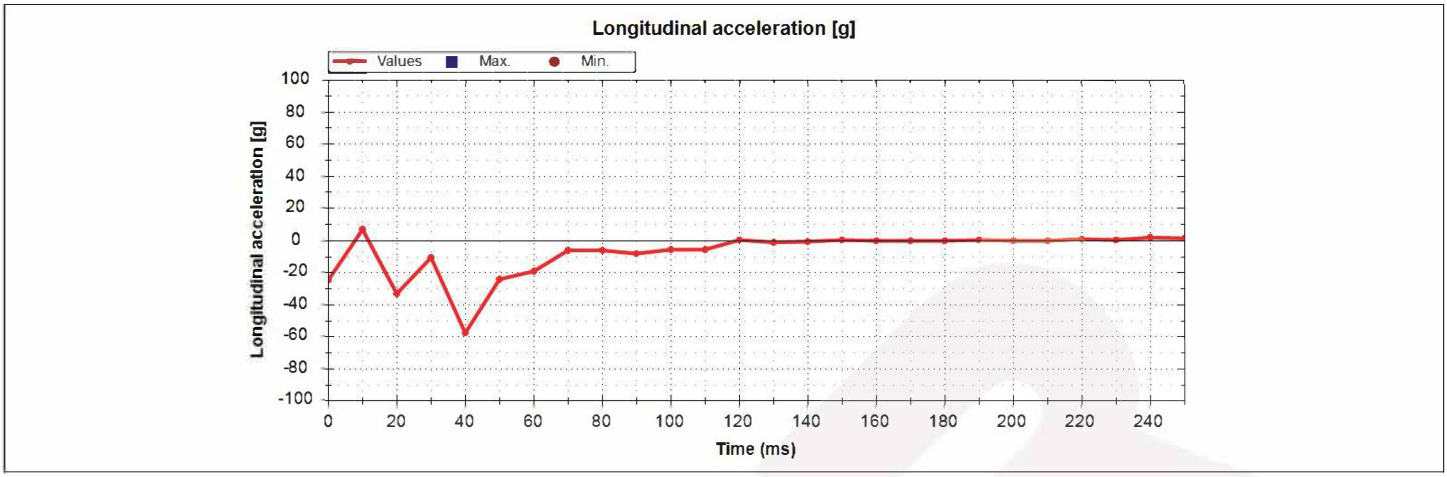
Airbag warning lamp on/off	OFF
Safety seat belt status, driver	ON
Safety seat belt status, passenger	OFF
Seat track position switch foremost status, driver	Not Supported
Seat track position switch foremost status, passenger	Not Supported
Occupant size classification, driver (5% female or larger)	Not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

Deployment Command Data at Event

Front airbag deployment time, driver (first stage) [msec]	17
Front airbag deployment time, passenger (first stage) [msec]	No deployment
Front airbag deployment time, driver (second stage) [msec]	22
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, passenger (third stage) (Yes or No)	NO
Front side airbag deployment time, driver [msec]	No deployment
Front side airbag deployment time, passenger [msec]	22
Curtain airbag deployment time, driver [msec]	No deployment
Curtain airbag deployment time, passenger [msec]	22
Seat belt pretensioner deployment time, driver [msec]	7
Seat belt pretensioner deployment time, passenger [msec]	No deployment

‹ Event 1 ›

Longitudinal crash pulse_acceleration (g, 0 ~ 250msec)

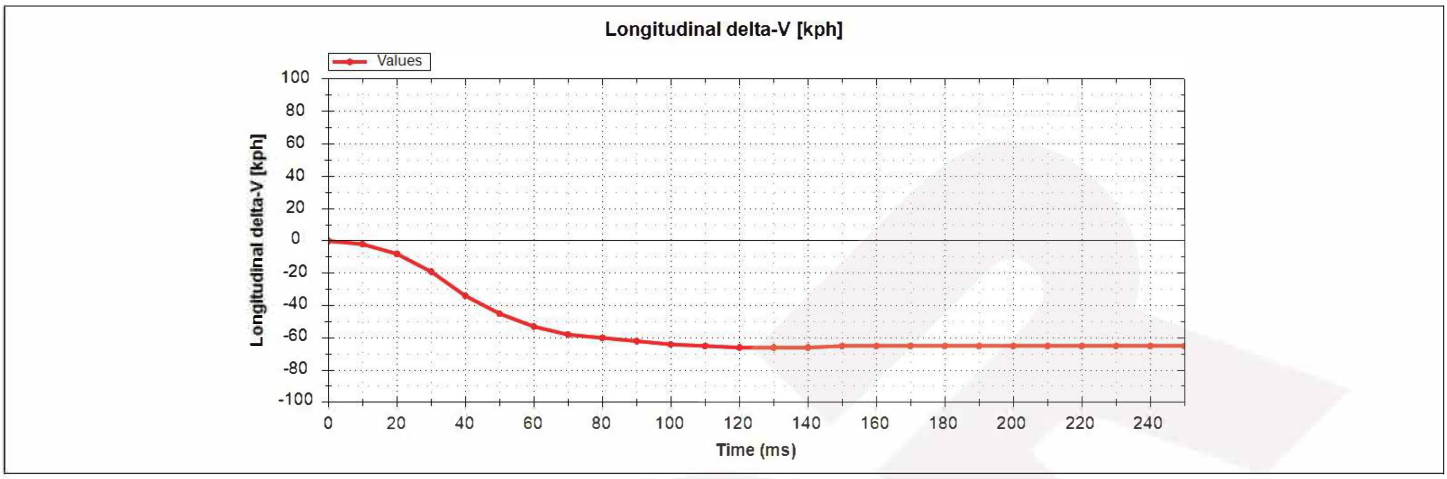


Num	Time (ms)	Longitudinal acceleration [g]
1	0.0	-24.5
2	10.0	7.0
3	20.0	-33.0
4	30.0	-10.5
5	40.0	-57.5
6	50.0	-24.0
7	60.0	-19.0
8	70.0	-6.0
9	80.0	-6.0
10	90.0	-8.0
11	100.0	-5.5
12	110.0	-5.5
13	120.0	0.5
14	130.0	-1.0
15	140.0	-0.5
16	150.0	0.5
17	160.0	0.0
18	170.0	0.0
19	180.0	0.0
20	190.0	0.5
21	200.0	0.0
22	210.0	0.0
23	220.0	1.0
24	230.0	0.5
25	240.0	2.0
26	250.0	1.5

‹ Event 1 ›

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

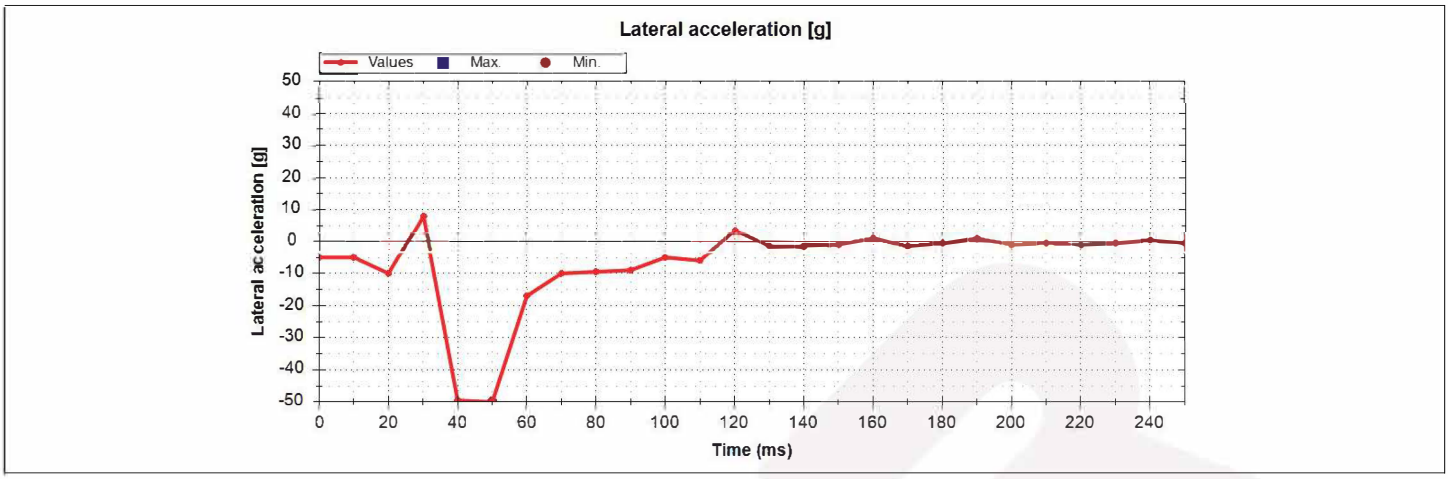
Max. delta-V [kph]	-66
Time, Max. delta-V [msec]	112.5



Num	Time (ms)	Longitudinal delta-V [kph]
1	0.0	0
2	10.0	-2
3	20.0	-8
4	30.0	-19
5	40.0	-34
6	50.0	-45
7	60.0	-53
8	70.0	-58
9	80.0	-60
10	90.0	-62
11	100.0	-64
12	110.0	-65
13	120.0	-66
14	130.0	-66
15	140.0	-66
16	150.0	-65
17	160.0	-65
18	170.0	-65
19	180.0	-65
20	190.0	-65
21	200.0	-65
22	210.0	-65
23	220.0	-65
24	230.0	-65
25	240.0	-65
26	250.0	-65

‹ Event 1 ›

Lateral crash pulse_acceleration (g, 0 ~ 250msec)

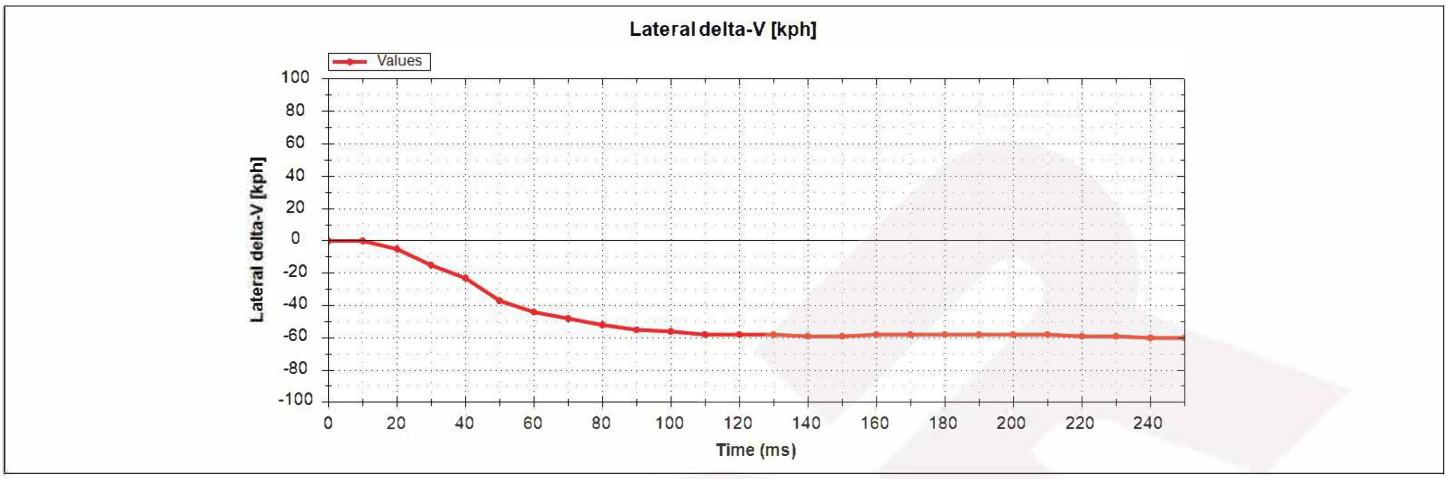


Num	Time (ms)	Lateral acceleration [g]
1	0.0	-5.0
2	10.0	-5.0
3	20.0	-10.0
4	30.0	8.0
5	40.0	-49.5
6	50.0	Exceed the minimum sensor range
7	60.0	-17.0
8	70.0	-10.0
9	80.0	-9.5
10	90.0	-9.0
11	100.0	-5.0
12	110.0	-6.0
13	120.0	3.5
14	130.0	-1.5
15	140.0	-1.5
16	150.0	-1.0
17	160.0	1.0
18	170.0	-1.5
19	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]	-62
Time, Max. delta-V [msec]	295.0



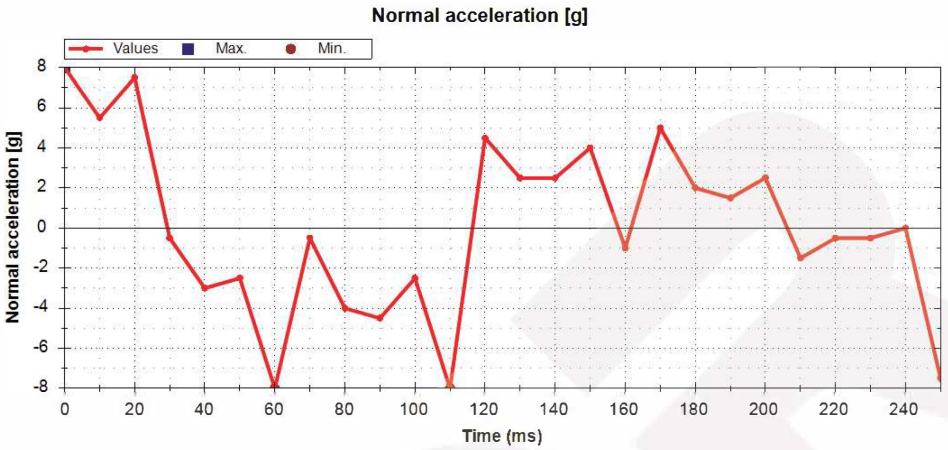
Num	Time (ms)	Lateral delta-V [kph]
1	0.0	0
2	10.0	0
3	20.0	-5
4	30.0	-15
5	40.0	-23
6	50.0	-37
7	60.0	-44
8	70.0	-48
9	80.0	-52
10	90.0	-55
11	100.0	-56
12	110.0	-58
13	120.0	-58
14	130.0	-58
15	140.0	-59
16	150.0	-59
17	160.0	-58
18	170.0	-58
19	180.0	-58
20	190.0	-58
21	200.0	-58
22	210.0	-58
23	220.0	-59
24	230.0	-59
25	240.0	-60
26	250.0	-60

< Event 1 >

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

Time, Max. delta-V, resultant [msec]	130.0

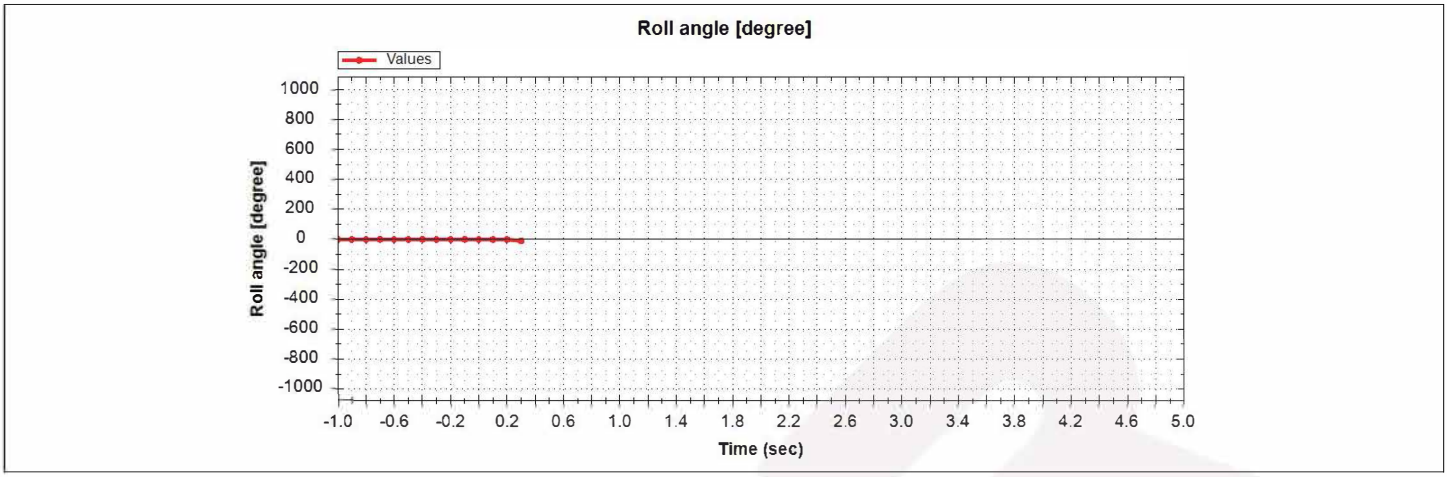
Normal acceleration (g, 0 ~ 250msec)



Num	Time (ms)	Normal acceleration [g]
1	0.0	Exceed the maximum sensor range
2	10.0	5.5
3	20.0	7.5
4	30.0	-0.5
5	40.0	-3.0
6	50.0	-2.5
7	60.0	Exceed the minimum sensor range
8	70.0	-0.5
9	80.0	-4.0
10	90.0	-4.5
11	100.0	-2.5
12	110.0	-8.0
13	120.0	4.5
14	130.0	2.5
15	140.0	2.5
16	150.0	4.0
17	160.0	-1.0
18	170.0	5.0
19	180.0	2.0
20	190.0	1.5
21	200.0	2.5
22	210.0	-1.5
23	220.0	-0.5
24	230.0	-0.5
25	240.0	0.0
26	250.0	-7.5

< 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	-10
15	0.4	Invalid data
16	0.5	Invalid data
17	0.6	Invalid data
18	0.7	Invalid data
19	0.8	Invalid data
20	0.9	Invalid data
21	1.0	Invalid data
22	1.1	Invalid data
23	1.2	Invalid data
24	1.3	Invalid data
25	1.4	Invalid data
26	1.5	Invalid data
27	1.6	Invalid data
28	1.7	Invalid data
29	1.8	Invalid data
30	1.9	Invalid data
31	2.0	Invalid data

32	2.1	Invalid data
33	2.2	Invalid data
34	2.3	Invalid data
35	2.4	Invalid data
36	2.5	Invalid data
37	2.6	Invalid data
38	2.7	Invalid data
39	2.8	Invalid data
40	2.9	Invalid data
41	3.0	Invalid data
42	3.1	Invalid data
43	3.2	Invalid data
44	3.3	Invalid data
45	3.4	Invalid data
46	3.5	Invalid data
47	3.6	Invalid data
48	3.7	Invalid data
49	3.8	Invalid data
50	3.9	Invalid data
51	4.0	Invalid data
52	4.1	Invalid data
53	4.2	Invalid data
54	4.3	Invalid data
55	4.4	Invalid data
56	4.5	Invalid data
57	4.6	Invalid data
58	4.7	Invalid data
59	4.8	Invalid data
60	4.9	Invalid data
61	5.0	Invalid data

< Event 1 >

Raw Data

< Event 2 >

There is no recorded event.

DOT HS 813 489
July 2023

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

16003-071123-v2a