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of Transportation
**National Highway
Traffic Safety
Administration**

NHTSA

DOT HS 813 175

September 2021

Special Crash Investigations: On-Site Guardrail End Terminal Crash Investigation; Vehicle: 2007 Chevrolet HHR; Location: Missouri; Crash Date: June 2017

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15. Supplementary Notes

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

16. Abstract

This on-site investigation documents a passenger vehicle impact to an ET-Plus guardrail end terminal that is of interest to the Federal Highway Administration. This investigation was conducted on behalf of the FHWA. This crash occurred in an interchange of a four-lane, divided interstate highway. The Chevrolet was a 4-door station wagon equipped with dual-stage frontal air bags and an event data recorder driven by an unbelted 46-year-old male. The Chevrolet was traveling east in the left eastbound lane at a high rate of speed and was being pursued by an SUV of unknown year, make, and model that the Chevrolet had just rear-ended at a stop sign before speeding away. The Chevrolet departed the left side of the roadway into the grass median and the front plane struck the end terminal (Event 1). The damaged guardrail penetrated the right plane of the Chevrolet (Event 2) into the occupant compartment. The vehicle then rolled over (Event 3), right side leading, three quarter turns with the top plane and left plane striking the guardrail during the rollover (Events 4 and 5). The vehicle came to final rest on its left plane on top of the guardrail facing northwest. The driver sustained police-reported "C" (possible) injuries. The driver was transported by ambulance and hospitalized 5 days for treatment.

17. Key Words	18. Distribution Statement
ET-Plus guardrail end, motor vehicle traffic crash terminal, police-reported "C" (possible), rollover, injury	Document is available to the public from the National Technical Information Service, www.ntis.gov.

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Special Crash Investigations
On-Site Guardrail End Terminal Crash Investigation
Case No.: IN17023
Vehicle: 2017 Chevrolet HHR
Location: Missouri
Crash Date: June 2017

Background

This on-site investigation documents a passenger vehicle impact to an ET-Plus 10 cm (4 in) model guardrail end terminal (Figure 1) that is of interest to the Federal Highway Administration (FHWA). This investigation was conducted on behalf of the FHWA. This crash was identified by an engineer with the Missouri Department of Transportation (MoDOT), who submitted images of the damaged guardrail end terminal and vehicle to the FHWA. The FHWA determined that the guardrail end terminal and crash type were of interest. This crash investigation was then initiated by the National Highway Traffic Safety Administration in June 2017 and assigned to the Special Crash Investigations (SCI) team at the Indiana University Transportation Research Center. This single-vehicle crash involved a 2007 Chevrolet HHR (Figure 2) in Missouri in June 2017 at night and was investigated by a local police agency. The vehicle, crash scene, and guardrail were inspected and documented in June 2017.

Figure 1. Overview of damaged guardrail and final rest position of ET-Plus (arrow), view east

Figure 2. The damaged 2007 Chevrolet HHR

This crash occurred in an interchange on the north side of the eastbound lanes of a four-lane, divided interstate highway. The Chevrolet was a 4-door station wagon equipped with dual-stage frontal air bags and an event data recorder (EDR). An unbelted 46-year-old male drove the vehicle. The Chevrolet was traveling east in the left eastbound lane and was being pursued by an SUV of unknown year, make, and model that the Chevrolet had just rear-ended at a stop sign before speeding away. The Chevrolet departed the left side of the roadway into the grass median and the front struck the end terminal (Event 1). The damaged guardrail struck and penetrated the right plane (Event 2) into the occupant compartment. The vehicle then rolled over (Event 3), right side leading, three quarter turns with the top plane and left plane impacting the guardrail during the rollover (Events 4 and 5). The vehicle came to final rest on its left plane on top of the guardrail heading northwest. The driver sustained police-reported “C” (possible) injuries and was transported by ambulance to a hospital where he was hospitalized for 5 days.

Crash Summary

Crash Site

This crash occurred at night in an interchange area on the north side of the eastbound lanes of a four-lane, divided interstate highway. The weather conditions were clear with south-southeast winds at 10 km/h (6 mph), a temperature of 23.9 °C (75 °F),[1] and a dew point of 11.7 °C (53 °F), according to local weather reports. The interstate traversed in an east/west direction and the eastbound roadway was curved slightly to the right on the approach to the guardrail. The calculated radius of curvature was 774.7 m (2,541.0 ft). The eastbound roadway was bordered by a 0.7 m (2.3 ft) wide bituminous median shoulder and a 4.2 m (13.8 ft) wide bituminous outside shoulder. The right eastbound lane was 4.0 m (13.1 ft) wide and the left eastbound lane was 4.2 m (13.8 ft) wide. A blocked-out W-beam guardrail equipped with an ET-Plus 10 cm (4 in) model end terminal was located on the median side of the road adjacent to the shoulder. The guardrail was protecting the approach to an overpass bridge. The area was illuminated by overhead luminaires. The speed limit was 97 km/h (60 mph). A crash diagram is included at the end of this report.

Pre-Crash

The following sequence of events took place prior to the crash according to the police crash report. A vehicle described as an SUV was stopped at a stop sign near an interchange to the interstate highway. The Chevrolet approached the SUV from behind and struck it in the back plane. The driver of the Chevrolet then backed up and sped around the SUV. The driver of the SUV accelerated from the stop light and began pursuing the Chevrolet. The Chevrolet then spun out of the roadway. The driver of the SUV stopped his vehicle and called police. While he was on his cell phone the driver of the Chevrolet approached his vehicle and yelled an obscenity at him. The driver of the Chevrolet returned to his car and again sped away. The driver of the SUV gave chase and both vehicles entered the eastbound roadway of the interstate and the chase continued. The Chevrolet's EDR reported the Chevrolet's speed as 164 km/h (102 mph) at -5.0 sec prior to algorithm enable (AE), increasing to 168 km/h (104 mph) at -1.0 sec, which was the end of the pre-crash recording. Both vehicles were traveling east in the left lane (Figure 3) and had just entered a slight right curve when the Chevrolet departed the left side of the roadway (Figure 4) and entered the median 34.0 m (111.5 ft) prior to the end terminal. A tire mark path from the vehicle's left side tires was found in the grass at the SCI crash scene inspection. The path arced back toward the roadway indicating the driver initiated a right steering maneuver in an attempt to reenter the roadway. The grass along the path of the vehicle as it approached impact showed evidence of only rolling tires, indicating the driver did not apply the brakes. The EDR recorded no ABS brake application.

[1] The outside air temperature is based on the vehicle's EDR-reported value.

Figure 3. Eastbound approach of the Chevrolet to the right curve and roadway departure

Figure 4. Location where the Chevrolet departed the roadway and entered the median, small orange cones shows path of left side tires

Crash

The left corner of the vehicle's front plane (Figure 5) struck the end terminal (Figure 6, Event 1) resulting in the extrusion of 9.0 m (29.5 ft) of guardrail to the field side. The speed of the vehicle at impact was calculated to be in a range of 161 to 164 km/h (100 to 102 mph) based on the EDR-reported speed of -168 km/h (104 mph) at -1.0 sec prior to AE and assuming a deceleration range of -0.20 to -0.08 g[2] for -1.0 sec. The force direction on the Chevrolet was within the 12 o'clock sector and the impact resulted in a stage one deployment of the driver's frontal air bag. The vehicle's EDR reported an extended crash pulse with the maximum longitudinal velocity change reaching -54.52 km/h (-33.88 mph) at 220 msec following AE, which was the end of recording. The maximum lateral velocity change was 5.46 km/h (3.39 mph) occurring at 130 msec following AE. WinSMASH could not be used to calculate delta V since an impact with a yielding object is out of scope for the program. However, WinSMASH was used to calculate a barrier equivalent speed (BES) of 46 km/h (29 mph) based on the crush to the front plane. The BES appeared reasonable.

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[2] Fricke, L. B. (1990). *Traffic accident reconstruction [*Volume 2 of *The traffic accident investigation manual*]. Northwestern University Traffic Institute. A deceleration value of -0.20 is given for braking without skidding and -0.08 is the reported value for engine braking.

Figure 5. Damage to front plane from impact with ET-Plus

Figure 6. Direct damage to the face of the ET-plus

The vehicle rotated counterclockwise as the guardrail deformed and the right plane, beginning at the right front corner (Figure 7), struck the deformed guardrail (Event 2). This impact resulted in extensive intrusion of the right front door and right B-pillar into the occupant compartment as well as intrusion of a section of the deformed guardrail, which penetrated diagonally through the front right, second row center, and second row left seating positions (Figure 8). The vehicle then rolled over (Event 3), right side leading, three quarter turns. The top plane struck the guardrail (Event 4) during the second quarter turn and the left plane struck the guardrail (Event 5) during the third quarter turn as the vehicle came to final rest on the left plane on top of the guardrail heading northwest (Figure 9). The distance traversed during the rollover is not known.

Figure 7. Damage to the right plane of the Chevrolet from impact with the deformed guardrail

Figure 8. Pole shows path of guardrail penetration into Chevrolet's occupant compartment

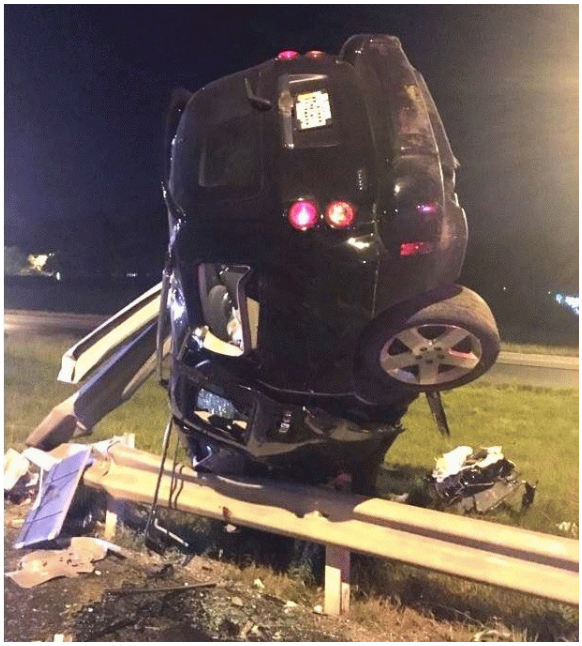


Figure 9. MoDOT-provided photo of Chevrolet at final rest

Post-Crash

The police were notified of the crash and arrived minutes later. Emergency responders used a hydraulic rescue tool to cut and remove the right B-pillar and right rear door to gain access and remove the driver. The driver sustained serious AIS 3-level injuries and was transported by ambulance to a hospital. The Chevrolet was towed from the crash scene due to damage.

End Terminal and Guardrail Damage

The front plane impact of the Chevrolet to the end terminal extruded 9.0 m (29.5 ft) of guardrail to the field side (Figure 10). The crash damaged 21.1 m (69.2 ft) of guardrail and separated the end terminal from the guardrail projecting it 38.1 m (125.0 ft) downstream where it came to final rest on the field side of the guardrail. Wooden posts 1 to 8 were fractured and destroyed. Posts 9 to 12 were constructed of steel and had steel offset blocks. Post 9 was bent downstream approximately 70 degrees off vertical. The offset block remained attached to the post and the mounting bolt was pulled through the guardrail. Post 10 was also bent downstream approximately 70 degrees off vertical. The offset block remained attached to the post and the mounting bolt was pulled through the guardrail. Post 11 was slightly displaced and twisted. The offset block and guardrail remained attached to the post. Post 12 was slightly damaged but was not displaced. The offset block and guardrail remained attached to the post. The guardrail was kinked in seven locations (Figure 11). The width of the feeder channel was 10 cm (4.0 in) and the guide chute exit height was 39 cm (15.5 in). The connection of the feeder channel to the head was not damaged. The bottom welds on the connection between the feeder channel and extruder head were fractured. The anchor cable was disconnected from its anchor and was not found during the SCI crash scene investigation. The height of the undamaged guardrail was 70 cm (27.5 in). The FHWA guardrail form is attached to the end of this report as Appendix B.

Figure 10. The damaged ET-Plus and extruded guardrail

Figure 11. Kinks in the damaged guardrail

2007 Chevrolet HHR

Description

The Chevrolet was a front-wheel-drive, 5-door station wagon with the Vehicle Identification Number 3GNDA33P57Sxxxxxx. The vehicle was equipped with a 2.4-liter I-4 engine, 4-speed automatic transmission, dual-stage frontal air bags, and an EDR. The specified wheelbase was 263 cm (103.1 in). It seated five people.

The vehicle manufacturer's recommended tire size was P215/50R17. The vehicle was equipped with Kenetica Kenda Radial of the recommended size. The manufacturer's recommended cold tire pressure for the front and rear tires was 240 kPa (35 psi).

The front row had leather-covered bucket seats with adjustable head restraints. The second row was equipped with a leather-covered split bench seat with folding backs. The adjustable head restraints in the outboard seating positions had been removed from the vehicle and were not present at the SCI vehicle inspection. The driver's seat track was adjusted to the rear-most position. The seat back was deformed from contact by the intruded guardrail and the recline angle of the seat back could not be determined. The remaining seating positions were not occupied at the time of the crash.

Exterior Damage

Exterior Damage Event 1: The impact with the ET-Plus occurred at the left corner of the front plane and the front bumper, left headlamp/turn signal assembly, grille, hood, and left fender were directly damaged. The direct damage began at the left corner of the front bumper and extended 52 cm (20.5 in) to the right across the front plane. The Field L was 103 cm (40.6 in). Crush measurements were taken on the bumper bar and the maximum residual crush was 49 cm (19.3 in) occurring 76 cm (29.9 in) left of the vehicle's centerline. The crush values were: C_1 = 49 cm (19.3 in), C_2 = 45 cm (17.7 in), C_3 =39 cm (15.4 in), C_4 = 31 cm (12.6 in), C_5 = 23 cm (9.1 in), C_6 = 18 cm (7.1 in).

Damage Classification Event 1: The Collision Deformation Classifications (CDC) was 12FYEW3 (0 degrees). The severity of the damage was moderate.

Exterior Damage Event 2: The right plane sustained an impact with the guardrail as the guardrail was deformed. The direct damage began 313 cm (123.2 in) forward of the right rear axle and extended 267 cm (105.1) rearward from the front corner of the right plane onto the right fender, A- and B-pillars, and both doors. The Field L was 276 cm (108.7 in). Crush measurements were taken at the upper-door level and the maximum residual crash was 58 cm (22.8 in) occurring 112 cm (44.1 in) forward of the right rear axle. The crush to the right plane was estimated using a tape measure attached to the vehicle to represent an approximate crush profile based on judgement and the damage. This approach was taken since both doors and the B-pillar were separated from the vehicle. The crush measurements are only an attempt to provide an estimation of the crush to the right side plane and do not reflect the penetration of the guardrail into the occupant compartment. A second set of crush measurements was taken at the sill as required by the crush measurement protocol since there was striker and hinge separation of

the right front door during the crash. The maximum residual crush at the sill-level was 18 cm (7.1 in) occurring 112 cm (44.1 in) forward of the right-rear axle. The average crush values for both levels of crush were: C_1 = 0 cm, C_2 = 31 cm (12.2 in), C_3 =33 cm (13.0 in), C_4 = 15 cm (5.9 in), C_5 = 19 cm (7.5 in), C_6 = 36 cm (14.2 in).

Damage Classification Event 2: The CDC was 02RYHW9. The extent zone reflected is based upon the damage observed by the right front door. The guardrail intruded into the passenger compartment starting at the right front passenger position traveling diagonally across the passenger compartment and impacting the left C-pillar at the left second row seating position. The severity of the damage was severe.

Exterior Damage Events 3 to 5: The top of the front portion of the hood contacted the ground, as did the front plane when the vehicle came to final rest on its left plane on top of the guardrail.

There was no other discernable evidence of ground contact during the rollover. The top and left planes were damaged during the rollover from contact with the guardrail. Any damage that may have occurred to the right plane was masked by the damage from the guardrail impact. A damage pattern consistent with contact to the guardrail extended from the right A-pillar across the roof to the left roof side rail. Damage from contact with the guardrail during the rollover was also present on the left front and rear doors and the left roof side rail.

Damage Classification Event 3 to 5: The CDC for the rollover (Event 3) was 00TFDO2. The CDC for the top plane impact to the guardrail (Event 4) during the rollover was 00TPDN2. The damage for the left plane impact with the guardrail (Event 5) during the rollover was 00LPAW2. The severity of the damage for all three impacts was minor.

Event Data Recorder

The Chevrolet's EDR was imaged with version 17.3 of the Bosch Crash Data Retrieval software and reported with version 19.3.1. The vehicle was powered with an auxiliary 12-volt power source and the data was imaged via connection to the Diagnostic Link Connector (DLC). The EDR reported a deployment event. The supplemental inflatable restraint (SIR) warning lamp was reported as "Off" and no diagnostic trouble codes were reported. The ignition cycles at the time of the crash and when the data was imaged were 14,021. The driver's "Belt Switch Circuit Status" was reported as "Unbuckled." The EDR reported a stage one deployment of the driver's frontal air bag, which occurred during the impact with the ET-Plus. The time from AE to when the deployment criteria were met was reported as 20 msec. The frontal seat belt pretensioners were commanded to deploy. The maximum longitudinal and lateral velocity changes were reported as 54.52 km/h (-33.88 mph) and 5.46 km/h (3.39 mph), respectively occurring at 220 and 130 msec following AE. The EDR report is attached at the end of this report as Appendix B.

Interior Damage

The interior of the Chevrolet sustained severe damage from intrusion of the right front door, right B-pillar, and guardrail. The right front door and B-pillar were estimated to have intruded laterally a total of 65 cm (25.5 in) and 20 cm (7.9 in)into the front row. It was necessary to estimate the intrusion since each component had been removed from the vehicle by emergency responders. The guardrail penetrated diagonally through the front row right seating position and contacted and deformed the driver's seatback. It then penetrated diagonally through the second-row center and left seating positions and contacted and damaged the left rear door. So, the guardrail

intrusion direction was considered to be lateral and the intrusion magnitude was 46 cm (18.1 in) in the front row right seating position and 45 cm (17.8 in) in the second-row center and left seating positions. There was no discernable evidence of occupant contact. The left front and left rear doors were jammed shut.

Manual Restraint Systems

The front and second row seating positions were equipped with lap and shoulder seat belts with sliding latch plates. The upper anchors in the front row were adjustable and fixed in the second row. The driver's upper anchor was adjusted to the full-down position. The driver's seat belt was pulled tautly in the retractor from pretensioner actuation indicating he was not belted at the time of the crash. The vehicle's EDR also reported the status of the driver's seat belt buckle switch was "Unbuckled."

Supplemental Restraint Systems

The Chevrolet had dual-stage frontal air bags. Stage one of the driver's frontal air bag deployed during the impact with the ET-Plus. Inspection of the air bag revealed no discernable evidence of occupant contact and no damage. The front driver air bag was measured at 55 cm (21.6 in) in diameter with the cover flaps in the steering wheel hub measuring at 12 cm (4.7 in) in height and 16 cm (6.2 in) in width.

Occupant Driver Demographics

Age/sex:	46 years/male
Height:	170 cm (66.9 in)
Weight:	113 kg (250 lb)
Eyewear:	Glasses
Seat type:	Bucket
Seat track position:	Rear-most
Manual restraint usage:	None
Usage source:	Vehicle inspection and EDR
Air bags:	Frontal, deployed
Alcohol/drug involvement:	BAC=.20 g/dl; negative for drugs
Egress from vehicle:	Removed by emergency responders
Transport from scene:	Ambulance
Medical treatment:	Hospitalized for 5 days

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Open transverse fracture of right mid radial shaft	752252.3	Intruding guardrail	Probable
2	Open transverse fracture of right ulna shaft	752254.3	Intruding guardrail	Probable
3	Comminuted fracture of right scapular body	750951.2	Intruding guardrail	Probable
4	28 x 3 x 2.5 cm laceration of right lower back/flank down through subcutaneous fat, full thickness	410604.2	Intruding guardrail	Certain
5	28 x 3 x 2.5 cm laceration of right lower back/flank down through subcutaneous fat, full thickness	510604.2	Intruding guardrail	Certain
6	Non-displaced spinous process fracture of C7	650218.1	Right front seatback	Probable
7	Non-displaced fracture of L1 right transverse process	650620.1	Intruding guardrail	Probable
8	Abrasion to top of head	110202.1	Roof	Probable
9	Contusion over right scapula	710402.1	Intruding guardrail	Probable
10	Abrasion to right shoulder	710202.1	Intruding guardrail	Probable

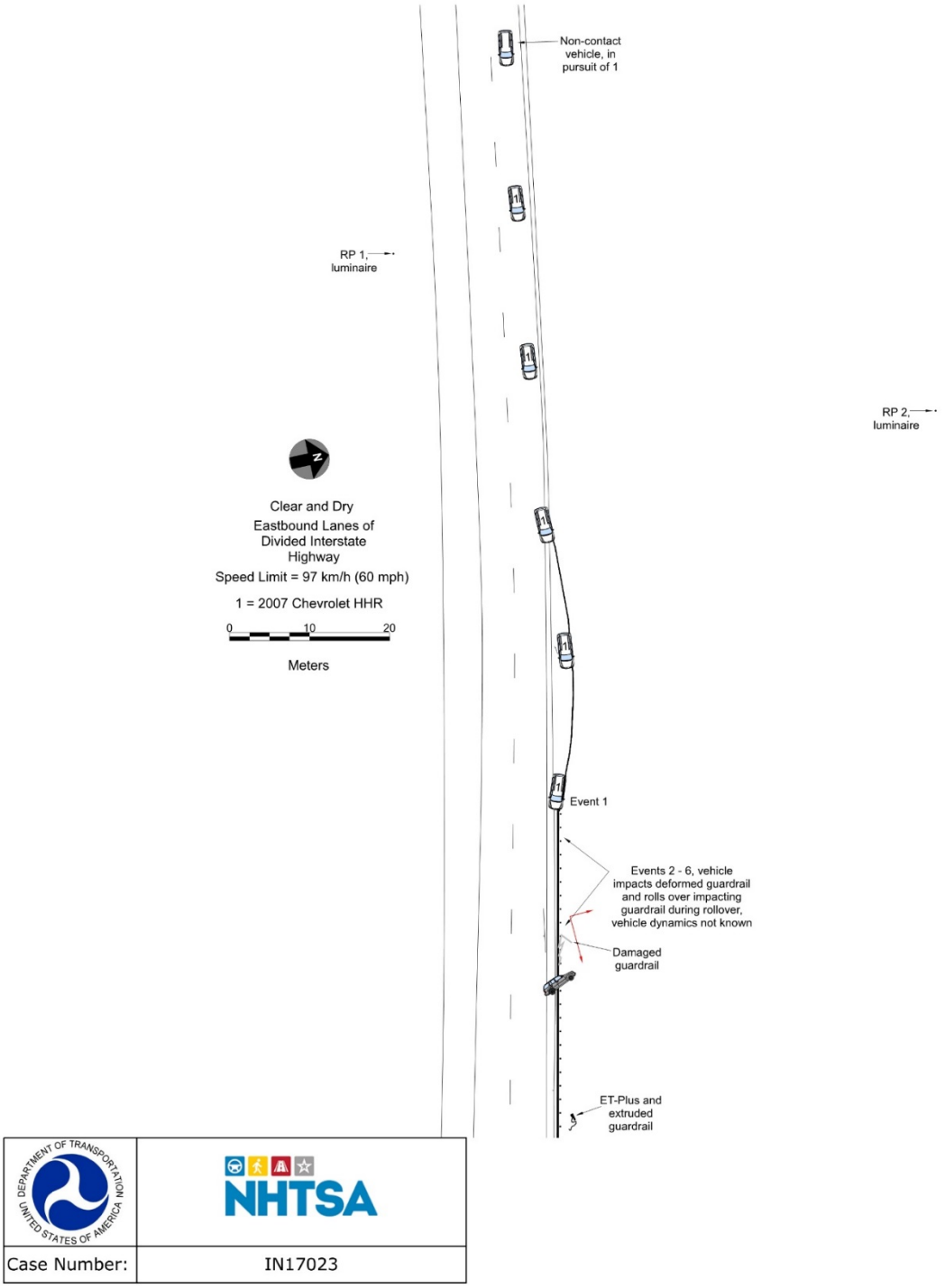
Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
11	Contusion to left shoulder	710402.1	Left B-pillar	Possible
12	Abrasion to left shoulder	710202.1	Left B-pillar	Possible
13	Contusion to right forearm	710402.1	Intruding guardrail	Probable
14	Abrasion to right forearm	710202.1	Intruding guardrail	Probable
15	Superficial abrasion to left wrist	710202.1	Left instrument panel	Probable
16	Superficial abrasion to left forearm	710202.1	Left instrument panel	Probable
17	Contusion to right gluteal region	810402.1	Center console	Probable
18	Contusion to right hip	810402.1	Center console	Probable
19	Superficial abrasion overlying left tibia	810202.1	Left lower instrument panel	Probable

Source: Hospital records

Driver Kinematics

The driver was not belted. His seat track was adjusted to the rear-most position. The recline angle of the seatback could not be determined since the seatback was deformed during the crash. The front plane impact to the end terminal resulted in a stage one deployment of the driver's frontal air bag. He was displaced forward and his face and chest loaded the deployed air bag. The driver was then redirected to the right as the right plane of the vehicle struck the deformed guardrail. The guardrail penetrated the right front door. The driver contacted the intruding guardrail resulting in open transverse fractures of the right mid radius and ulna, comminuted fracture of the right scapula, a fracture of the transverse process of L1, a large full thickness laceration of the right lower back and flank, and soft tissue injures of the right shoulder area and right forearm. He also sustained a non-displaced fracture of the spinous process of C7 from probable contact with the deformed right front seatback and right hip and gluteal contusions from the center console. The driver was redirected in multiple directions during the rollover. He sustained left shoulder abrasions and contusions from probable contact with the left B-pillar, a scalp abrasion from the roof, and left wrist abrasions from probable contact with the left instrument panel. Emergency responders used a hydraulic rescue tool to cut and remove the right B-pillar and right rear door to gain access to the interior of the vehicle. They probably removed the driver through the right front door. He was transported by ambulance to a hospital where he was hospitalized for 5 days.

Crash Diagram



	NHTSA
Case Number:	IN17023

Appendix A: FHWA Guardrail Form

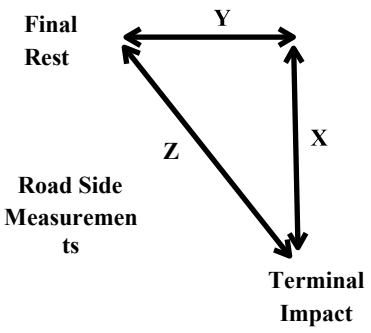
Case No.: IN17023

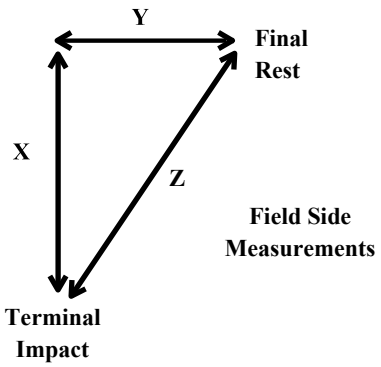
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	June 2017	**TIME OF CRASH (MILITARY)**	Nighttime
Case Number	IN17023	**State**	Missouri
Traffic Route	Interstate	**Direction (Southbound = SB)**	EB
Ambient Conditions (at time of crash)			
Temperature (°F)	70	**Lighting**	Overhead luminaires
Atmospheric	Clear		

SCENE INFORMATION	
Type of area where crash occurred	❒Urban ❒Rural ☒Suburban
Terminal on a horizontal curve?	❒No ❒Curve/LT ☒Curve/RT
Estimated or Reconstructed Speed at Impact (MPH)	100 – 102 mph
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 70.5 ft
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 70.5 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 6.6 ft
Super elevation	☒+2% ❒-2% ❒ NONE or FLAT
Curve Radius (ft.)	2,541 ft

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: IN17023

ON-SCENE INFORMATION		
End Treatment Type	☒Extruder	❒ET2000 ☒ET-PLUS 4in ❒ET-PLUS 5in ❒SKT ❒FLEAT ❒SOFT STOP
	❒Telescope	❒X-LITE ❒X-TENSION
Curb?	☒No ❒Yes	❒AASHTO Type A ❒AASHTO Type B ❒AASHTO Type C ❒AASHTO Type D ❒AASHTO Type E ❒AASHTO Type F ❒AASHTO Type G ❒AASHTO Type H
Curb Height:		

GUARDRAIL INSTALLATION									
Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	Wood	8 x 5.5	N/A	N/A	N/A	Unknown	5.75	N/A	6’ 2”
2	Wood	8 x 6.75	N/A	N/A	N/A	Unknown	6.0	N/A	6’ 4”

Case No.: IN17023

Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
3	Wood	Unk	Unk			Unknown	6.0	N/A	6’ 3”
4	Wood	Unk	Unk			Unknown	6.0	N/A	6’ 3”
5	Wood	Unk	Unk			Unknown	5.7	N/A	6’ 6”
6	Wood	Unk	Unk			Unknown	5.4	N/A	6’ 2”
7	Wood	Unk	Unk			Unknown	5.4	N/A	6’ 1”
8	Wood	Unk	Unk			Unknown	6.0	N/A	6’ 9”

Case No.: IN17023

Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
9	Steel	6 x 4	Steel	6 x 4		Unknown	5.4	N/A	6’ 3”
10	Steel	5.75 x 4	Steel	6 x 4		Unknown	5.6	N/A	6’ 1”
11	Steel	6 x 4	Steel	6 x 4		Unknown	5.5	N/A	6’ 5”
12	Steel	5.75 x 4	Steel	6 x 4		Unknown	5.1	N/A	6’ 5”

Additional Comments:

Case No.: IN17023

EXTRUDER			
Feeder Channel Width at impact head	☒4inches ☐5 inches ☐Other _____		
Guide Chute Exit Height (in.)	15.5”		
Connection of feeder channels to head damaged?	☐No ☒Yes	Are Welds Broken?	☐No ☒Yes
Anchor Cable Present?	☒No ☐Yes	Connected?	☒No ☐Yes
Rail Extrusion?	☐No ☒Yes	Length (ft. in.)	29’ 6”
Rail Extrusion Direction	☐Traffic Side ☒Field Side		
Total Length of Rail Damaged (ft.) [total length would include extruded rail plus damaged rail downstream from head.]	69.2		

TELESCOPE				
Rail Displacement	☐No	☐Yes; Length:	No of Panels Displaced	☐1 ☐2 ☐3 ☐4 ☐5 ☐6

ALL-SYSTEM PERFORMANCE			
Railkinks Downstream of Head?	☐No	☒Yes ;	No. of Kinks in Rail: 7
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	☐No ☒Yes		
Did vehicle impact other objects after impact with terminal?	☐No ☒Yes		
Object Contacted	Ground (Rollover)		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	-15%	-15%	-14%
Adjacent Lane Width (ft)	13.8		
Lane Type (NAS EDS Variable: Sur. Type)	Bituminous		
Shoulder Type	Bituminous		

Case No.: IN17023

Shoulder Width (ft)	2.3
Guardrail Height (in)	27.5

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	Station Wagon	
Vehicle Identification Number (VIN)	3GNDA33P57Sxxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	3,175	
Vehicle orientation upon impact	☒Case Type 1 ❒ Case Type 2 ❒Case Type 3 ❒ Case Type 4 ❒ Case Type 5 ❒ Case Type 6 ❒ Case Type 7 ❒ Case Type 8 ❒ Other	
If 'Other', describe		
Collision Deformation Classification	12FYEW3	
Delta-V	35 mph (Event Data Recorder)	
Occupant Compartment Penetration of rail	❒No ☒Yes	Describe: Section of guardrail penetrated through RF door and passed diagonally through RF seating position and 2nd row center and left seating positions.
Quarter Turns (NASS EDS variable: Rollover)	❒1 ❒2 ☒3 ❒4 ❒5 ❒6 ❒7 ❒8 ❒9 ❒10 ❒11 ❒12 ❒13 ❒14 ❒15 ❒16 ❒17+	
Object Precipitating Rollover, (NASS EDS variable: Rollobj)	Guardrail	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	"Other," Vehicle became entangled with displaced and deformed guardrail and rolled over right side leading.	

Appendix B: 2007 Chevrolet HHR, Event Data Recorder Report

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

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

CDR File Information

User Entered VIN	3GNDA33P57S******
User	
Case Number	
EDR Data Imaging Date	
Crash Date	
Filename	201750S2IN17023_V1_ACM.CDRX
Saved on	
Imaged with CDR version	Crash Data Retrieval Tool 17.3
Imaged with Software Licensed to (Company Name)	NHTSA
Reported with CDR version	Crash Data Retrieval Tool 19.3.1
Reported with Software Licensed to (Company Name)	NHTSA
EDR Device Type	Airbag Control Module
Event(s) recovered	Deployment

Comments

No comments entered.

Data Limitations

Recorded Crash Events:

There are two types of recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event records data but does not deploy the air bag(s). The minimum SDM Recorded Vehicle Velocity Change, that is needed to record a Non-Deployment Event, is five MPH. A Non-Deployment Event may contain Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle velocity change. This event will be cleared by the SDM, after approximately 250 ignition cycles. This event can be overwritten by a second Deployment Event, referred to as Deployment Event #2, if the Non-Deployment Event is not locked. The data in the Non-Deployment Event file will be locked, if the Non-Deployment Event occurred within five seconds of a Deployment Event. A locked Non Deployment Event cannot be overwritten or cleared by the SDM.

The second type of SDM recorded crash event is the Deployment Event. It also may contain Pre-Crash and Crash data. The SDM can store up to two different Deployment Events. If a second Deployment Event occurs any time after the Deployment Event, the Deployment Event #2 will overwrite any non-locked Non-Deployment Event. Deployment Events cannot be overwritten or cleared by the SDM. Once the SDM has deployed an air bag, the SDM must be replaced.

Data:

-SDM Recorded Vehicle Velocity Change reflects the change in velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. For Deployment Events, the SDM can record up to 220 milliseconds of data after Deployment criteria is met and up to 70 milliseconds before Deployment criteria is met. For Non-Deployment Events, the SDM can record up to the first 300 milliseconds of data after algorithm enable. Velocity Change data is displayed in SAE sign convention.

-The CDR tool displays time from Algorithm Enable (AE) to time of Deployment command in a Deployment event and AE to time of maximum SDM recorded vehicle velocity change in a Non-Deployment event. Time from AE begins when the first air bag system enable threshold is met and ends when Deployment command criteria is met or at maximum SDM recorded vehicle velocity change. Air bag systems such as frontal, side, or rollover, may be a source of an enable. The time represented in a CDR report can be that of the enable of one air bag system to the Deployment time of another air bag system.

-Maximum Recorded Vehicle Velocity Change is the maximum square root value of the sum of the squares for the vehicle's combined "X" and "Y" axis change in velocity. If a CDR Printout user were to calculate resultant velocity change using X and Y axis time history data, the calculated value may be different than the Maximum SDM Recorded Velocity Change parameter value displayed in the CDR report. This is due to the rounding that occurs within the SDM while calculating the Maximum SDM Recorded Velocity Change value.

-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.

-SDM Recorded Vehicle Speed accuracy can be affected by various factors, including but not limited to the following:

- -Significant changes in the tire's rolling radius
- -Final drive axle ratio changes

-Wheel lockup and wheel slip
-Brake Switch Circuit Status indicates the open/closed state of the brake switch circuit.
-Pre-Crash data is recorded asynchronously. The 1.0 second Pre-crash data value (most recent recorded data point) is the data point last sampled before AE. That is to say, the last data point may have been captured just before AE but no more than 1.0 second before AE. All subsequent Pre-crash data values are referenced from this data point.
-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if:
-The SDM receives a message with an "invalid" flag from the module sending the pre-crash data
-No data is received from the module sending the pre-crash data
-No module is present to send the pre-crash data
-Vehicle speed, Transmission Gear Select, and Transmission Actual Gear will be marked as invalid for manual transmission vehicles
-Pre-crash data associated with this event will always be for the first event even if it is not recorded.
-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit, except: The Passenger Belt Switch Circuit Status for 2005 vehicles is available only on the Cadillac STS. The Passenger Belt Switch Circuit Status for 2006 Chevrolet Cobalt Sport Coupe (AP) model vehicles, with the option package that includes Recaro brand seats (RPO ALV), always reports a default value of "Buckled," because there is no passenger belt switch with the Recaro seat option. The Passenger Belt Switch Circuit Status for 2010 Chevrolet Cobalt and 2010 Pontiac G5 vehicles, with RPO Z49, will report a default value of "Buckled". The Passenger Belt Switch Circuit Status for 2010 and 2011 Chevrolet HHR, with the LS or LT trim package and RPO Z49, will report a default value of "Buckled".
-The Time Between Non-Deployment to Deployment Events is displayed in seconds. If the time between the two events is greater than five seconds, "N/A" is displayed in place of the time. If the value is negative, then the Deployment Event occurred first. If the value is positive, then the Non-Deployment Event occurred first. Time Between events is measured from end of one event to the beginning of a next event. An event may occur within 5 seconds of another event, known as an extended event. This occurs when three or more sequential events are separated by more than 5 seconds but each event in the sequence is no more than 5 seconds apart from a subsequent event. Pre-crash data is locked to the first event in an extended event.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
-The ignition cycle counter relies upon the transitions through OFF->RUN->CRANK power-moding messages, on the GMLAN communication bus, to increment the counter. Applying and removing of battery power to the module will not increment the ignition counter.
-Steering Wheel Angle data is reported in 16 degree increments. 2005 through 2010 Chevrolet Cobalt, 2005 and 2006 Pontiac Pursuit, 2007 through 2010 Pontiac G5, and 2006 through 2011 Chevrolet HHR, do not record Steering Wheel Angle data and should not be relied upon.
-If more than one event is recorded, use the follow to determine which event the Multiple Event Data is associated with:
-If a Deployment event and not locked Non-Deployment event are recorded, the Multiple Event Data is associated with the Deployment event.
-If a Deployment event and a locked Non-Deployment event are recorded, then the Multiple Event Data is associated with both events.
-If a Deployment event and Deployment event #2 are recorded, then the Multiple Event Data is associated with both events.
-All data should be examined in conjunction with other available physical evidence from the vehicle and scene.

Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Status Data (Pre-Crash) is transmitted to the SDM, by various vehicle control modules, via the vehicle's communication network.
-The Belt Switch Circuit is wired directly to the SDM.

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

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

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

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

01016_SDMEps_r011

Multiple Event Data

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

System Status At AE

Vehicle Identification Number	**NDA33P*7*******
Low Tire Pressure Warning Lamp (If Equipped)	OFF
Vehicle Power Mode Status	Run
Remote Start Status (If Equipped)	Inactive
Run/Crank Ignition Switch Logic Level	Active
Brake System Warning Lamp (If Equipped)	OFF

System Status At 1 second

Transmission Range (If Equipped)	Third Gear
Transmission Selector Position (If Equipped)	Fourth Gear
Traction Control System Active (If Equipped)	No
Service Engine Soon (Non-Emission Related) Lamp	OFF
Service Vehicle Soon Lamp	OFF
Outside Air Temperature (degrees F) (If Equipped)	75
Left Front Door Status (If Equipped)	Closed
Right Front Door Status (If Equipped)	Closed
Left Rear Door Status (If Equipped)	Unused
Right Rear Door Status (If Equipped)	Unused
Rear Door(s) Status (If Equipped)	Closed

Pre-crash data

Parameter	-2 sec	-1 sec
Reduced Engine Power Mode	OFF	OFF
Cruise Control Active (If Equipped)	No	No
Cruise Control Resume Switch Active (If Equipped)	No	No
Cruise Control Set Switch Active (If Equipped)	No	No

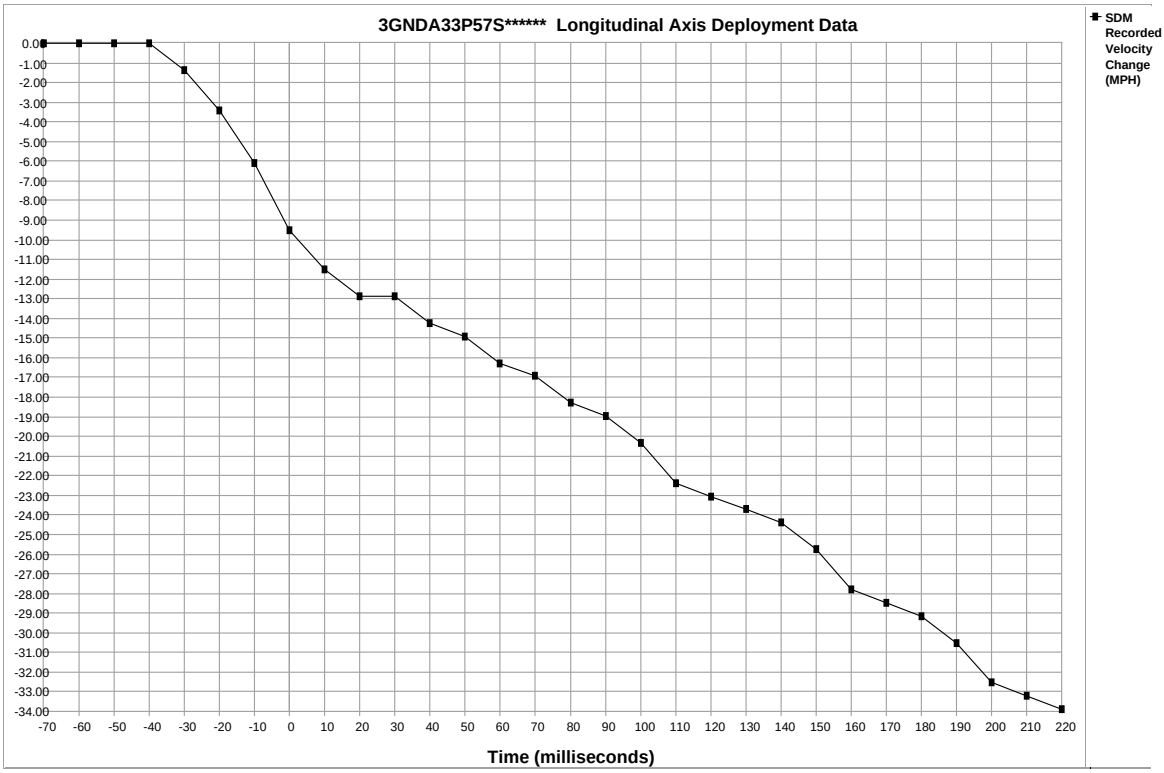
Pre-Crash Data

Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Vehicle Speed (MPH)	102	103	103	104	104
Engine Speed (RPM)	5504	5568	3840	5632	5632
Percent Throttle	77	78	76	82	73
Accelerator Pedal Position (percent)	83	82	82	85	81
Antilock Brake System Active (If Equipped)	No	No	No	No	No
Lateral Acceleration (feet/s²)(If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid
Yaw Rate (degrees per second) (If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid

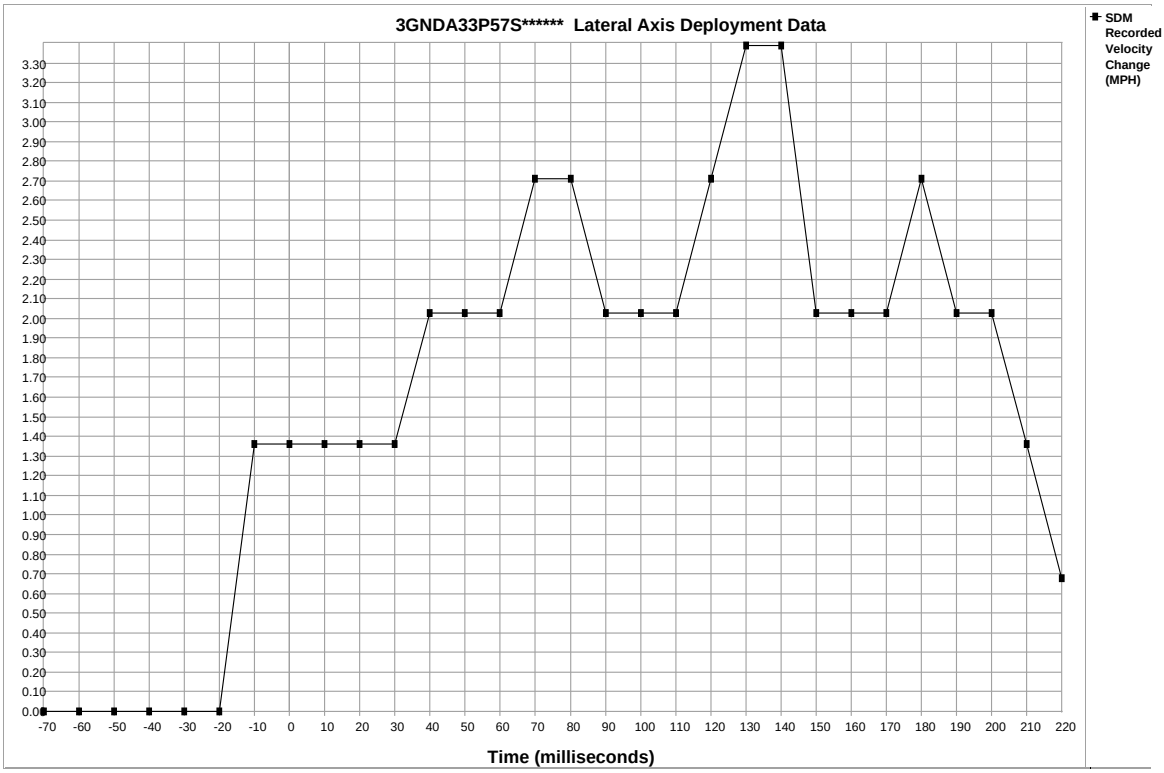
Parameter	-5 sec	-4 sec	-3 sec	-2 sec	-1 sec
Steering Wheel Angle (degrees) (If Equipped)	0	0	0	0	0
Vehicle Dynamics Control Active (If Equipped)	Invalid	Invalid	Invalid	Invalid	Invalid

System Status At Deployment

Ignition Cycles At Investigation	14021
SIR Warning Lamp Status	OFF
SIR Warning Lamp ON/OFF Time (seconds)	655200
Number of Ignition Cycles SIR Warning Lamp was ON/OFF Continuously	4182
Ignition Cycles At Event	14021
Ignition Cycles Since DTCs Were Last Cleared	254
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Belt Switch Circuit Status (If Equipped)	UNBUCKLED
Diagnostic Trouble Code at Event Enable, fault number: 1	N/A
Diagnostic Trouble Code at Event Enable, fault number: 2	N/A
Diagnostic Trouble Code at Event Enable, fault number: 3	N/A
Diagnostic Trouble Code at Event Enable, fault number: 4	N/A
Diagnostic Trouble Code at Event Enable, fault number: 5	N/A
Diagnostic Trouble Code at Event Enable, fault number: 6	N/A
Automatic Passenger SIR Suppression System Validity Status at AE	Valid
Automatic Passenger SIR Suppression System Status at AE	Air Bag Suppressed
Automatic Passenger SIR Suppression System Validity Status at First Deployment Command	Valid
Automatic Passenger SIR Suppression System Status at First Deployment Command	Air Bag Suppressed
Driver 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	20
Driver 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger 1st Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Passenger 2nd Stage Time From Algorithm Enable to Deployment Command Criteria Met (msec)	N/A
Time Between Events (sec)	N/A
Driver First Stage Deployment Loop Commanded	Yes
Driver Second Stage Deployment Loop Commanded	No
Driver Side Deployment Loop Commanded	No
Driver Pretensioner Deployment Loop Commanded	Yes
Driver (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Driver (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Driver Knee Deployment Loop Commanded	No
Passenger First Stage Deployment Loop Commanded	No
Passenger Second Stage Deployment Loop Commanded	No
Passenger Side Deployment Loop Commanded	No
Passenger Pretensioner Deployment Loop Commanded	Yes
Passenger (Initiator 1) Roof Rail/Head Curtain Loop Commanded	No
Passenger (Initiator 2) Roof Rail/Head Curtain Loop Commanded	No
Passenger Knee Deployment Loop Commanded	No
Second Row Left Pretensioner Deployment Loop Commanded	No
Third Row Left Roof Rail/Head Curtain Loop Commanded	No
Second Row Right Pretensioner Deployment Loop Commanded	No
Third Row Right Roof Rail/Head Curtain Loop Commanded	No
Second Row Center Pretensioner Deployment Loop Commanded	No
Driver 2nd Stage Deployment Loop Commanded for Disposal	No
Passenger 2nd Stage Deployment Loop Commanded for Disposal	No
Crash Record Locked	Yes
Vehicle Event Data (Pre-Crash) Associated With This Event	Yes
Event Recording Complete	Yes



Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Longitudinal Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	-1.36	-3.39	-6.10	-9.49	-11.52	-12.88	-12.88	-14.23	-14.91	-16.26	-16.94
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Longitudinal Axis Recorded Velocity Change (MPH)	-18.30	-18.98	-20.33	-22.36	-23.04	-23.72	-24.40	-25.75	-27.79	-28.46	-29.14	-30.50	-32.53	-33.21	-33.88



Time (milliseconds)	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70
SDM Lateral Axis Recorded Velocity Change (MPH)	0.00	0.00	0.00	0.00	0.00	0.00	1.36	1.36	1.36	1.36	1.36	2.03	2.03	2.03	2.71
Time (milliseconds)	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220
SDM Lateral Axis Recorded Velocity Change (MPH)	2.71	2.03	2.03	2.03	2.71	3.39	3.39	2.03	2.03	2.03	2.71	2.03	2.03	1.36	0.68

Hexadecimal Data

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```

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.

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September 2021

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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