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

16. Abstract

This report documents the on-site investigation of the crash of a 2008 Ford Explorer into a 4-inch ET-Plus guardrail end terminal. The Ford was traveling west on a limited-access roadway when it departed the right side of the road and struck the guardrail end treatment. The ET-Plus end terminal was displaced along a portion of the guardrail and deformed the W-beam. Following engagement with the guardrail system, the Ford climbed over the W-beam and rolled over, coming to rest on its left plane. The Ford was driven by an unbelted 55-year-old male driver, who reported to the police that he had fallen asleep. It was determined by the police investigation that the driver was intoxicated. The driver sustained incapacitating (A-level) injuries and was airlifted by helicopter from the crash scene to a regional trauma center. The crash was identified by the Pennsylvania Turnpike Commission, which in turn notified the Federal Highway Administration (FHWA). The FHWA determined that the crash type and guardrail end treatment met the criteria for further research and subsequently forwarded the notification to the Crash Investigation Division of the National Highway Traffic Safety Administration in November 2016. NHTSA assigned an on-site investigation of the crash to the Special Crash Investigations team at Crash Research & Analysis, Inc., on the same day. The SCI team initiated contact and gained full cooperation with the PTC, and the on-site investigation took place in November 2016.

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SPECIAL CRASH INVESTIGATIONS
ON-SITE GUARDRAIL END TERMINAL IMPACT INVESTIGATION
CASE NO.: CR16030
VEHICLE: 2008 FORD EXPLORER
LOCATION: PENNSYLVANIA
CRASH DATE: NOVEMBER 2016

BACKGROUND

Figure 1: Northwest-facing view of the struck ET- Plus guardrail end terminal.

This report documents the on-site investigation of the crash of a 2008 Ford Explorer into a 4-inch ET-Plus guardrail end terminal (**Figure 1**). The Ford was traveling west on a limited-access roadway when it departed the right side of the road and struck the guardrail end treatment. The ET-Plus end terminal was displaced along a portion of the guardrail and deformed the W-beam. Following engagement with the guardrail system, the Ford climbed over the W-beam and rolled over, coming to rest on its left plane. The Ford was driven by an unbelted 55-year-old male, who reported to the police that he had fallen asleep. The police investigation determined the driver was intoxicated. The driver sustained incapacitating (A-level) injuries and was airlifted by helicopter to a regional trauma center. The crash was identified by the Pennsylvania Turnpike Commission (PTC), which notified the Federal Highway Administration (FHWA). The FHWA determined that the crash type and guardrail end treatment met the criteria for further research and subsequently forwarded the notification to NHTSA's Crash Investigation Division in November 2016. NHTSA assigned an on-site investigation of the crash to the Special Crash Investigations (SCI) team at Crash Research & Analysis, Inc., on the same day. The SCI team contacted and gained full cooperation with the PTC, and the on-site investigation took place in November 2016.

The on-site investigation documented the guardrail system and assessed the damage it sustained during the crash. The physical environment of the roadway and guardrail was documented using a Nikon Nivo 5+M total station. Following inspection of the crash site, the Ford was inspected to document its exterior and interior damage, identify the interior occupant points of contact, assess its manual restraint systems, and evaluate supplemental restraint deployment/actuation. The Ford was equipped with an event data recorder (EDR) supported by the Bosch Crash Data Retrieval (CDR) tool, and data was imaged from the EDR during the on-site SCI investigation. The driver did not respond to repeated requests for an interview.

CRASH SUMMARY

Crash Site

The crash occurred on the north shoulder of a divided interstate highway during nighttime. The posted speed limit was 113 km/h (70 mph). The National Weather Service reported a

temperature at 7 ºC (44 ºF) and a relative humidity of 76%, with clear skies and calm winds at the time of the crash. The police-reported environmental conditions were clear and dry.

Figure 2: West-facing image approaching the crash site 15 m (50 ft) east of the point of impact.

The trafficway was oriented in an east/west direction in the vicinity of the crash site, t. The westbound portion consisted of two 3.5 m (11.5 ft) lanes with a large radius left curve. The radius of curvature measured approximately 1,220 m (4000 ft). Along the approach, the grade was level, having transitioned from a positive grade at a hillcrest that was located approximately 0.8 km (0.5 miles) east of the crash site. The travel lanes and shoulders were surfaced with asphalt, while the north roadside was gravel. The right westbound lane measured 3.4 m (11.1 ft) wide and the left westbound lane measured 3.6 m (11.8 ft) in width. The lanes were separated by broken white lines and delineated by a solid yellow left edge line and a solid white right edge line. The right shoulder measured 3.7 m (12.1 ft). A tactile warning (rumble strip) was cut into the shoulder surface immediately adjacent to the right edge line. The ET-Plus end-terminal and guardrail was installed adjacent to the right shoulder edge (**Figure 2**). This guardrail protected the swale, embankment, and negative grade located in the roadside.

Pre-Crash

The 55-year-old male driver of the Ford was traveling west in the right lane. The driver stated to the police that he had fallen asleep. However, their investigation determined that the driver was intoxicated with a BAC of .176 g/dL. Data imaged from the Ford's EDR reported that the speed of the vehicle 5 seconds prior to algorithm enable (AE) was 116.8 km/h (72.6 mph) and the accelerator pedal was depressed 11 percent. The accelerator pedal was released with a zero percent recorded value from 4 seconds prior to AE until impact. Consequently, the speed of the vehicle uniformly decreased through rolling resistance to 108.3 km/h (67.3 mph) at 1-second prior to AE. No brake application was recorded. Without driver input, the Ford drifted to the right and onto the north shoulder as the roadway curved to the left. The reconstructed departure angle was estimated to be between three and five degrees, based on the location and nature of the vehicle's damage pattern coupled with the guardrail impact damage. There were no tire marks at the scene related to the Ford's pre-crash trajectory. A crash diagram is included at the end of this report.

Crash

The front right corner of the Ford struck the end terminal located at Post 1 (Event 1, **Figure 3**). The force of the impact resulted in the deployment of the driver's air bag. The right bias of the crash force caused the Ford to rotate clockwise as the vehicle crushed and displaced the end terminal to the west, extruding the W-beam. After the displaced end terminal detached the W-beam from Post 3, the exposed right end of the bumper reinforcement bar engaged the left side of the end terminal and was drawn into the feeder chute. The interference between the W-beam and reinforcement bar in the feeder chute choked the displacement of the end terminal (**Figure 4**).

Figure 3: West-facing trajectory view for the Ford at the point of impact (Event 1).

Figure 4: South-facing image depicting the choked end terminal and the bumper reinforcement beam.

As the Ford maintained its westward trajectory, the reinforcement bar was torn away from the vehicle's left frame rail. The force of this action accentuated the clockwise rotation of the vehicle, evidenced by two arcing tire marks attributed to the left side tires (**Figures 5 and 6**). The Ford's front plane engaged the face of the guardrail between Posts 4 and 5 (Event 2).

Figure 5: West-facing image depicting the arcing left front tire marks.

Figure 6: West-facing image depicting the left rear tire mark and deformed W-beam.

The momentum of the vehicle accelerated the combined mass of the end terminal and the extruded rail, which projected (whipped) the end terminal to the northwest and deformed the W-beam into a U-shaped pattern between Posts 5 and 6 (**Figure 7**). Absent the bumper reinforcement bar, the lower radiator support and engine cradle became exposed and struck the guardrail posts at locations 4 and 5 during the vehicle's displacement, which was evidenced by the U-shaped deformation pattern observed at the vehicle inspection.

Figure 7: West-facing image depicting the U-shaped deformation of the W-beam between Posts 5 and 6.

Figure 8: Southeast-facing lookback view from the vehicle's final rest position.

The Ford began to override and then climbed over the deformed W-beam guardrail at Posts 5, 6, and 7. Black scuff marks indicative of tire contact were observed on the face of the guardrail in the vehicle's trajectory. Instability was created as the vehicle climbed over the guardrail, which resulted in a left side leading rollover (Event 3). The Ford rolled one quarter-turn about its longitudinal axis as it continued to rotate clockwise about the vertical axis. The vehicle then slid to rest on its left plane on the field side (north) of the guardrail, facing south (**Figure 8**). Neither the left side-mounted side impact air bag nor the inflatable curtain air bags deployed in the event. At rest, the Ford had rotated approximately 250 degrees clockwise of its initial pre-crash trajectory and its center of mass was located approximately 20.9 m (68.6 ft) west of Post 1.

Post-Crash

Passersby reported the crash to the emergency response system. Police, fire department, and emergency medical service (EMS) personnel responded to the crash site. The unbelted driver was in a semi-conscious state and suffered from a suspected head injury. The positioning of the vehicle and his condition necessitated extrication. Firefighters stabilized the vehicle and cut the laminated windshield, then used hydraulic equipment to cut the four right upper pillars of the Ford to deform the entire roof toward the ground in order to access the driver. Medical record data indicated that the driver became combative during his removal from the vehicle. He was placed on a backboard and transported by helicopter to a Level 1 trauma center, where he was admitted for the treatment of his injuries. The Ford was winched onto a flatbed tow truck and transported to the local yard where it was located for this SCI investigation.

ET-PLUS END TERMINAL AND GUARDRAIL

Figure 9: Oblique view of an exemplar 10 cm (4 in) ET-Plus installation.

The ET-Plus end treatment, manufactured by Trinity Highway Products, was an energy-absorbing end terminal at the end of the W-beam guardrail. The end terminal met the requirements of National Cooperative Highway Research Program (NCHRP) 350 Test Level 3.[1] **Figure 9** is an oblique view of an exemplar ET-Plus installation. The end terminal was designed to be displaced along the W-beam by the force of the impact and dissipate the impact forces by flattening the W-beam during its movement. The flattened and deformed beam was projected out of the impact head toward the field (off-traffic) side. The feeder chute of the end terminal involved in this crash was 10 cm (4.0 in) wide. The manufacturer's literature and installation manuals can be found at www.highwayguardrail.com/products/etplus.html.

The end terminal and guardrail treatment system were inspected post-crash and documented by the SCI investigator with measurements and photographs. A diagram depicting the deformed guardrail is included. The completed FHWA Guardrail Forms are included at the end of this report as **Appendix A**.

The involved system's installation was a nine-post tangent configuration over a distance of 15.2 m (50.0 ft). The instruction manual indicated that this installation consisted of a 10 cm (4 in) ET- Plus rail flattening head assembly; a hinged break-away (HBA) post and foundation tube at Post 1; a ground strut between Posts 1 and 2; a tension cable from Post 1 to the W-beam guardrail between Posts 1 and 2; 10 cm x 15 cm (4 in x 6 in) standard yielding terminal (SYT) posts at locations 2 to 8; and sections of standard W-beam guardrail. At Post 9, the guardrail system transitioned into standard guardrail, with steel posts, wooden block-outs, and carriage bolts. An anchor plate and bolt held the ET-Plus head assembly at Post 1, while the W-beam guardrail at Post 1 was free-floating. The W-beam was supported by a carriage bolt at Post 2 and by composite block-outs and carriage bolts at Posts 3 to 9.

Inspection of the installation determined that the crash resulted in an approximate overall damage length of 12.8 m (42.0 ft) that extended to the area of Post 8. The HBA-designed Post 1 separated from its foundation on impact; however, the hanger bolt between the end terminal and the post did not shear. Post 1 remained attached to the end terminal during the crash sequence. The SYT-designed Post 2 was deformed 80 degrees to the west, bent at ground level, and sheared at the weakening holes. The ground strut between Posts 1 and 2 remained in place. SYT-designed Posts 3, 4, and 5 were deformed approximately 80 to 90 degrees along the vehicle's trajectory at the ground-level weakening holes.

[1] This research is a joint program sponsored by the American Association of State Highway and Transportation Officials in cooperation with the Federal Highway Administration. It is conducted for them by the Transportation Research Board of the National Research Council.

Figure 10 depicts Post 1 and the ET-Plus end terminal at the time of the SCI inspection. **Figure 11** depicts deformed Posts 3 and 4. Composite block-outs and carriage bolts were used at each post. The carriage bolts pulled through and released the W-beam at these locations, with displacement of the block-outs.

Figure 10: Northeast-facing image of Post 1, which remained attached to the displaced end terminal.

Figure 11: North-facing view of deformed Post 3 (right) and Post 4 (left).

The W-beam deformed into a U-shape at the vertex between Post 5 and 6 (**Figure 12**). Post 6 was deformed approximately 60 degrees to the west, and bent at ground level. Post 7 was deflected approximately 30 degrees. The carriage bolts at both posts pulled through and separated from the W-beam and the composite block-outs remained attached. The carriage bolt at Post 8 had only partially pulled through the W-beam. The deflection at this post was approximately 10 degrees to the west. There was no damage to Post 9 and beyond. The height of the W-beam at an undamaged location between Posts 10 and 11 measured 72 cm (28.5 in).

Figure 12: Northwest-facing view depicting the U-shaped deformed W-beam guardrail.

During the crash sequence, the Ford departed the right road edge and the right corner of the vehicle struck the face of the end terminal. The impact face measured 38 cm x 71 cm (15 in by 28 in) width by height. The face did not appear to be significantly damaged. The force of the impact displaced the end terminal to the west and the W-beam extruded normally until approximately Post 3. At this location, due to the orientation and location of the impact and the CW rotation of the Ford, the right end of the Ford's bumper reinforcement bar engaged the feeder chute of the end terminal.

As the end terminal slid along the W-beam, the reinforcement beam was pulled laterally into the feeder chute approximately 36 cm (14 in) (**Figure 13**). The right lateral force (with respect to the vehicle) deformed the left frame rail of the Ford and separated the reinforcement beam from the vehicle. The reinforcement beam's structure crushed and rotated approximately 90 degrees in the feeder chute. The interference created by the presence of the reinforcement beam against the W-beam and feeder chute (**Figure 14**) choked its displacement. In total, 4.3 m (14 ft) of W-beam was extruded.

Figure 13: Northwest-facing image depicting the right (field) side of the end terminal and the end of the reinforcement bar in the feeder chute.

Figure 14: Overhead view depicting the bumper reinforcement bar in the displaced end terminal.

With the end terminal choked, the longitudinal force of the impact transferred to the W-beam. This sudden loading of the W-beam was evidenced by a 0.7 m (2.3 ft) buckled section of the beam located immediately downstream of the end terminal (**Figure 15**). Through the U-shaped bending of the W-beam, the end terminal came to rest on the north side of the guardrail adjacent to Post 7. The extruded W-beam extended beyond Post 9. Inspection of the W-beam revealed that the initial 2.1 m (7 ft) of the extrusion was abraded, flattened and folded onto itself (**Figure 16**). It was determined that this section of the extruded W-beam was struck and flattened by the left plane of the Ford after the vehicle had climbed the guardrail and overturned.

Figure 15: South-facing image of the buckled W-beam downstream of the end terminal.

Figure 16: East-facing image of the extruded W-beam flattened by the Ford as it struck the ground near its final rest position.

2008 FORD EXPLORER

Description

The 2008 Ford Explorer (**Figure 17**) was manufactured in September 2007 and was identified by the Vehicle Identification Number 1FMEU74EX8Uxxxxxx. This sport utility vehicle (SUV) was configured on a 289 cm (113.7 in) wheelbase and outfitted with the Eddie Bauer trim package. The all-wheel drive powertrain consisted of a 4.0 liter gasoline engine linked to a 6-speed automatic transmission with a console-mounted shifter. Service brakes were power-assisted, hydraulic, 4-wheel discs with ABS. Standard equipment included traction control, electronic stability control, and an indirect tire pressure monitoring system. The exterior was configured with original equipment manufacturer's step bars that extended from the A- to C-pillars, a roof rack with lateral load bars, and a frame-mounted Class III receiver trailer hitch. The gross vehicle weight rating was 2,808 kg (6,190 lb), with specific gross axle weight ratings of 1,343 kg (2,960 lb) front and 1,515 kg (3,340 lb) rear. The curb weight was 2,100 kg (4,630 lb). The Ford was equipped with Firestone Destination tires of the vehicle manufacturer recommended size of P235/65R18, with matching Tire Identification Numbers. The vehicle manufacturer's recommended tire pressure was 221 kPa (32 PSI) for all axle positions. An invoice found in the Ford documented the purchase of four new tires on October 16, 2016, at odometer reading of 145,862 km (90,627 mi). Specific tire data at the time of the SCI vehicle inspection included the following.

Figure 17: Right front oblique view of the Ford.

	Measured Tire Pressure	Measured Tread Depth	Restricted	Damage
LF	Flat	9 mm (12/32 in)	No	Tire debeaded, rim surface abraded
LR	193 kPa (28 PSI)	9 mm (11/32 in)	No	No tire damage, rim surface abraded
RR	193 kPa (28 PSI)	9 mm (11/32 in)	No	None
RF	Flat	9 mm (12/32 in)	N/A	Tire debeaded, rim struck and deformed, suspension fractured

The interior of the Ford was configured for seating of seven occupants with three rows of seats (2/3/2). Power adjustable bucket seats with adjustable head restraints comprised the front row, a three-occupant split bench seat with forward folding seat backs made up the second row, and a two-occupant split bench seat with folding backs comprised the third row.

The driver's head restraint was adjusted 5 cm (2 in) above the seat back while the front row right was adjusted 1 cm (0.5 in) above the seat back. The second row left and right head restraints were altered from their at-crash position during the extrication of the driver. The second row center head restraint was fixed. All seating surfaces were leather. Manual safety

systems consisted of 3-point lap and shoulder seat belts for the seven positions. Supplemental safety systems consisted of Certified Advanced 208-Compliant frontal air bags for the driver and front row right positions, front seat-mounted side impact air bags, and dual-sensing (side impact and rollover) inflatable curtain (IC) air bags.

Exterior Damage

The Ford exhibited damage to its front and left planes consistent with the events of the crash sequence. The front plane/right aspect of the Ford struck the end terminal (**Figure 18**). Through inspection, it was determined that the right frame rail was not damaged or compressed. The force of the Event 1 impact was located to the right of the bumper reinforcement bar and the right frame rail. Due to the overlapping damage as a result of the engagement with multiple components of the guardrail system, the direct contact damage resultant to the end terminal impact could only be estimated. The direct contact attributed to the end terminal impact (Event 1) began an estimated 56 cm (22 in) right of center and extended 23 cm (9 in) to the front right corner. The force of the impact deformed the (relatively) soft structures of the corner and the end terminal engaged the right front wheel assembly. The suspension fractured and the right front wheel rim collapsed. The right bias of the impact caused the Ford to initiate a clockwise rotation. The Collision Deformation Classification (CDC) assigned to the damage pattern was 12FREE3. An analysis of the corner impact configuration was beyond the scope of the WinSMASH program. The EDR-reported maximum longitudinal delta-V was -26.52 km/h (-16.48 mph) at 238 milliseconds.

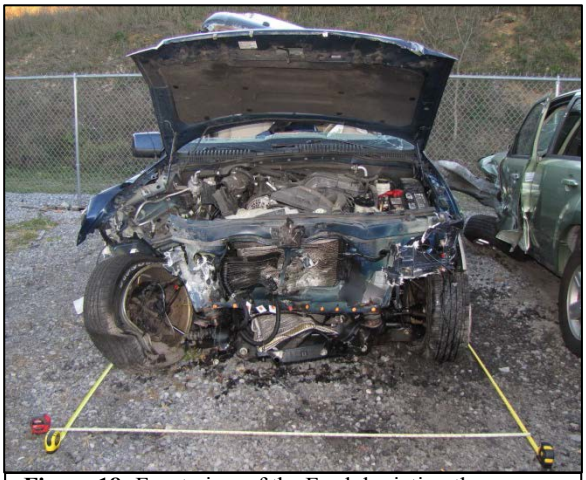


Figure 18: Front view of the Ford depicting the deformation attributed to Events 1 and 2.

The right end of the reinforcement bar engaged the left side of the end terminal and a 36 cm (14 in) length of the structure was drawn into the feeder chute. The overall length of the reinforcement bar measured 102 cm (40 in). The interference caused by the reinforcement choked the displacement of the end terminal. The vehicle's continued displacement imparted a lateral force to the left frame through the jammed reinforcement bar. This lateral force deformed the left frame an estimated 25 cm (10 in) to the right and the reinforcement bar was torn from its attachment to the frame.

With the reinforcement beam separated from the frame, the width of the front plane engaged the face of the W-beam and the exposed structure of the lower radiator support struck the guardrail posts (Event 2). The residual crush profile documented along the lower radiator support [Field L = 73 cm (28.7 in)] was as follows: C1 = 0, C2 = 8 cm (3.1 in), C3 = 23 cm (9.1 in), C4 = 14 cm (5.5 in), C5 = 10 cm (3.9 in), C6 = 0. Maximum crush was 28 cm (11.0 in), located on the vehicle's centerline. The CDC assigned as representation of the vehicle's engagement with these guardrail components was 12FDEW2. Due to the overlapping damage, a WinSMASH analysis was not conducted.

The Ford climbed the guardrail and overturned one quarter-turn to its left (Event 3). The left plane exhibited multiple scratch marks, abrasions and body deformation due to impact with the extruded W-beam and the ground (**Figure 19**). The scratches were oriented in multiple directions indicative of the vehicle's rotation about the vertical axis as it slid to final rest. There was no lateral displacement or vertical crush of the occupant compartment structure. Additionally, the vehicle was dragged along the roadside during its recovery, which contributed to the left plane damage. All the left side glazing and the backlight were disintegrated. The CDC attributed to the rollover damage was 00LDAO3.

Figure 19: Oblique view of the damage to the Ford's left plane.

Event Data Recorder

The 2008 Ford Explorer was equipped with a restraints control module (RCM) that controlled the diagnostic, sensing, and deployment of the vehicle's supplemental safety systems. The RCM was located on the centerline of the vehicle between the front seats. The RCM had event data recorder (EDR) capabilities. The EDR data was imaged during the SCI inspection using software version 17.0 of the Bosch CDR tool via a direct-to-module connection and external 12-volt electrical power. The imaged data was reported with software version 17.9.1 and is included at the end of this report as **Appendix B**.

The data limitations reported by this EDR were limited in scope and definitions. The limitations stated that the EDR was capable of recording both non-deployment and deployment events. A non-deployment event was not considered severe enough to warrant the deployment of an air bag device and could be overwritten. Deployment events by definition commanded the deployment of an air bag. A deployment event became locked and could not be overwritten. The EDR could store up to three deployment events. Although the vehicle was capable of sensing bi-directional and rollover crash dynamics, only longitudinal deceleration (delta-V) data was provided in the output file. A 5-second pre-crash buffer that described various vehicle performance parameters was recorded for each event record. These performance parameters were recorded asynchronously in approximately 1.0-second intervals.

The title page of the imaged data indicated that two frontal events were recovered. Both occurred on the same ignition cycle with a reported "Key-on Timer" value of 11,020 seconds and a "Lifetime Operating Timer" value of 12,415,140 seconds. The specific time between the recorded events was not reported. The driver seat belt switch circuit status was reported as "Unbuckled." The two events also shared identical pre-crash data.

<u>First Record</u>

The first record was a deployment event that was attributed to Event 1 of the SCI reconstruction. The recorded "Key-on Timer" value indicated that the vehicle had been in operation for just over 3 hours at the time of the crash. Details regarding its operation were unknown. Additional system status data indicated that the air bag warning was "Off" at the time of the recording and no fault

codes were present. The deployment times for stage one and stage two of the driver air bag were 32 milliseconds and 42 milliseconds after algorithm enable (AE), respectively.

The longitudinal crash pulse was recorded for a duration of 238 milliseconds after AE. The maximum recorded delta-V occurred at 238 milliseconds and had a magnitude value of -26.52 km/h (-16.48 mph). A review and analysis of the acceleration data indicated that the crash pulse was still active and had not plateaued. This was an indicator that impact forces were still being generated and that the crash event was not fully recorded.

Second Record

This event was a frontal event that occurred an unknown time after the first record and was likely associated with the prolonged engagement with the guardrail. The time between events was not reported. The air bag warning lamp was "Off" at the start of the event; however, fault codes were present. Data fields reported faults at the driver B-pillar sensor, driver C-pillar sensor and passenger B-Pillar sensor. Additionally, the battery voltage was reported as less than 10 volts, but also greater than 16 volts. These opposing logic statements were indicators of a possible incomplete recording. This record had no recorded air bag deployment data. The maximum longitudinal delta-V of this record was -23.66 km/h (-14.70 mph) at 210 milliseconds.

Pre-Crash Data

	-5 sec	**-4 sec**	**-3 sec**	**-2 sec**	**-1 sec**
Speed	116.8 km/h (72.6 mph)	115.0 km/h (71.5 mph)	112.5 km/h (69.9 mph)	110.4 km/h (68.6 mph)	108.3 km/h (67.3 mph)
Accelerator Pedal Percent	11	0	0	0	0
Brake event	No	No	No	No	No

Identical pre-crash data was recorded for both events. The data trends indicated that the accelerator pedal was released approximately 5 seconds prior to AE. The Ford then coasted, slowing by rolling resistance, until AE. A brake application was not recorded

Interior Damage

The interior of the Ford (**Figure 20**) sustained minor severity damage from the multiple event crash. The damage was associated with the deployment of the driver air bag and driver contact to the interior. There was no measureable intrusion. The driver seat was located in a full-rear track position with the seatback reclined 35 degrees aft of vertical. The horizontal distance from the seatback to the center hub of the steering wheel rim measured 82 cm (32.3 in) at a height of 46 cm (18 in) above the seat bight. There was no deformation of the steering wheel rim or movement of steering column's shear capsules.

Figure 20: Overall right interior view of the Ford.

Figure 21: Interior image of the Ford depicting the driver contact to the left instrument panel and knee bolster.

The unbelted driver responded to the crash force with a forward trajectory. His knees contacted the knee bolster and the lower/mid left instrument panel (**Figure 21**). His right knee contact was evidenced by fabric transfers at the protrusion of the bolster for the steering column. The left knee scuffed and fractured the polymer panel left of the bolster at the location of the headlight switch. The switch panel was displaced forward. Located directly above the left knee contact was a HVAC vent louver. This louver was displaced from its mount from a probable left hand/arm contact. A scuff mark was present on the lower aspect of the upper left A-pillar trim panel. Blood was present on the forward aspect of the left front door panel.

Post-crash, the rescue personnel cut the right side pillars and displaced the roof downward to the left against the ground to extricate the driver. The Ford's laminated windshield was cut from the vehicle. Numerous foot prints were present on the headliner, which masked possible occupant contact evidence.

Manual Restraint Systems

The Ford was configured with manual 3-point lap and shoulder seat belt systems for the seven designated seat positions. All seat belt systems used continuous loop webbing and sliding latch plates. The driver's seat belt retracted onto an emergency locking retractor (ELR) while the other systems used dual mode ELR/automatic locking retractors. Both front row seat belt systems were configured with adjustable D-rings. The driver's D-ring was found adjusted to the full-up position at the time of the SCI inspection while the position of the front row right was cut and altered during the extrication of the driver. The seat belts in the front row used retractor and buckle pretensioners.

The driver's seat belt displayed evidence of historical usage that included worn edges of the webbing, wear marks on the latch plate, and staining of the webbing. However, the driver did not wear the seat belt at the time of the crash. At inspection, the webbing was stowed on the retractor and the retractor was operational. There was no loading evidence on the system. Neither the retractor nor the buckle pretensioner was actuated. The driver was not restrained by the seat belt at the time of the crash based on the observations of the SCI inspection, which concurred with the imaged EDR data that reported the driver seat belt as "Unbuckled."

Supplemental Restraint Systems

The Ford was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual-stage air bags for the driver and the front row right occupant position. In addition to the air bags, the CAC system used an occupant classification (weight) sensor in the front row right seat cushion, front seat belt buckle switches, front row seat belt pretensioners, and front seat track positioning sensors. Side impact protection was supplemented by front row seat-mounted side impact air bags and dual sensing (side impact and rollover sensing) IC air bags. The IC air bags were mounted to the roof side rails and concealed by the headliner.

The driver's air bag (**Figure 22**) deployed at impact with the end terminal (Event 1). Stage 1 deployment was commanded at 32 milliseconds, with stage 2 commanded at 42 milliseconds. Blood evidence and post-crash dirt was present in the 12 o'clock sector of the air bag. The front row right occupant position was unoccupied; therefore the front air bag for this position was suppressed. The seat belts were not buckled; therefore, the ACM did not command actuation of the buckle and retractor pretensioners.

Figure 22: Image depicting the deployed drive air bag in the Ford.

Contrary to expectation, the dual-sensing IC and left side impact air bags did not deploy during the rollover (SCI Event 3) and the ground contact. Although the root cause of the non-deployment could not be determined, the presence of fault codes in the EDR and indicators of a potential power loss may have prevented the detection of the rollover event and the IC deployment. Prior to the crash sequence, the air bag warning lamp was "Off." This was an indicator that the air bag systems were functioning as designed. The ACM sensed the force of the impact to the guardrail and the vehicle's prolonged engagement with the structure. The EDR recorded the frontal impact with the guardrail in the first and second records of the data.

It was theorized that the faulted satellite sensors at driver B-pillar, driver C-pillar, and passenger B-pillar that were reported in the second record of the EDR and the electrical power fluctuations, implied in the battery voltage fields of the data, may have prevented the proper sensing of the crash dynamics during the later stages of the crash sequence. The EDR had the capacity to record three events; however, the rollover event record was not recorded. The lack of a recording indicated that the rollover vehicle dynamics were not detected; thus the deployment of the IC air bags was not commanded.

2008 FORD EXPLORER OCCUPANT DATA

Driver Demographics

Age/Sex:	55 years/male
Height:	176 cm (69.3 in)
Weight:	76 kg (168 lb)
Eyewear:	Unknown
Seat type:	Forward-facing bucket seat with adjustable head restraint
Seat track position:	Rearmost
Manual restraint usage:	None; 3-point lap and shoulder seat belt available
Usage source:	Vehicle inspection
Air bags:	Front, seat-mounted and IC air bags available; front deployed
Alcohol/drug involvement:	BAC = .176 g/dL (hospital record)
Egress from vehicle:	Removed by EMS due to perceived serious injury
Transport from scene:	Ambulance to Level 1 trauma center
Type of medical treatment:	Admitted for one day

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component	IPC Confidence Level
1	Closed head injury with concussive symptoms and LOC	161002.2	Left A-pillar	Possible
2	Abrasion to forehead	210202.1	Left A-pillar	Possible
3	Laceration to left upper back, 1 cm in size	410602.1	Unknown	N/A
4	Scattered abrasions over right and left knees	810202.1	Lower left instrument panel	Certain
5	Scattered contusions over right and left knees	810402.1	Lower left instrument panel	Certain

Source – Hospital records

Driver Kinematics

The 55-year-old male driver of the Ford was seated in a full-rear track position with the seat back slightly reclined and the adjustable head restraint positioned 5 cm (2 in) above the seat back. He was not using the manual 3-point lap and shoulder seat belt system. The lack of seat belt use was determined from the stowed position of the webbing against the B-pillar, the lack of loading evidence on the system, the non-actuated retractor pretensioners and the recorded data from the vehicle's EDR. The police report also listed him as unrestrained due to the reports of the first responders. His driving posture is unknown as he stated he had fallen asleep prior to the crash.

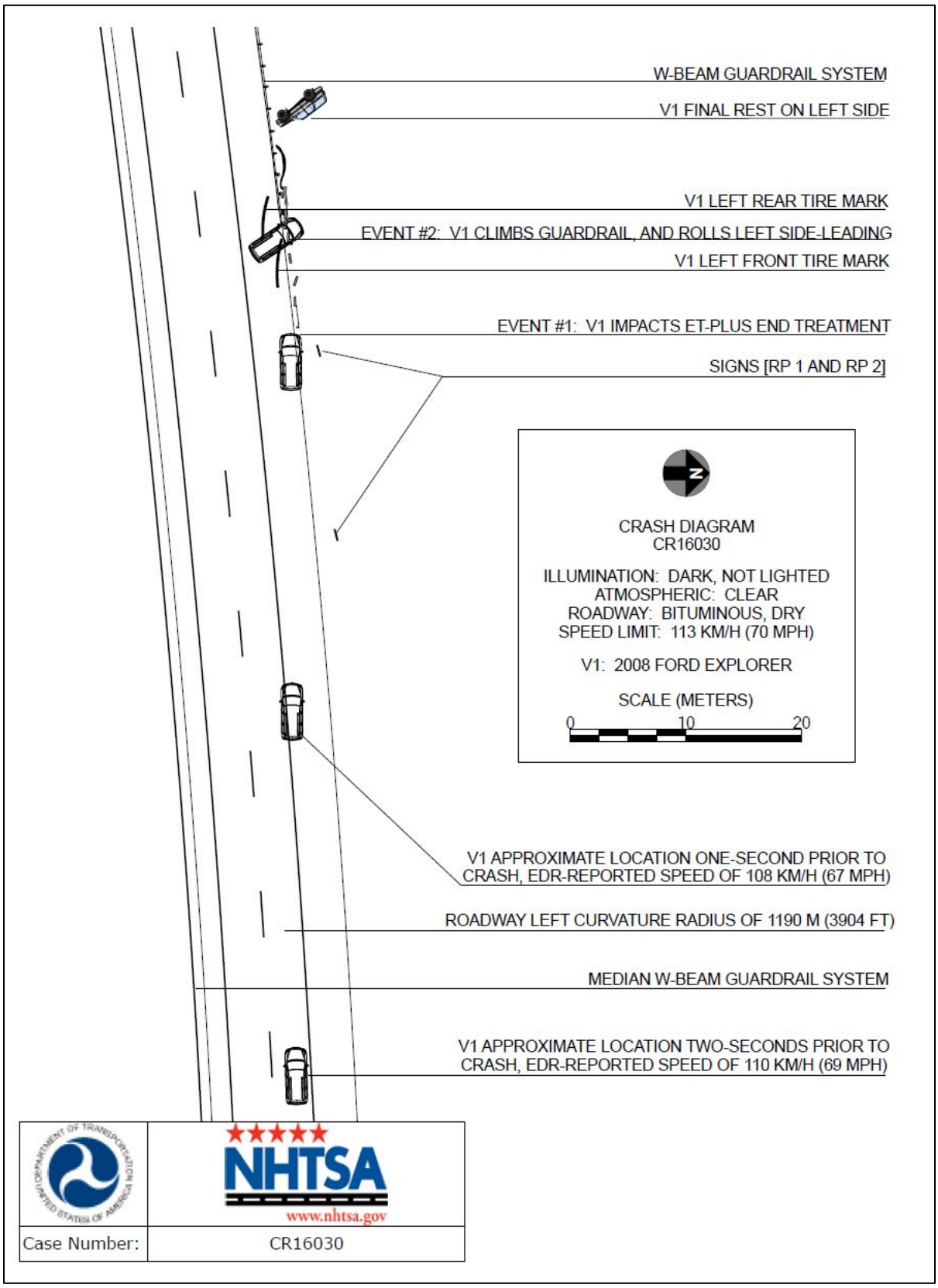
The Ford departed the westbound travel lane and entered the north shoulder in a tracking mode. As the front plane struck the end terminal of the guardrail system, the driver's frontal air bag

deployed. The unrestrained driver initiated a forward trajectory in response to the 12 o'clock direction of the impact and loaded the deployed (Stage 2) air bag. There was no specific contact evidence to the deployed air bag or compression of the energy absorbing steering column. The four-spoke steering wheel rim was not deformed. His left knee contacted and scuffed the knee bolster and the left mid-instrument panel, fracturing the panel and displacing forward the trim panel that contained the headlight switch. The driver's right knee contacted the knee bolster at the formed protrusion on the right side of the steering column. His lower extremity contacts resulted in soft tissue abrasions and contusions. Fabric transfers evidenced the contact.

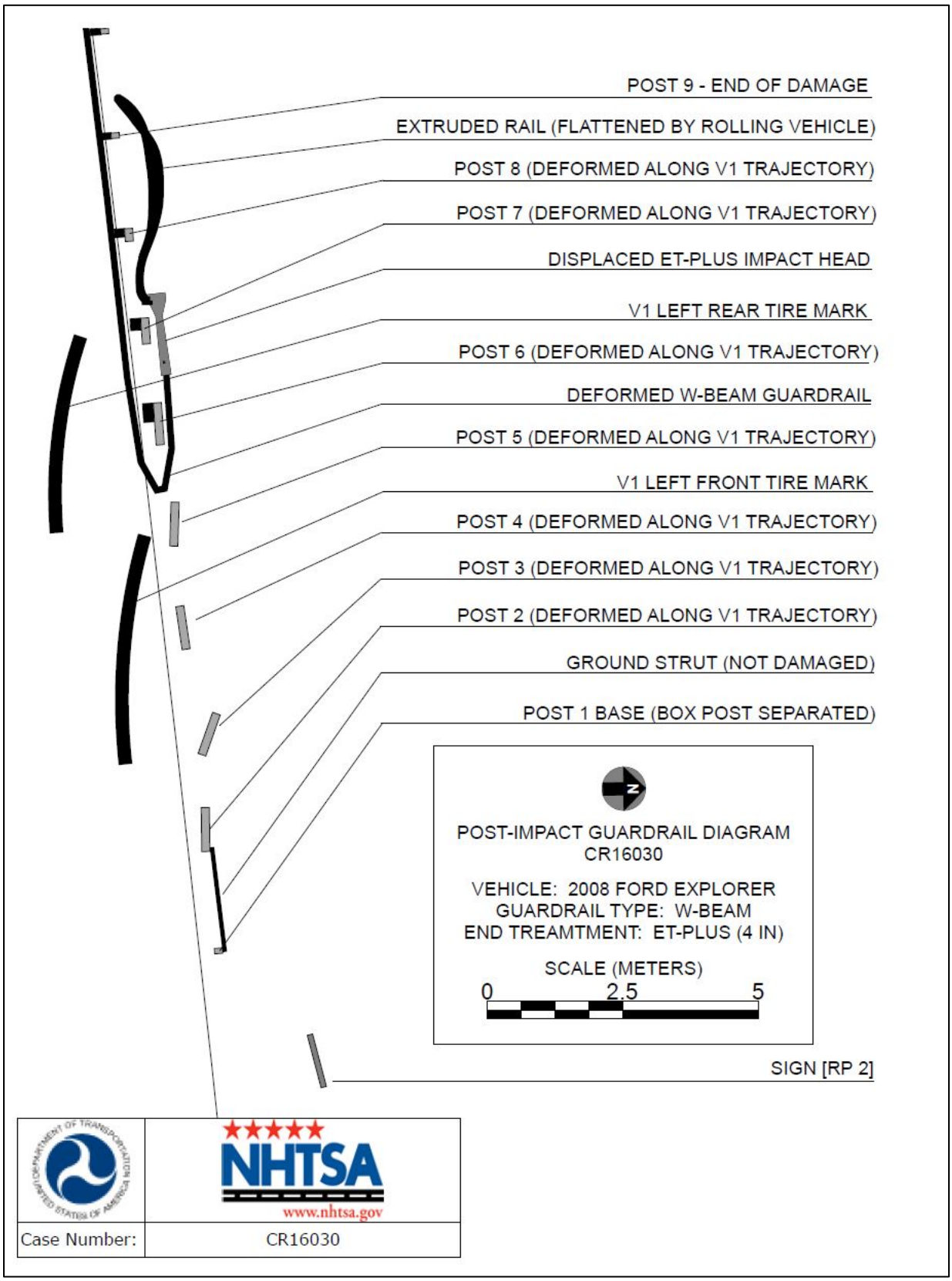
During the left side-leading rollover, the driver responded to his left due to the force of gravity. He possibly contacted the upper left A-pillar with his head, evidenced by a scuffmark, at this time. This contact was the possibly source of his loss of consciousness and the forehead abrasion. A blood transfer was located on the door trim at the upper forward quadrant. His left hand/arm probably contacted and displaced the vent louver located at the mid left instrument panel.

The driver came to rest in the Ford slumped against the left door panel. The police report listed him as unconscious. The first responders used hydraulic equipment to cut the right side pillars and deform the roof to extricate the driver from the vehicle. He was transferred to an awaiting helicopter and transported to a Level 1 trauma center, where he was hospitalized one day for the treatment of his injuries.

CRASH DIAGRAM



POST-IMPACT GUARDRAIL DIAGRAM



APPENDIX A:

FHWA Guardrail Form

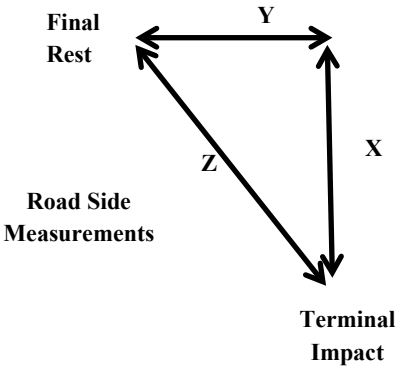
Case No.: CR16030

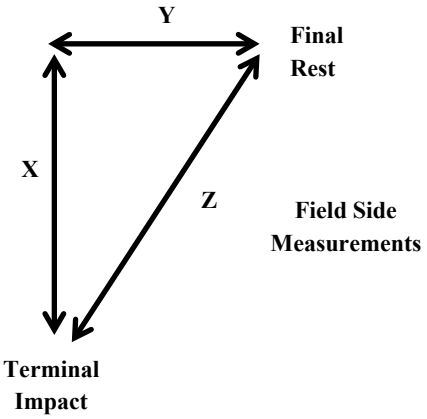
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	November 2016	**Time of Crash (Military)**	Nighttime
Case Number	CR16030	**State**	PA
Traffic Route	Limited Access	**Direction (Southbound = SB)**	WB
Ambient Conditions (at time of crash)			
Temperature (°F)	44°	**Lighting**	Dark, not lighted
Atmospheric	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)	67.3 mph (*EDR-reported*)
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 60.3 ft ❒ Road side ■ Field Side
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 59.8 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 7.6 ft
Super elevation	❒ +2% ❒ -2% ■ NONE or FLAT
Curve Radius (ft.)	3904 ft

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: CR16030

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: N/A		

Case No.: CR16030

GUARDRAIL INSTALLATION									
Post No.	Post		Block-Out		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	-	-	-	-	-	-	-	-	-
1	Steel	6 x 4	None	N/A	No	N/A	12 ft 10 in	N/A	6 ft 4 in

GUARDRAIL INSTALLATION									
Post No.	**Post**		**Block-Out**		**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.)**					
2	Steel	6 x 4	Composite	3.8x7.5x14	No	N/A	12 ft 10 in	N/A	5 ft 10 in
3	Steel	6 x 4	Composite	3.8x7.5x14	No	N/A	13 ft 1 in	N/A	6 ft 4 in
4	Steel	6 x 4	Composite	3.8x7.5x14	No	N/A	13 ft 0 in	N/A	6 ft 4 in
5	Steel	6 x 4	Composite	3.8x7.5x14	No	N/A	12 ft 11 in	N/A	6 ft 2 in
6	Steel	6 x 4	Composite	3.8x7.5x14	No	N/A	12 ft 11 in	N/A	6 ft 2 in

GUARDRAIL INSTALLATION									
Post No.	**Post**		**Block-Out**		**PRE-Existing Damage**		**Offset to post or post hole (ft.)**		**Spacing to next post (ft. -in.)**
	Type	**Dim.**	**Type**	**Dim.**					
	Steel Wood Other	**D x W (in.) or Dia. (in.)**	**Steel Wood Composite**	**D x W (in.)**	**Yes No Unknown**	**Describe**	**Travel way**	**Curb**	
7	Steel	6 x 4	Composite	3.8x7.5x14	No	N/A	12 ft 8 in	N/A	6 ft 3 in
8	Steel	6 x 4	Composite	3.8x7.5x14	No	N/A	12 ft 8 in	N/A	6 ft 1 in
9	Steel	6 x 4	Wood	6x7.5 x14	No	N/A	12 ft 6 in	N/A	6 ft 8 in
10	-	-	-	-	-	-	-	-	-

Additional Comments:

None

Case No.: CR16030

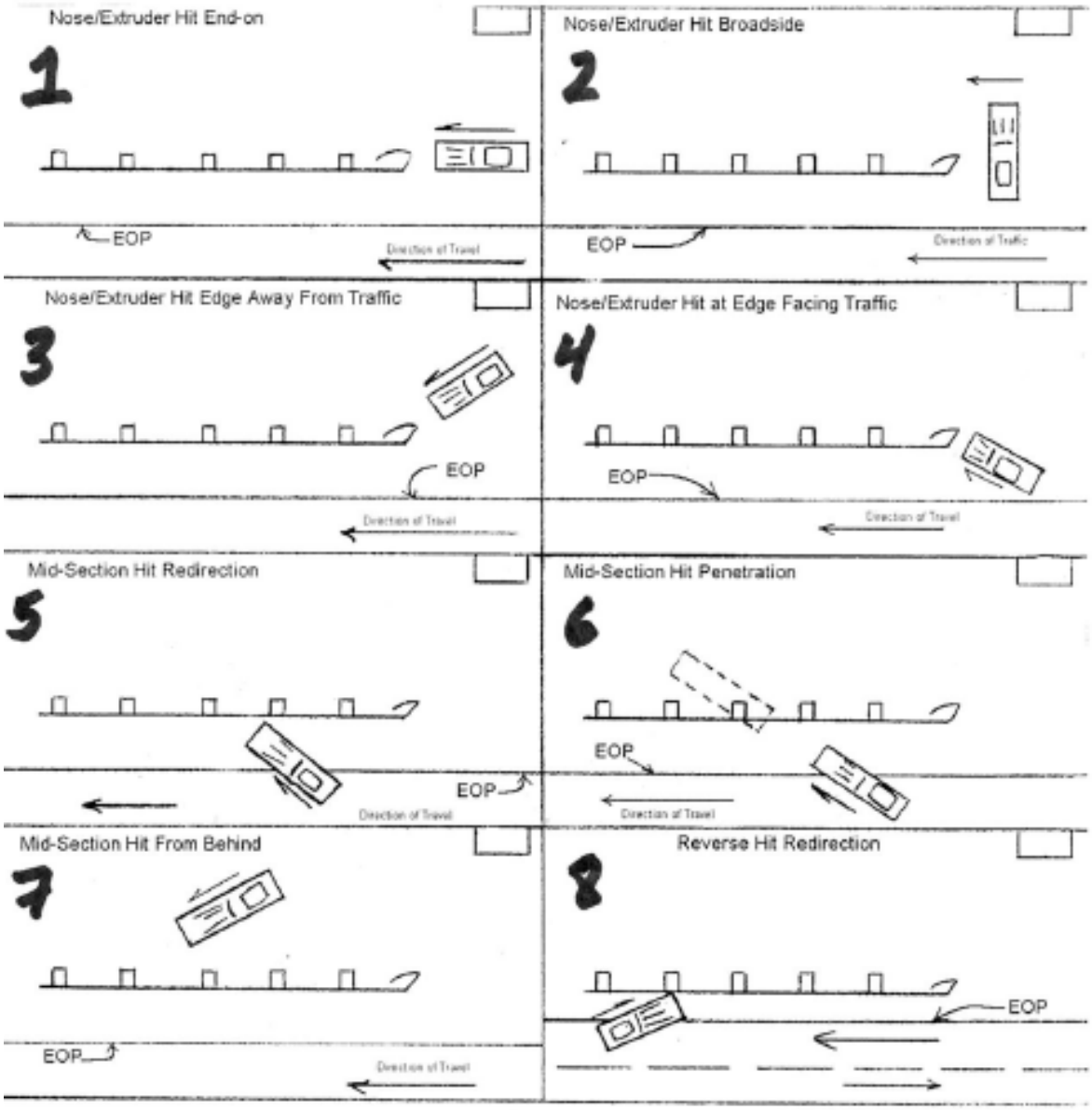
EXTRUDER			
Feeder Channel Width at impact head	■ 4inches ❒ 5 inches ❒ Other _____		
Guide Chute Exit Height (in.)	20 in		
Connection of feeder channels to head damaged?	■ No ❒ Yes	Are Welds Broken?	❒ No ■ Yes
Anchor Cable Present?	❒ No ■ Yes	Pre-crash Connected?	❒ No ■ Yes
Rail Extrusion?	❒ No ■ Yes	Length (ft. in.)	14'-0"
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.]	**Total = 42 ft** *[4 ft (extruded) + 6.6 ft (inside terminal) + 23.3 ft]*		

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:
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 (*during rollover*)		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	13%	11.7%	12.8%
Adjacent Lane Width (ft)	11 ft 2 in		
Lane Type (NAS EDS Variable: Sur. Type)	Asphalt		
Shoulder Type	Asphalt		
Shoulder Width (ft)	12 ft 4 in		
Guardrail Height (in)	18.5 in (*measured between Posts 10 and 11*)		

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	2008 Ford Explorer	
Vehicle Identification Number (VIN)	1FMEU74EX8Uxxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	4620 lb	
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	12FREE3, 12FDEW2, 00LDAO2	
Delta-V	15-25 mph (Estimated)	
Occupant Compartment Penetration of rail	■ No	❒ Yes; Describe: N/A
Did the Vehicle Rollover?	■ Yes ❒ No	
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 Face	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	Climb Over	


Nose/Extruder Hit End-on
1
EOP
Direction of Travel
Nose/Extruder Hit Broadside
2
EOP
Direction of Traffic
Nose/Extruder Hit Edge Away From Traffic
3
EOP
Direction of Travel
Nose/Extruder Hit at Edge Facing Traffic
4
EOP
Direction of Travel
Mid-Section Hit Redirection
5
EOP
Direction of Travel
Mid-Section Hit Penetration
6
EOP
Direction of Travel
Mid-Section Hit From Behind
7
EOP
Direction of Travel
Reverse Hit Redirection
8
EOP

APPENDIX B:

2008 Ford Explorer Event Data Recorder (EDR) Report

The EDR report 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.

BOSCH

CDR CRASH DATA RETRIEVAL

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 User Case Number	1FMEU74EX8U******
EDR Data Imaging Date Crash Date Filename Saved on	 CR16030_V1_ACM.CDRX
Imaged with CDR version Imaged with Software Licensed to (Company Name)	Crash Data Retrieval Tool 17.0 Company Name information was removed when this file was saved without VIN sequence number
Reported with CDR version Reported with Software Licensed to (Company Name) EDR Device Type	Crash Data Retrieval Tool 17.9.1 NHTSA Airbag Control Module
ACM Adapter Detected During Download Event(s) Recovered	Yes Frontal event, Frontal event

Comments

No comments entered.

The retrieval of this data has been authorized by the vehicle's owner, or other legal authority such as a court order or search warrant, as indicated by the CDR tool user on .

Data Limitations

RESTRAINTS CONTROL MODULE RECORDED CRASH EVENTS:

Deployment Events cannot be overwritten or cleared from the Restraints Control Module (RCM). Once the RCM has deployed any airbag device, the RCM must be replaced. The data from events which did not qualify as deployable events can be overwritten by subsequent events.

The RCM can store up to three deployment events.

AIRBAG CONTROL MODULE DATA LIMITATIONS:

- Restraints Control Module Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced from the point of algorithm wake up. It is not the speed the vehicle was traveling before the event. Note that the vehicle speed is recorded separately five seconds prior to algorithm wake up. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change.
- If power to the Airbag Module is lost during a crash event, all or part of the crash record may not be recorded.

AIRBAG CONTROL MODULE DATA SOURCES:

Event recorded data are collected either internally or externally to the RCM.

- INTERNAL DATA is measured, calculated, and stored internally; sensors external to the RCM include the following:
  > The Driver and Passenger Belt Switch Circuits are wired directly to the RCM.
  > The Driver's Seat Track Position Switch Circuit is wired directly to the RCM.
  > The Side Impact Sensors (if equipped) are located on the side of vehicle and are wired directly to the RCM.
  > The Occupant Classification Sensor is located in the front passenger seat and transmits data directly to the RCM on high-speed CAN bus.
  > Front Impact Sensors (right and left) are located at the front of vehicle and are wire directly to the RCM.

- EXTERNAL DATA recorded by the RCM are data collected from the vehicle communication network from various sources such as Powertrain Control Module, Brake Module, etc.

02008_RCM-RC5_r001

System Status at Time of Retrieval

Current lifetime operating timer (sec)	12,415,140
Deployment command counter	1
Restraints Control Module Part Number	7L24-14B321-DA
Restraints Control Module Serial Number	0000006630802473
RCM Software Version	Rev Level 7 of 29 July 2005

System Configuration at Time of Retrieval

Configured for driver airbag, stage one	Yes
Configured for passenger airbag, stage one	Yes
Configured for driver airbag, stage two	Yes
Configured for passenger airbag, stage two	Yes
Configured for driver retractor pretensioner	Yes
Configured for passenger retractor pretensioner	Yes
Configured for driver pretensioner	Yes
Configured for passenger pretensioner	Yes
Configured for driver side thorax airbag	Yes
Configured for passenger side thorax airbag	Yes
Configured for driver side curtain	Yes
Configured for passenger side curtain	Yes
Configured for driver adaptive load limiter	Yes
Configured for passenger adaptive load Limiter	Yes
Configured for driver adaptive vent	Yes
Configured for passenger adaptive vent	Yes
Configured for driver front satellite sensor	Yes
Configured for passenger front satellite sensor	Yes
Configured for driver side, row 1 satellite sensor	Yes
Configured for passenger side row 1 satellite sensor	Yes
Configured for driver side row 2 satellite sensor	Yes
Configured for passenger side row 2 satellite sensor	Yes
Configured for driver seat track position sensor	Yes
Configured for driver seat belt buckle sensor	Yes
Configured for passenger seat belt buckle sensor	Yes
Configured for airbag cut off sensor	No
Configured for side event detection	Yes
Configured for roll over event detection	Yes
Configured for OCS	Yes
Configured for driver belt minder	Yes
Configured for passenger belt minder	Yes
Configured for passenger airbag disable indicator	Yes
Configured for emergency notification system	No
Configured for fuel cut off system	No

Deployment Data (First Record)

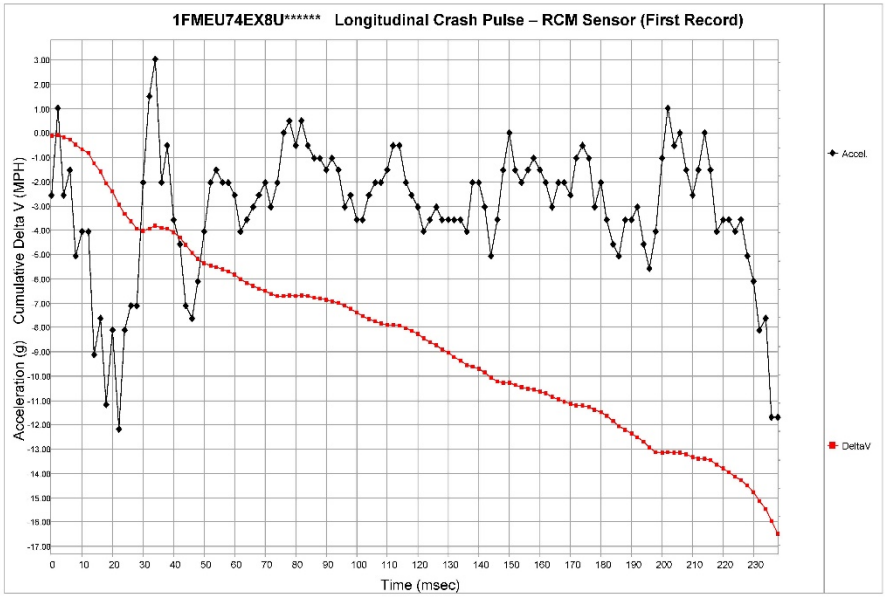
Driver airbag, stage one deployment Time (msec)	32.0
Driver airbag, stage two deployment Time (msec)	42.0

System Status at Event (First Record)

Life time operating timer at start of event (sec)	12,415,140
Key on timer at start of event (sec)	11,020
Driver belt switch circuit status at start of event	Unbuckled
Driver seat position at start of event	Not Forward
Passenger belt switch circuit status at start of event	Unbuckled
Last passenger OCS classification at start of event	Empty
Battery less than 10 volts at start of event	No
Battery greater than 16 volts at start of event	No
Warning lamp command at start of event	Off
CAN OCS message missing at start of event	No
Driver B-pillar satellite sensor faulted at start of event	No
Driver C-pillar satellite sensor faulted at start of event	No
Passenger B-pillar satellite sensor faulted at start of event	No
Passenger C-pillar satellite sensor faulted at start of event	No
Driver front satellite sensor faulted at start of event	No
Passenger front satellite sensor faulted at start of event	No
PADI lamp faulted at start of event	No
Warning lamp faulted at start of event	No
Energy reserve faulted at start of event	No

Pre-Crash Data (First Record)

Time (sec)	-5	-4	-3	-2	-1
Accelerator Pedal (%)	11	0	0	0	0
Vehicle speed (MPH [km/h])	72.6 [116.8]	71.5 [115.0]	69.9 [112.5]	68.6 [110.4]	67.3 [108.3]
ABS event in progress	No	No	No	No	No
TCS engine event in progress	No	No	No	No	No
TCS brake event in progress	No	No	No	No	No
Brake depressed	No	No	No	No	No
IVD Event in Progress	No	No	No	No	No
OCS classification	Empty	Empty	Empty	Empty	Empty


1FMEU74EX8U****** Longitudinal Crash Pulse – RCM Sensor (First Record)
Cumulative Delta V (MPH)
Acceleration (g)
Time (msec)
Accel.
DeltaV

Longitudinal Crash Pulse - RCM Sensor (First Record)

Time (msec)	Recorded vehicle longitudinal acceleration (g)	Cumulative longitudinal velocity change (MPH [km/h])	Time (msec)	Recorded vehicle longitudinal acceleration (g)	Cumulative longitudinal velocity change (MPH [km/h])	Time (msec)	Recorded vehicle longitudinal acceleration (g)	Cumulative longitudinal velocity change (MPH [km/h])
0	-2.54	-0.11 [-0.18]	80	-0.51	-6.70 [-10.78]	160	-1.52	-10.63 [-17.11]
2	1.01	-0.07 [-0.11]	82	0.51	-6.68 [-10.75]	162	-2.03	-10.71 [-17.24]
4	-2.54	-0.18 [-0.29]	84	-0.51	-6.70 [-10.78]	164	-3.04	-10.85 [-17.46]
6	-1.52	-0.25 [-0.40]	86	-1.01	-6.75 [-10.86]	166	-2.03	-10.94 [-17.61]
8	-5.07	-0.47 [-0.76]	88	-1.01	-6.79 [-10.93]	168	-2.03	-11.03 [-17.75]
10	-4.06	-0.65 [-1.05]	90	-1.52	-6.86 [-11.04]	170	-2.54	-11.14 [-17.93]
12	-4.06	-0.82 [-1.32]	92	-1.01	-6.91 [-11.12]	172	-1.01	-11.18 [-17.99]
14	-9.13	-1.23 [-1.98]	94	-1.52	-6.97 [-11.22]	174	-0.51	-11.20 [-18.02]
16	-7.61	-1.56 [-2.51]	96	-3.04	-7.11 [-11.44]	176	-1.01	-11.25 [-18.11]
18	-11.16	-2.05 [-3.30]	98	-2.54	-7.22 [-11.62]	178	-3.04	-11.38 [-18.31]
20	-8.12	-2.41 [-3.88]	100	-3.55	-7.37 [-11.86]	180	-2.03	-11.47 [-18.46]
22	-12.18	-2.94 [-4.73]	102	-3.55	-7.53 [-12.12]	182	-3.55	-11.63 [-18.72]
24	-8.12	-3.30 [-5.31]	104	-2.54	-7.64 [-12.30]	184	-4.57	-11.83 [-19.04]
26	-7.10	-3.61 [-5.81]	106	-2.03	-7.73 [-12.44]	186	-5.07	-12.05 [-19.39]
28	-7.10	-3.92 [-6.31]	108	-2.03	-7.82 [-12.59]	188	-3.55	-12.21 [-19.65]
30	-2.03	-4.01 [-6.45]	110	-1.52	-7.89 [-12.70]	190	-3.55	-12.36 [-19.89]
32	1.52	-3.94 [-6.34]	112	-0.51	-7.91 [-12.73]	192	-3.04	-12.50 [-20.12]
34	3.04	-3.81 [-6.13]	114	-0.51	-7.93 [-12.76]	194	-4.57	-12.70 [-20.44]
36	-2.03	-3.90 [-6.28]	116	-2.03	-8.02 [-12.91]	196	-5.58	-12.94 [-20.82]
38	-0.51	-3.92 [-6.31]	118	-2.54	-8.13 [-13.08]	198	-4.06	-13.12 [-21.11]
40	-3.55	-4.08 [-6.57]	120	-3.04	-8.26 [-13.29]	200	-1.01	-13.16 [-21.18]
42	-4.57	-4.28 [-6.89]	122	-4.06	-8.44 [-13.58]	202	1.01	-13.12 [-21.11]
44	-7.10	-4.59 [-7.39]	124	-3.55	-8.60 [-13.84]	204	-0.51	-13.14 [-21.15]
46	-7.61	-4.92 [-7.92]	126	-3.04	-8.73 [-14.05]	206	0.00	-13.14 [-21.15]
48	-6.09	-5.19 [-8.35]	128	-3.55	-8.89 [-14.31]	208	-1.52	-13.21 [-21.26]
50	-4.06	-5.37 [-8.64]	130	-3.55	-9.04 [-14.55]	210	-2.54	-13.32 [-21.44]
52	-2.03	-5.46 [-8.79]	132	-3.55	-9.20 [-14.81]	212	-1.52	-13.39 [-21.55]
54	-1.52	-5.52 [-8.88]	134	-3.55	-9.36 [-15.06]	214	0.00	-13.39 [-21.55]
56	-2.03	-5.61 [-9.03]	136	-4.06	-9.53 [-15.34]	216	-1.52	-13.45 [-21.65]
58	-2.03	-5.70 [-9.17]	138	-2.03	-9.62 [-15.48]	218	-4.06	-13.63 [-21.94]
60	-2.54	-5.81 [-9.35]	140	-2.03	-9.71 [-15.63]	220	-3.55	-13.79 [-22.19]
62	-4.06	-5.99 [-9.64]	142	-3.04	-9.85 [-15.85]	222	-3.55	-13.94 [-22.43]
64	-3.55	-6.15 [-9.90]	144	-5.07	-10.07 [-16.21]	224	-4.06	-14.12 [-22.72]
66	-3.04	-6.28 [-10.11]	146	-3.55	-10.22 [-16.45]	226	-3.55	-14.28 [-22.98]
68	-2.54	-6.39 [-10.28]	148	-1.52	-10.29 [-16.56]	228	-5.07	-14.50 [-23.34]
70	-2.03	-6.48 [-10.43]	150	0.00	-10.29 [-16.56]	230	-6.09	-14.77 [-23.77]
72	-3.04	-6.62 [-10.65]	152	-1.52	-10.36 [-16.67]	232	-8.12	-15.12 [-24.33]
74	-2.03	-6.70 [-10.78]	154	-2.03	-10.45 [-16.82]	234	-7.61	-15.46 [-24.88]
76	0.00	-6.70 [-10.78]	156	-1.52	-10.51 [-16.91]	236	-11.67	-15.97 [-25.70]
78	0.51	-6.68 [-10.75]	158	-1.01	-10.56 [-16.99]	238	-11.67	-16.48 [-26.52]

Longitudinal Crash Pulse - Satellite Sensors (First Record)

Time (msec)	RCM recorded front left satellite acceleration (g)	RCM recorded front right satellite acceleration (g)
0	2.08	-49.92
2	-8.32	24.96
4	10.40	-10.40
6	-12.48	126.88
8	37.44	49.92
10	16.64	66.56
12	-37.44	-108.16
14	-16.64	-68.64
16	-14.56	-31.20
18	-8.32	8.32
20	-10.40	8.32
22	0.00	43.68
24	10.40	29.12
26	0.00	-31.20
28	0.00	0.00
30	4.16	0.00
32	10.40	35.36
34	-14.56	-2.08
36	0.00	2.08
38	0.00	-47.84
40	-4.16	-24.96
42	-29.12	0.00
44	-6.24	10.40
46	10.40	0.00
48	-4.16	2.08
50	0.00	-10.40
52	-6.24	-6.24
54	-2.08	2.08
56	2.08	-12.48
58	-4.16	0.00

Deployment Data (Second Record)

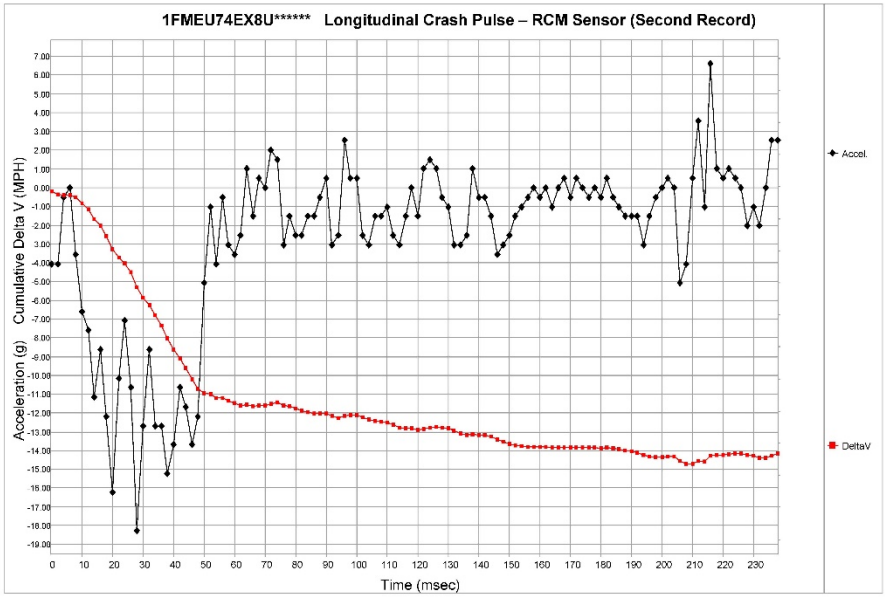
Contains No Recorded Data

System Status at Event (Second Record)

Life time operating timer at start of event (sec)	12,415,140
Key on timer at start of event (sec)	11,020
Driver belt switch circuit status at start of event	Unbuckled
Driver seat position at start of event	Not Forward
Passenger belt switch circuit status at start of event	Unbuckled
Last passenger OCS classification at start of event	Empty
Battery less than 10 volts at start of event	Yes
Battery greater than 16 volts at start of event	Yes
Warning lamp command at start of event	Off
CAN OCS message missing at start of event	No
Driver B-pillar satellite sensor faulted at start of event	Yes
Driver C-pillar satellite sensor faulted at start of event	Yes
Passenger B-pillar satellite sensor faulted at start of event	Yes
Passenger C-pillar satellite sensor faulted at start of event	No
Driver front satellite sensor faulted at start of event	No
Passenger front satellite sensor faulted at start of event	No
PADI lamp faulted at start of event	No
Warning lamp faulted at start of event	No
Energy reserve faulted at start of event	No

Pre-Crash Data (Second Record)

Time (sec)	-5	-4	-3	-2	-1
Accelerator Pedal (%)	11	0	0	0	0
Vehicle speed (MPH [km/h])	72.6 [116.8]	71.5 [115.0]	69.9 [112.5]	68.6 [110.4]	67.3 [108.3]
ABS event in progress	No	No	No	No	No
TCS engine event in progress	No	No	No	No	No
TCS brake event in progress	No	No	No	No	No
Brake depressed	No	No	No	No	No
IVD Event in Progress	No	No	No	No	No
OCS classification	Empty	Empty	Empty	Empty	Empty


1FMEU74EX8U****** Longitudinal Crash Pulse – RCM Sensor (Second Record)
Acceleration (g) Cumulative Delta V (MPH)
Time (msec)
Accel.
DeltaV

Longitudinal Crash Pulse - RCM Sensor (Second Record)

Time (msec)	Recorded vehicle longitudinal acceleration (g)	Cumulative longitudinal velocity change (MPH [km/h])	Time (msec)	Recorded vehicle longitudinal acceleration (g)	Cumulative longitudinal velocity change (MPH [km/h])	Time (msec)	Recorded vehicle longitudinal acceleration (g)	Cumulative longitudinal velocity change (MPH [km/h])
0	-4.06	-0.18 [-0.29]	80	-2.54	-11.76 [-18.93]	160	-0.51	-13.81 [-22.23]
2	-4.06	-0.36 [-0.58]	82	-2.54	-11.87 [-19.10]	162	0.00	-13.81 [-22.23]
4	-0.51	-0.38 [-0.61]	84	-1.52	-11.94 [-19.22]	164	-1.01	-13.86 [-22.31]
6	0.00	-0.38 [-0.61]	86	-1.52	-12.01 [-19.33]	166	0.00	-13.86 [-22.31]
8	-3.55	-0.53 [-0.85]	88	-0.51	-12.03 [-19.36]	168	0.51	-13.83 [-22.26]
10	-6.59	-0.82 [-1.32]	90	0.51	-12.01 [-19.33]	170	-0.51	-13.86 [-22.31]
12	-7.61	-1.16 [-1.87]	92	-3.04	-12.14 [-19.54]	172	0.51	-13.83 [-22.26]
14	-11.16	-1.65 [-2.66]	94	-2.54	-12.25 [-19.71]	174	0.00	-13.83 [-22.26]
16	-8.62	-2.03 [-3.27]	96	2.54	-12.14 [-19.54]	176	-0.51	-13.86 [-22.31]
18	-12.18	-2.56 [-4.12]	98	0.51	-12.12 [-19.51]	178	0.00	-13.86 [-22.31]
20	-16.23	-3.27 [-5.26]	100	0.51	-12.10 [-19.47]	180	-0.51	-13.88 [-22.34]
22	-10.15	-3.72 [-5.99]	102	-2.54	-12.21 [-19.65]	182	0.51	-13.86 [-22.31]
24	-7.10	-4.03 [-6.49]	104	-3.04	-12.34 [-19.86]	184	-0.51	-13.88 [-22.34]
26	-10.65	-4.50 [-7.24]	106	-1.52	-12.41 [-19.97]	186	-1.01	-13.92 [-22.40]
28	-18.26	-5.30 [-8.53]	108	-1.52	-12.47 [-20.07]	188	-1.52	-13.99 [-22.51]
30	-12.68	-5.86 [-9.43]	110	-1.01	-12.52 [-20.15]	190	-1.52	-14.06 [-22.63]
32	-8.62	-6.24 [-10.04]	112	-2.54	-12.63 [-20.33]	192	-1.52	-14.12 [-22.72]
34	-12.68	-6.79 [-10.93]	114	-3.04	-12.76 [-20.54]	194	-3.04	-14.26 [-22.95]
36	-12.68	-7.35 [-11.83]	116	-1.52	-12.83 [-20.65]	196	-1.52	-14.32 [-23.05]
38	-15.22	-8.02 [-12.91]	118	0.00	-12.83 [-20.65]	198	-0.51	-14.35 [-23.09]
40	-13.70	-8.62 [-13.87]	120	-1.52	-12.90 [-20.76]	200	0.00	-14.35 [-23.09]
42	-10.65	-9.09 [-14.63]	122	1.01	-12.85 [-20.68]	202	0.51	-14.32 [-23.05]
44	-11.67	-9.60 [-15.45]	124	1.52	-12.79 [-20.58]	204	0.00	-14.32 [-23.05]
46	-13.70	-10.20 [-16.42]	126	1.01	-12.74 [-20.50]	206	-5.07	-14.55 [-23.42]
48	-12.18	-10.74 [-17.28]	128	-0.51	-12.76 [-20.54]	208	-4.06	-14.72 [-23.69]
50	-5.07	-10.96 [-17.64]	130	-1.01	-12.81 [-20.62]	210	0.51	-14.70 [-23.66]
52	-1.01	-11.00 [-17.70]	132	-3.04	-12.94 [-20.82]	212	3.55	-14.55 [-23.42]
54	-4.06	-11.18 [-17.99]	134	-3.04	-13.08 [-21.05]	214	-1.01	-14.59 [-23.48]
56	-0.51	-11.20 [-18.02]	136	-2.54	-13.19 [-21.23]	216	6.59	-14.30 [-23.01]
58	-3.04	-11.34 [-18.25]	138	1.01	-13.14 [-21.15]	218	1.01	-14.26 [-22.95]
60	-3.55	-11.49 [-18.49]	140	-0.51	-13.16 [-21.18]	220	0.51	-14.23 [-22.90]
62	-2.54	-11.61 [-18.68]	142	-0.51	-13.19 [-21.23]	222	1.01	-14.19 [-22.84]
64	1.01	-11.56 [-18.60]	144	-1.52	-13.25 [-21.32]	224	0.51	-14.17 [-22.80]
66	-1.52	-11.63 [-18.72]	146	-3.55	-13.41 [-21.58]	226	0.00	-14.17 [-22.80]
68	0.51	-11.61 [-18.68]	148	-3.04	-13.54 [-21.79]	228	-2.03	-14.26 [-22.95]
70	0.00	-11.61 [-18.68]	150	-2.54	-13.65 [-21.97]	230	-1.01	-14.30 [-23.01]
72	2.03	-11.52 [-18.54]	152	-1.52	-13.72 [-22.08]	232	-2.03	-14.39 [-23.16]
74	1.52	-11.45 [-18.43]	154	-1.01	-13.77 [-22.16]	234	0.00	-14.39 [-23.16]
76	-3.04	-11.58 [-18.64]	156	-0.51	-13.79 [-22.19]	236	2.54	-14.28 [-22.98]
78	-1.52	-11.65 [-18.75]	158	0.00	-13.79 [-22.19]	238	2.54	-14.17 [-22.80]

Longitudinal Crash Pulse - Satellite Sensors (Second Record)

Time (msec)	RCM recorded front left satellite acceleration (g)	RCM recorded front right satellite acceleration (g)
0	-37.44	41.60
2	-139.36	2.08
4	-8.32	47.84
6	-10.40	14.56
8	-33.28	35.36
10	-41.60	49.92
12	-68.64	47.84
14	-35.36	81.12
16	-35.36	20.80
18	-180.96	0.00
20	-10.40	0.00
22	2.08	0.00
24	-56.16	0.00
26	4.16	0.00
28	4.16	0.00
30	-137.28	0.00
32	-81.12	0.00
34	-79.04	0.00
36	112.32	0.00
38	-18.72	0.00
40	-33.28	0.00
42	2.08	0.00
44	8.32	0.00
46	-168.48	0.00
48	-162.24	0.00
50	-79.04	0.00
52	29.12	0.00
54	12.48	0.00
56	35.36	0.00
58	2.08	0.00

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.

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77  1D  69
CB  A9  C6  02
37  4C  32  34
14  0B  03  21
06  00
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30  80  24  73
22  8A  EB  02
E7  4B  E3  02
9C  B1  E2  02
52  35  5F  30  34  31  43  4E  2E  50  31  38
DE  B3  C6  02
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FF  FF  FF  FF
FF  FF  FF  FF
FF  FF  2A  2A
2A  2A  2A  2A
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AA
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0D
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41 00 00 00 66 30 80 24 73 FF|FF FF FF 00 00 00
66 30 80 24 73 FF FF E4 8D FD|51 F0 30 0C FF 01
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AE 54 00 54 FE 52 2C 52 48 55|49 50 57 49 82 65
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00 00 03 FE FD FE 01 02 06 06|05 FE 01 01 03 07
06 05 03 02 01 00 01 00 02 00|FF 01 FF 00 01 00
00 00 01 FF 01 02 03 03 03 06|03 01 00 FF 00 0A
08 FF F9 02 F3 FE FF FE FF 00|04 02 04 00 FB FB
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FE 42 27 26 CA 09 10 FF FC 51|4E 26 F2 FA EF FF
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DOT HS 812 836
November 2019

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

14542-103019-v1b