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Special Crash Investigations: On-Site Guardrail End Treatment Crash Investigation; Vehicle: 2012 Ford Escape; Location: Missouri; Crash Date: July 2016

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15. Supplementary Note
Each crash represents a unique sequence of events, and 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 this report was published.

16. Abstract
This report documents the on-site investigation of a Soft Stop end terminal during an impact with a 2012 Ford Escape. The crash occurred when the Ford departed the gore area at a left exit ramp from an interstate highway. The Ford struck a road sign during the maneuver and then continued forward, striking the end terminal with its front plane. The vehicle separated from this impact with a counterclockwise rotation and subsequently rolled over. The Ford was equipped with certified advanced 208-compliant (CAC) frontal air bags, front seat-mounted side impact air bags, and inflatable curtain (IC) air bags. The frontal and IC air bags deployed during the crash. The vehicle's unbelted 29-year-old male driver sustained police-reported A-level (incapacitating) injuries and an unbelted adult female (age unknown) seated in the front-row right position of the Ford sustained B-level (non-incapacitating) injuries. Both occupants were transported to a hospital for treatment.

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On-Site Guardrail End Treatment Crash Investigation
Case Number: CR16018
Vehicle: 2012 Ford Escape
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BACKGROUND

This report documents the on-site investigation of a Soft Stop end terminal during an impact with a 2012 Ford Escape (**Figure 1**). The crash was identified by the Missouri Department of Transportation (MoDOT), which in turn submitted notification to the Federal Highway Administration (FHWA). The FHWA determined that the crash type and end terminal met the criteria for further research and subsequently forwarded the notification to the Crash Investigation Division of the National Highway Traffic Safety Administration in July 2016. The CID 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 initiated contact and cooperation with MoDOT, and the on-site investigation took place in July 2016. The crash occurred when the Ford departed the gore area at a left-exit ramp from an interstate highway. The Ford struck a road sign during the maneuver and continued forward, then struck the end terminal with its front plane. The vehicle separated from that impact with a counterclockwise rotation and subsequently rolled over. The Ford was equipped with certified advanced 208-compliant (CAC) frontal air bags, front-seat-mounted, side-impact air bags, and inflatable curtain (IC) air bags. The frontal, front-row right-side impact, and both IC air bags deployed in the crash. The vehicle's unbelted 29-year-old male driver sustained police-reported A-level (incapacitating) injuries and an unbelted adult female (age unknown) seated in the front-row right position of the Ford sustained B-level (non-incapacitating) injuries. Both occupants were transported to a hospital for treatment.

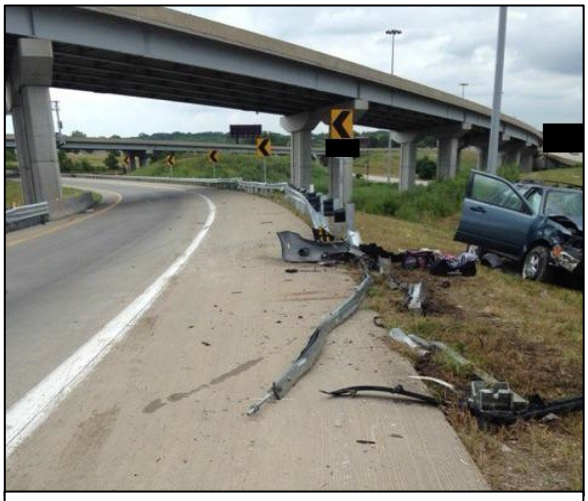


Figure 1. North-looking view of the crash site and the Ford Escape. (Image supplied by MoDOT.)

The on-site investigation involved the inspection and measurement of the terminal system and the documentation of the crash site's environment. The condition of the end terminal was assessed. The Ford was inspected to document the exterior and interior condition and deformation, quantify the occupant compartment intrusion, identify points of occupant contact in the interior, and assess the use and status of the vehicle's safety systems. The Ford was equipped with an Event Data Recorder (EDR) supported by the Bosch Crash Data Retrieval (CDR) software and tool, and its data was imaged during the SCI inspection. The driver declined to be interviewed and participate in the research.

SUMMARY

Crash Site

This single-vehicle crash occurred during the afternoon of July 2016 on the northbound lanes of a two-lane, divided, interstate highway. There was a left exit ramp at the crash site. The interstate highway speed limit was 97 km/h (60 mph). An advisory speed of 80 km/h (50 mph) was posted on the exit sign for the single-lane exit ramp. The police-reported environmental conditions at the time of the crash were daylight, clear, and dry. The National Weather Service reported a temperature of 26.7 ˚C (80 ˚F), 67% relative humidity, variable winds at 5.6 km/h (3.5 mph) and scattered cloud cover.

Figure 2. South-facing lookback view from the gore area created by the interstate and the left exit ramp.

The physical environment of the crash site and guardrail was documented during the SCI inspection using a Nikon Nivo 5.M+ total station. In the area of the crash, the asphalt-surfaced interstate was oriented primarily in the north/south direction. There was a sweeping left curve, the radius of which measured approximately 785 m (2,575 ft), leading into the area of the crash. The two northbound lanes were separated by broken white lines. The width of the right lane measured 3.7 m (12.1 ft) and the width of the left lane measured 3.6 m (11.8 ft). The right shoulder was 3.4 m (11.1 ft) wide and was separated from the right travel lane by a solid white line. The left exit ramp diverged from the left lane of the interstate (**Figure 2**) and accommodated exiting traffic that intended to travel northward on an adjacent roadway. The ramp was oriented as a left curve with a radius that measured approximately 250 m (820 ft). It was 5.2 m (17.1 ft) wide and was bordered by a solid white line on the right and a solid yellow line on the left. The right shoulder of the ramp measured 2.4 m (7.9 ft) wide. The Soft Stop end terminal and guardrail was installed adjacent to the right shoulder (**Figure 3**). This guardrail protected multiple fixed objects and a depression created by the diverging roadways. A highway exit sign and the guardrail system were the points of impact in this crash.

Figure 3. North-facing view of the crash site and the damaged guardrail during the SCI inspection.

Pre-Crash

The Ford traveled north in the right lane of the interstate at an EDR-reported speed of 110.0 km/h (68.4 mph) 5-seconds prior to algorithm enable (AE). It was occupied by a 29-year-old

unbelted male driver and an unbelted adult female (age unknown) in the front-row right position. It was reported to a MoDOT inspector that the Ford's occupants were following GPS-directions and realized that it was necessary to take the left exit from the interstate. The driver initiated an aggressive left steering maneuver late in the pre-crash window and traversed across the left northbound lane and into the gore area at the exit (**Figure 4**) with a counterclockwise yaw trajectory. The change in the magnitude of the lateral stability control acceleration EDR data indicated that the steering maneuver occurred approximately 2.6 seconds prior to the AE of the first crash event. A crash diagram depicting the crash site and the vehicle's motion is included at the end of this report.

Figure 4. North-facing trajectory view of the Ford approximately 1-second prior to the crash.

Crash

The right plane/forward aspect of the Ford struck the left vertical post of the exit sign (Event 1) at an EDR-reported speed of 108.0 km/h (67.1 mph). The breakaway sign post was constructed with a 3.0 m (10.0 ft) long I-beam fastened to a concrete base that was buried at ground level. Impact forces separate the post's connection to the concrete base and rotated the sign clockwise, out of the vehicle's path. A black transfer to the face of the I-beam evidenced the impact (**Figure 5**). This sign post was under repair at the time of the SCI scene inspection. The Ford's trajectory was not affected by its impact to the sign post. The vehicle's front right tire ran over the post attachment at the concrete base and subsequently aired out.

Figure 5. North-looking trajectory view of the Ford at impact with the exit sign post.

The Ford continued forward 9.1 m (29.9 ft) where its front plane struck the Soft Stop end terminal (**Figure 6**). The force of this impact (Event 2) displaced the end terminal approximately 8.1 m (26.3 ft) northward along the W-beam. During this displacement, the forward undercarriage of the Ford struck the raised structure at post 0 of the guardrail system, resulting in a fracture to the Ford's transmission case (Event 3).

Figure 6. North-facing trajectory view of the Ford at impact with the guardrail.

As the Ford displaced the end terminal to the north, its counterclockwise rotation was accentuated. The vehicle achieved a right-side-leading attitude and the lateral forces at the tire/ground interface resulted in an instability, which tripped the vehicle into a right-side-leading rollover (Event 4) as its front plane separated from the end terminal. The Ford rolled two-quarter turns and its roof struck the post 5 I-beam support (Event 5). This impact punctured and tore the sheet metal of the roof, deformed the lateral load bar of the roof rack, and disintegrated the backlight glazing. The overturned vehicle came to rest facing south on top of the guardrail. Its roof remained engaged with post 5. The disintegrated backlight glazing was captured in the concave profile of the W-beam between post 5 and 6 (**Figure 7**). During a review of an on-scene image supplied by MoDOT, it was observed that the glazing was also sprayed onto the roadway adjacent to this location. The location of the disintegrated glazing in these areas was indicative of the impact dynamics. The vehicle dynamics were also captured in the recorded EDR data.

Figure 7. Southwest-facing image depicting the final rest location of the Ford between posts 5 and 6, evidenced by the disintegrated glazing.

Post-Crash

The driver and front row right occupant exited the overturned vehicle under their own power and waited for the arrival of the responding police, fire and emergency medical services (EMS) personnel. Both occupants were transported by ambulance to a hospital. The driver sustained a cervical injury and was hospitalized for 7 days. The front row right occupant sustained police-reported soft tissue injuries to her hands, head and face. She was treated and released on the day of the crash. The Ford was then removed from the crash scene on a flatbed truck and transferred to an insurance vehicle salvage facility, where it was located at the time of the SCI inspection.

Figure 8. Image depicting an exemplar Soft Stop end terminal and guardrail located approximately 18 km (11 miles) west of the crash site.

SOFT STOP END TERMINAL AND GUARDRAIL

The Soft Stop end terminal was an energy absorbing end treatment used to terminate 79 cm (31 in) high W-beam guardrail (**Figure 8**). The Soft Stop installation consisted of a Soft Stop rail flattening head, Soft Stop anchor W-beam guardrail, anchor post (post 0), two steel yielding terminal posts (SYTP) at post locations 1 and 2, and six standard posts at post locations 3-8 that supported the W-beam with a composite

block-out and carriage bolt. The Soft Stop installation was manufactured by Trinity Highway Products (Trinity Industries, Inc., Dallas, Texas) and the end terminal was a MASH TL-3 system. The manufacturer's literature and installation manuals can be retrieved from www.highwayguardrail.com/products/SoftStop.html.

The struck guardrail was a curved system with a measured W-beam height of 77 cm (30.5 in). This height was measured at an undamaged section between post 11 and 12. The Ford struck the impact-face of the end terminal (originally located at post 1) and displaced it along the W-beam. The impact face measured 18 x 51 cm (7.1 x 20.1 in), width x height. Due to its design, the terminal crushed and flattened the W-beam during its movement, thus absorbing energy of the impact. The posts numbered 0 to 10 of the installation were damaged, with W-beam damage that extended to the splice located at post 11. The total length of damaged W-beam measured 19.5 m (63.9 ft). The length of extruded (crushed) rail measured approximately 8.1 m (26.3 ft), from post 0 to the displaced position of the end terminal between post 4 and 5. The deformed guardrail was inspected and documented through measurements and photographs. A diagram depicting the deformed guardrail is included on Page 21. The completed FHWA Guardrail Form is included at the end of this report as **Appendix A.**

Post 0 was a 16 x 16 cm (6.25 x 6.25 in) I-beam that was embedded into the ground and anchored the W-beam through a turnbuckle attachment. During a crash, it was the intended design of the anchor to remain attached in the U-slot of post 0 and tension the deforming W-beam. It was observed that the deformed W-beam came free from post 0 at some point during its deformation. Refer to Figure 1. The end of the deformed W-beam was found in the roadway by the MoDOT inspector following the crash. The inspector replaced the turnbuckle of the deformed guardrail back into the U-slot of post 0.

A ground angle strut bolted between post 0 and 1 also tensioned the system. The bolted connection between the angle strut at both posts remained intact. Post 1 was a yielding 15 x 10 cm (5.9 x 3.9 in) I-beam that supported the end terminal pre-crash. This post was weakened by holes drilled through the end plates of the I-beam. At inspection, these holes were located approximately at ground level as per the installation instructions. During the impact, the post fractured at the weakening holes and deformed longitudinally, in the direction of the Ford's travel.

Figure 9. South-facing image depicting the post 2 deformation and the displaced block-out.

Post 2 was also a yielding 15 x 10 cm (5.9 x 3.9 in) I-beam. Based on the pattern of the dirt, it appeared that these holes were also approximately at ground level. This post deformed approximately 90 degrees by bending and fracture of the beam at the weakening holes. Based on the observations of the inspection, the W-beam was bolted to this post through a composite block-out. The carriage bolt was deformed, and the composite block-out was fractured and separated (**Figure 9**) from the W-beam. The installation directions indicated that this post should have a block-out; however, the W-beam was not supposed to be attached to the post.

Posts 3 to 11 of the installation were standard 15 x 10 cm (5.9 x 3.9 in) I-beams that supported the W-beam with a composite block-out and carriage bolt. During the crash, the bolt heads at posts 3 to 6 and posts 8 to 10 pulled through the W-beam by deforming the hanger slot in the rail. Posts 3 and 4 were deformed to the north by bending at ground level. The bolt head remained engaged with the W-beam at post 7 and twisted the post clockwise. The composite block out at this location was partially fractured. The W-beam remained attached at post 11 and, relative to this crash, the guardrail system appeared to be undamaged beyond this post. It should be noted that the guardrail system had sustained two separate impacts prior to the inspection and crash that are the subject of this report. These impacts occurred farther downstream in the vicinity of posts 35 and 60. The deformation relative to these crashes was visible in the images provided by MoDOT (refer to **Figure 1**), which were taken on the day of the crash under investigation.

The end terminal (**Figures 10** and **11**) was displaced approximately 8.1 m (26.3 ft) to the north by the Ford to the area of posts 4 and 5. Inspection of the end terminal was unremarkable. No welds were broken and it was relatively undeformed. At inspection, the deformed license plate and hood emblem of the Ford were wrapped around the impactor face (highlighted by the arrow in **Figure 11**). This physical evidence was indicative of the vehicle's alignment at the time of the crash. At impact, the centerline of the Ford was 5 cm (2.0 in) right of the centerline of the impact face.

Figure 10. East-facing image depicting the location and condition of the displaced end terminal adjacent to posts 4 and 5.

Figure 11. West-facing image depicting the location and condition of the displaced end terminal adjacent to posts 4 and 5.

Figure 12. Front-right oblique view of the Ford.

2012 FORD ESCAPE

Description

The 2012 Ford Escape (**Figure 12**) was a sport utility vehicle that was identified by the Vehicle Identification Number 1FMCU0C72CKxxxxxx. The vehicle was manufactured in July 2011 and equipped with the XLS level trim. Its digital odometer reading was 182,683 km (113,514 miles). The front-wheel-drive platform was

configured on a 262 cm (103.1 in) wheelbase and was powered by a 2.5 liter, I-4 gasoline engine that was linked to a 6-speed automatic transmission. Service brakes were a power-assisted front/rear disc system with ABS.

The Ford's gross vehicle weight rating was placarded at 2,014 kg (4,440 lb). Front and rear gross axle weight ratings were 1,057 kb (2,330 lb) and 1,012 kg (2,230 lb rear), respectively. The Ford's curb weight was 1,585 kg (3,495 lb). The manufacturer's recommended tire size was P235/70R16 at all four axle positions, with recommended cold tire pressures of 221 kPa (32 psi). At the time of the SCI inspection, the Ford was equipped with four Primewell Valera HT tires of the recommended size. All the tires had adequate tread and were not restricted or damaged.

The interior of the Ford was configured with two rows for the seating of up to five occupants (2/3) with a rear cargo area. The front bucket seats featured cloth upholstery, reclining seat backs, and adjustable head restraints. Each front seat was covered with a one-piece seat cover. At the time of the SCI inspection, the driver and front row right seat were adjusted to their full-rear track positions. The second-row seat was a fold-down split bench with adjustable head restraints in all three positions. All head restraints were fully down. Manual restraint systems consisted of 3-point lap and shoulder seat belts for all seat positions. Both front seat belts were equipped with buckle pretensioners. Supplemental restraint systems consisted of the driver and passenger frontal air bags, front-seat-mounted side-impact air bags, and roof-side rail-mounted IC air bags.

Figure 13. Right side view of the Ford depicting the Event 1 impact damage.

Exterior Damage

The Ford sustained direct impact damage to its front, undercarriage, right, and top planes consistent with the events of the crash. Induced damage due to the forces of the crash was also observed on the left and back planes. The direct contact damage relative to the sign post impact (Event 1) began on the front plane on the front right corner and consisted of abrasions to the right wraparound of the bumper fascia. This pattern extended rearward 41 cm (16.0 in) along the right plane with lateral crush to the fender (**Figure 13**). The direct damage ended 15 cm (6.0 in) forward of the right-front axle position. The maximum lateral crush measured 8 cm (3.2 in). The Collision Deformation Classification (CDC) associated with this damage was 12FREE3.

Figure 14. Front view of the Ford depicting the Event 2 impact damage.

The direct damage from impact with the end terminal (Event 2) was located near the centerline of the front plane and measured 18 cm (7.0 in) in width (**Figure 14**). At the bumper elevation, the direct contact began 9 cm (3.5 in) left of center

and ended 9 cm (3.5 in) right of center. The combined width of the direct and induced damage extended across the entire 109 cm (43.0 in) width of the front bumper reinforcement bar. The front bumper cover was fractured and separated during the impact.

The frontal impact involved the forward components of the engine compartment. Crush was noted to the grille and radiator core, and it extended vertically onto the hood face. There was no change in the wheelbase dimensions. A residual crush profile documented by the SCI Investigator using the total station produced the following measurements: C1 = 0, C2 = 22 cm (8.7 in), C3 = 33 cm (13.0 in), C4 = 29 cm (11.4 in), C5 = 15 cm (5.9 in), and C6 = 0. The CDC assigned to this damage pattern was 12FCEN2. This crash type was not in the scope of analysis by the WinSMASH program due to the yielding property of the guardrail end treatment. A borderline analysis of the crash severity (delta V) was calculated using the WinSMASH model's damage algorithm for comparison purposes only. The total calculated delta V was 36 km/h (22 mph) with longitudinal and lateral components of -36 km/h (-22 mph) and 0 km/h, respectively. The results of the borderline reconstruction appeared reasonable.

The undercarriage damage (Event 3) consisted of a fracture to the transmission case. Consistent impact damage was noted to the raised portion of post 0 during the scene inspection. The CDC assigned to this damage pattern was 12FCLN3.

Rollover damage (Event 4) was present on the right and top planes, and consisted of body panel deformation and surface abrasions. The right outside mirror mount was fractured and the mirror was missing. Dirt and debris was embedded in the right rear door seam from ground contact (**Figure 15**). The right D-pillar area struck the ground and was buckled and abraded over an 84 x 91 cm (33.0 x 36.0 in) area, width by height. The maximum vertical deformation measured 3 cm (1.0 in) at the right

Figure 15. Right-side view of the Ford depicting the rollover damage at the D-pillar.

Figure 16. Overhead image of the Ford depicting the roof puncture. Front of the vehicle is toward the top of the image.

Figure 17. Close-up overhead view of the roof puncture to the Ford with a measuring tape reference.

D-pillar. There was no lateral deformation of the roof structure. All the doors remained closed during the crash sequence and were operational post-crash. There was no damage to the glazing of the right-side windows. This CDC was represented by 00TDDO2.

Figures 16 and 17 depict the damage associated with the Event 5 roof impact that consisted of a puncture to the roof, deformation of the rearmost lateral load bar of the luggage rack, and the disintegration of the backlight glazing. The roof puncture (Event 5) measured 15 x 48 cm (5.9 x 18.9 in). The size, shape, and orientation of the puncture were consistent with an impact to an I-beam support post of the guardrail. The deformation of the load bar was consistent with contact to the W-beam. The disintegrated backlight glazing was captured in the concave profile of the W- beam between guardrail post 5 and 6. The reconstruction of the crash dynamics determined that the roof puncture had occurred from post 5, due to its location and orientation. The CDC of this impact was 00TPCW2.

Event Data Recorder

The 2012 Ford Escape 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 below the instrument stack and had EDR capabilities. Data was imaged from the EDR at the time of the SCI inspection using software version 16.4 of the Bosch CDR tool, via the diagnostic link connector and using the vehicle's residual 12-volt electrical power through the vehicle's electrical system. The imaged data was reported with software version 19.3.1, and is included at the end of this report as **Appendix B**.

The data 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. By definition, deployment events commanded the deployment of an air bag and became locked to memory, such that deployment event data could not be overwritten. The EDR could store up to two deployment events. Each event was characterized by the recording of the bi-directional velocity change and roll angle crash pulse data. The velocity change data was graphically displayed for 250 milliseconds and analyzed for 300 milliseconds after AE. The rollover data was graphically displayed for a total of 6 seconds, inclusive of 1 second prior to and 5 seconds after AE. A 5-second pre-crash buffer that described various vehicle performance parameters (including vehicle speed, accelerator pedal position, brake status, engine performance) was recorded for each event record. These performance parameters were recorded in 0.5-second intervals. Additionally, a 5-second pre-crash buffer of high frequency stability control data was also recorded. This high frequency data was recorded in 0.1-second intervals.

On the title page of the imaged data, the "Events Recovered" field indicated that the EDR had recognized and recorded a locked frontal, a locked side, and a locked rollover event. The locked frontal event was stored in the First Record of the data.

The locked side and rollover events were recorded in the second record of the EDR data set. Both records occurred on ignition cycle 16,880 and were completely recorded. The data was imaged on ignition cycle 16,888. The discrepancy in the ignition cycle count was attributable to the towing and salvage movement of the Ford post-crash. Data in both records indicated that the seat belt for the driver and front passenger were unbuckled. A data field in the second record

reported that the time between the recorded events was 2,000 milliseconds (2.0 seconds). The pre-crash data sets overlapped, and were consistent relative to the 2.0-second offset.

First Record: This record was a locked frontal event. An event-counter field in the data reported that this was the first recorded event. At the time of the event, the air bag warning lamp in the instrument cluster was "Off." There were no diagnostic trouble codes present. The SCI crash reconstruction determined that AE of this record was related to the sign post impact (Event 1). The maximum recorded longitudinal delta V was -4.77 km/h (-2.97 mph) at 241 milliseconds. The maximum lateral delta V was -3.47 km/h (-2.16 mph) at 236 milliseconds. A review of the respective data sets indicated that the decelerations of each crash pulse were still active and had not reached a plateau. The crash pulse appeared to have exceeded the 250 millisecond window of the recording. The following frontal air bag deployment times relative to AE were recorded:

Driver stage one:	583.0 milliseconds
Driver stage two:	733.0 milliseconds
Front passenger stage one:	583.0 milliseconds
Front passenger stage two:	613.0 milliseconds

The frontal air bag deployment times occurred a relatively long time after AE (approximately 600 milliseconds) and the deployment was commanded after the reported maximum delta V in an apparent elongated crash pulse. A time-distance reconstruction of the data determined that only approximately 0.3 seconds would have elapsed between the sign post impact (Event 1) and the guardrail end terminal impact (Event 2). It was apparent that the RCM assessed and recorded both of these closely spaced events in the EDR's First Record. In short, the sign post impact was the source of AE, but the frontal air bag deployment command was related to the guardrail impact. The delta V corresponding to the guardrail impact was not reported due to the limitations of the EDR. A speed change for the guardrail impact approximated by integrating the high-frequency stability control recorded by the EDR was -47 km/h (-29 mph).

Second Record: This record was a locked right-side impact and rollover event that resulted in the deployment of the front row right seat-mounted side impact air bag and both IC air bags. At the time of this record, the air bag warning lamp in the instrument cluster was "On" and there was one diagnostic trouble code related to the first record's frontal air bag deployment. The SCI crash reconstruction determined that AE of this record was related to the rollover dynamic of the vehicle.

The deployment times of the right-seat-mounted and IC air bags were 45.5 milliseconds after AE. The right plane impact to the ground was also recognized. The maximum recorded longitudinal delta V was 20.59 km/h (12.80 mph) at 300 milliseconds. The maximum lateral delta V was -14.02 km/h (-8.71 mph) at 300 milliseconds. The force direction of the recorded delta V was consistent with the SCI-reconstructed dynamics of the impact at the right D-pillar during the rollover.

The rollover crash pulse was reported as vehicle roll angle (in degrees) versus time (in seconds). This pulse depicted a two-quarter turn rollover (approximately -167 degrees) over a 2.5 second time period. After restitution of approximately 8 degrees, the pulse leveled off and plateaued for the remainder of the recording (approximately 3 seconds). The plateau in the rollover data (approximately -159 degrees) was an indicator that the Ford had reached a state of final rest on its roof.

SCI Reconstruction of EDR Data: The following table is a partial data set depicting the pre-crash time line, vehicle speed, and the Second Record stability control acceleration EDR data. The data in this table was analyzed to reconstruct the sequence of events in this crash. The entire tables are found on Pages 7, 16, and 17 of **Appendix B**. The pre-crash time lines relative to the individual records are displayed and reflect the 2.0-second offset between the EDR-recorded events.

The pre-crash data trends indicated that the Ford approached the crash site at a speed of 110.0 km/h (68.4 mph) 5 seconds prior to AE SCI Event 1. The crash sequence was initiated when the driver initiated an abrupt left steer to change from the right-most lane, crossing over one lane, in an attempt to travel on the left exit ramp of the interstate highway. Although the steering wheel angle data was not reported, the increasing magnitude of the lateral stability control acceleration data provided evidence of the maneuver. The change in the data parameters occurred approximately 2.6 seconds prior to AE of the first record. The sign post impact was the source of AE for the first record. A speed/time/distance calculation determined that the Ford was approximately 79 m (260 ft) south of the sign post impact. The speed of the Ford at AE (time 0.0) was 108.0 km/h (67.1 mph). A summary table of the Ford's pre-crash data can be found later in this technical report.

Impact forces displaced the sign post out of the vehicle's path as the Ford continued forward and struck the guardrail end terminal. The change in magnitude of the longitudinal stability control acceleration, approximately 0.3-seconds after AE, provided the evidence of the guardrail impact. This time interval was in agreement with a speed/time/distance calculation based on the impact speed at AE and the 9.1 m (30.0 ft) distance between the sign post and the end terminal.

Time (sec)		Vehicle Speed km/h (mph)	Stability Control Lateral Accel (g)	Stability Control Longitudinal Accel (g)	Stability Control Yaw Rate (deg/sec)	Stability Control Roll Rate (deg/sec)	SCI Reconstructed Crash and Vehicle Dynamics
First Record	Second Record						
-3.0	-5	110.0 (68.4)	0.024	-0.063	1.12	1.25	
-2.9	-4.9		0.03	-0.084	0.75	1.25	
-2.8	-4.8		0.055	-0.116	1.37	1.37	
-2.7	-4.7		0.044	-0.053	1.87	1	
-2.6	-4.6		0.103	-0.053	1.87	2	Approximate beginning of left steer maneuver – note increasing trends of lateral acceleration and yaw rate. Approx. 79 m (260 ft) south of the exit sign
-2.5	-4.5	110.0 (68.4)	0.1	-0.077	2.5	1.37	
-2.4	-4.4		0.109	-0.094	3.5	1.75	
-2.3	-4.3		0.156	-0.091	2.75	-0.12	
-2.2	-4.2		0.179	-0.072	3.12	0.37	
-2.1	-4.1		0.183	-0.098	3.75	0.5	
-2.0	-4	109 (67.7)	0.178	-0.091	4.25	1.12	
-1.9	-3.9		0.266	-0.113	5.75	5.25	
-1.8	-3.8		0.227	-0.065	7.25	3.62	
-1.7	-3.7		0.339	-0.091	6.75	0.37	
-1.6	-3.6		0.279	-0.096	5.62	-1	
-1.5	-3.5	110.0 (68.4)	0.303	-0.129	4.37	2	
-1.4	-3.4		0.257	-0.111	5	-0.12	
-1.3	-3.3		0.295	-0.125	5	4.37	
-1.2	-3.2		0.256	-0.084	7	9	
-1.1	-3.1		0.334	-0.118	9	13.75	
-1.0	-3	109 (67.7)	0.489	-0.129	11.5	14.37	
-0.9	-2.9		0.54	-0.149	13.25	5.5	
-0.8	-2.8		0.737	-0.142	13.25	-1	
-0.7	-2.7		0.689	-0.123	11.5	3	

Time (sec)		Vehicle Speed km/h (mph)	Stability Control Lateral Accel (g)	Stability Control Longitudinal Accel (g)	Stability Control Yaw Rate (deg/sec)	Stability Control Roll Rate (deg/sec)	SCI Reconstructed Crash and Vehicle Dynamics
First Record	Second Record						
-0.6	-2.6		0.636	-0.149	9.12	-1.12	
-0.5	-2.5	109 (67.7)	0.591	-0.129	7.37	-2.25	
-0.4	-2.4		0.659	-0.129	9.75	1.75	
-0.3	-2.3		0.619	-0.132	14	7.12	
-0.2	-2.2		0.593	-0.127	15.62	4.62	
-0.1	-2.1		0.566	-0.116	16.25	-6.12	
0.0	-2	108 (67.1)	0.354	0.106	14.37	18.75	AE SCI Event 1: sign post
0.1	-1.9		-0.24	-0.32	18.75	24.75	
0.2	-1.8		0.151	-0.442	12.62	-23.75	
0.3	-1.7		-1.976	-0.243	-2.62	-14.37	Approx. time of end terminal impact – note increased trend of longitudinal acceleration during impact and displacement of the end terminal. delta-V over this frame equates to approx. -47 km/h (-29 mph)
0.4	-1.6		-1.138	-0.958	-3.12	20.25	
0.5	-1.5	107.0 (66.5)	-0.37	-0.541	4.5	46.25	
0.6	-1.4		0.175	-0.723	6.12	12.37	
0.7	-1.3		0.795	-2	3	-23.37	
0.8	-1.2		-1.598	-2	18.75	0.12	
0.9	-1.1		0.412	-2	28.25	34.87	
1.0	-1	93.0 (57.8)	1.017	-2	12.12	25.5	
1.1	-0.9		-0.368	-2	12.75	-4.37	
1.2	-0.8		-0.046	-0.75	26.37	-35.25	Approximate time of the Ford's separation from the end terminal – note increasing trends of yaw rate and roll rate
1.3	-0.7		0.238	-0.346	33	-34	
1.4	-0.6		0.006	-0.373	39	-33.87	
1.5	-0.5	13.0 (8.1)	0.003	-0.417	45.62	-36.5	
.6	-0.4		-0.044	-0.437	52	-39.25	
1.7	-0.3		-0.071	-0.437	58	-40.87	
1.8	-0.2		-0.1	-0.417	65.5	-42.62	
1.9	-0.1		-0.092	-0.399	73	-44.25	
2.0	0	1.0 (0.6)	-0.096	-0.399	79.75	-46.75	AE SCI Event 4: Rollover

The Ford engaged and displaced the end terminal for a period of approximately 0.9-seconds, evidenced by the trend of the stability control longitudinal acceleration. As stated earlier, the approximate speed change during this time period was -47 km/h (-29 mph). As the vehicle decelerated over this time period, the Ford's linear momentum transferred to rotational momentum. These dynamics were reflected in the changing magnitude of the yaw and roll rates. The Ford separated from the end terminal and initiated the right-side-leading rollover (SCI Event 4), which was recognized as AE of the second record. The reader is encouraged to refer to the attached EDR data for further detail.

Interior Damage

The front row of the Ford's interior (**Figures 18** and **19**) sustained minimal damage, which consisted of air bag deployment and occupant contacts. There was no intrusion at these seat positions. The driver seat was adjusted fully rear and the seatback was upright. The horizontal distance from the seatback to the center hub of the steering wheel measured 61 cm (24.0 in). A 6 x 4 cm (2.5 x 1.5 in) scuff mark was observed on the headliner directly above the driver seat. This mark was consistent with contact to the headliner from the driver's head during the rollover. The front row right seat was also adjusted fully rear. This seatback was reclined 10 degrees aft of

vertical. The horizontal distance from the seatback to the vertical face of the instrument panel measured 84 cm (33.1 in). Above this seatback was a large-area scuff pattern that measured approximately 18 x 28 cm (7.1 x 11.0 in). This scuff pattern was most likely caused by the displaced front row right occupant during the rollover of the Ford.

The entire windshield was fractured due to the exterior forces of the crash events. Additionally, two distinct circular patterns, one at the upper left aspect forward the driver and one at the right upper aspect forward the front right occupant, were observed in the overall random fracture pattern of the laminate. These isolated contacts may have resulted from contact with the hands of the displaced occupants during the rollover. Post-crash blood evidence was noted to the center console and the police narrative reported that the hands of the front-right occupant were lacerated.

During the second-quarter turn of rollover, the I-beam support (post 5) penetrated the roof and headliner of the Ford above its unoccupied second row (**Figure 20** and **21**). The penetration was rectangular in shape, oriented laterally, and measured 15 x 48 cm (5.9 x 18.9 in).

Manual Restraint Systems

The Ford Escape was equipped with 3-point lap and shoulder seat belts for all seat positions. Each front seat belt system consisted of continuous-loop webbing, a sliding latch plate, an adjustable D-ring, and a buckle pretensioner. At the time of the SCI vehicle inspection, both front D-rings were adjusted to their lowest position. The driver's seat belt webbing retracted onto an emergency locking retractor (ELR), while the front right system used a switchable automatic locking retractor/ELR.

The initial observation of the driver seat belt system found the webbing stowed on the retractor. The retractor was operational. A comfort sleeve surrounded a portion of the webbing. Examination of the latch plate revealed

Figure 18. Left-front interior of the Ford.

Figure 19. Front-right interior image of the Ford.

Figure 20. Second-row interior view of the Ford and the puncture to the roof.

historical use evidence. However, there was no physical evidence of use during the crash. A flexible buckle stalk was attached to the inboard aspect of the seat frame and was equipped with a buckle pretensioner. The pretensioner was not actuated. Based on the inspection of the manual restraint, it was determined that this safety system was not in use at the time of the crash. Similarly, the front right seat belt was also stowed on its retractor at inspection. The retractor was operational. Examination of the seat belt hardware and webbing was unremarkable for crash-related physical evidence. The buckle pretensioner was not actuated. Based on the observations of the inspection, it was determined that the front right occupant was also unbelted at the time of the crash.

Figure 21. Oblique view of the Ford depicting the roof puncture.

Supplemental Restraint Systems

The Ford was equipped with Certified Advanced 208-Compliant air bags for the driver and front passenger front seat-mounted side impact air bags and dual-sensing IC air bags mounted above the headliner to the roof-side rails. During the crash sequence, the frontal air bags, front row right seat-mounted air bag, and both IC air bags deployed.

Figure 22. View of the Ford's deployed river air bag.

During the guardrail end terminal impact, the driver's frontal air bag deployed from its module located in the center hub of the steering wheel rim. In its deflated state, the driver air bag measured 48 cm (19.0 in) in diameter, was tethered by internal straps and was vented by two 5 cm (1.2 in) ports on the back side of the back in the 11 and 1 o'clock positions. There was no damage or evidence of occupant contact to the module cover flaps or the air bag. Examination of the deployed driver air bag (**Figure 22**) was unremarkable.

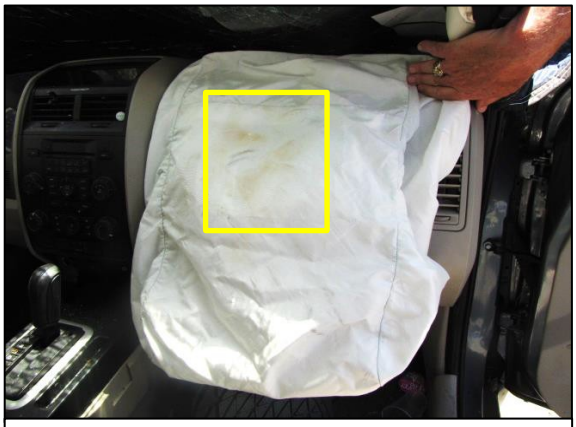


Figure 23. View depicting the make-up transfer to the face of the Ford's passenger frontal air bag.

The passenger's frontal air bag deployed from a mid-mounted module located in the right aspect of the instrument panel. The face of the air bag was rectangular and measured 36 x 61 cm (14.0 x 24.0 in), width by height, in its deployed state. The rearward excursion of the air bag was 56 cm (22.0 in). It was not tethered and was vented by two ports on the side panels of the bag. An 18 x 20 cm (7.0 x 8.0 in) make-up transfer was observed

on the air bag and was related to contact from the front-right occupant's face (**Figure 23**). In the make-up transfer were smaller transfers related to the occupant's eyebrows. A post-crash blood transfer was noted on the top surface/center aspect of the air bag.

Figure 24. Right-seat-mounted, side-impact air bag of the Ford.

The front-row, right-seat-mounted air bag deployed forward from the outer aspect of the seatback bolster. The air bag tore through the after-market seat cover as it inflated and expanded forward. The air bag was oblong in shape (**Figure 24**) and measured 25 x 20 cm (10.0 in x 8.0 in), length by height, in its deflated state. The bottom edge of the air bag measured 28 cm (11.0 in) above the seat bight. It was not tethered and was vented by a 3 cm (1.0 in) port on its outer surface. The air bag was devoid of occupant contact evidence.

Figure 25. Interior view of the Ford's left IC air bag at the driver's position.

The IC air bags deployed from the roof-side rails and extended 53 cm (21.0 in) downward. In their deflated states, the air bags extended approximately 8 cm (3.0 in) the They were tethered to the A-pillars by a 41 cm (16.0 in) strap. These air bags were rectangular in shape with a void in coverage along the rake angle of the A-pillar (**Figure 25**). The IC air bags measured 142 cm (56.0 in) in overall length. Each IC provided 46 cm (18.0 in) of longitudinal coverage forward of the B-pillar along the side glazing of the first row and 97 cm (38.0 in) of coverage along the second row glazing to the C-pillar area. There was no evidence of occupant contact to either IC air bag.

2012 FORD ESCAPE OCCUPANT DATA

Driver Demographics

Age/sex:	29 years/male
Height:	Unknown
Weight:	Unknown
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 system available
Usage source:	Vehicle inspection, EDR
Air bags:	CAC frontal, seat-mounted side-impact and IC air bags available; CAC frontal and IC air bags deployed
Alcohol/drug data:	BAC= .141 g/dL (medical record source)
Egress from vehicle:	Exited under own power
Transport from scene:	Ambulance to a local hospital
Type of medical treatment:	Admitted for 7 days

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1,2	C3-C4 spinal cord contusion	610202.2	Isolated IPC - Roof or convertible top	Probable
3	Bruising overlying left shoulder	710402.1	Isolated IPC - Roof or convertible top	Probable
4	Abrasion to forehead	210202.1	Isolated IPC Left air bag – Steering wheel hub	Probable

Source: hospital records.

Driver Kinematics

The 29-year-old male was seated in the driver's seat of the Ford with his seat adjusted to the full-rear track position. He did not use the vehicle's manual seat belt system. As the Ford traveled north in the right-most lane, the driver applied an aggressive left steering input in an attempt to take a left exit ramp from the interstate highway. The driver most likely moved to his right in response to the centrifugal force of the turn.

The Ford entered the gore area, traveled off the pavement, and the front right corner/fender area of the vehicle struck the support post of the road sign. The severity of this impact was insufficient to cause a kinematic response by the driver. The force of the impact displaced the sign post out of the vehicle's path as it continued to the north.

The front plane/center aspect of the Ford then struck the end terminal. The force of the crash caused the deployment of the vehicle's frontal air bags. The driver responded to the 12 o'clock direction of the impact by initiating a forward trajectory. He contacted the deployed air bag with his chest and face and began to ride down the force of the crash as the Ford displaced the end terminal along the guardrail. His left hand possibly struck and fractured the windshield.

During the displacement of the end terminal, the Ford rotated counterclockwise about its vertical axis and then tripped into a right-side leading rollover. It rolled two-quarter turns, and its roof struck the W-beam and post 5. This post penetrated the roof at the vehicle's second row.

During these dynamics, the unbelted driver was displaced from his seat in an uncontrolled manner. His head likely contacted the roof as the vehicle rolled to an inverted orientation. A scuff mark to the headliner provided evidence of the contact. The unbelted body mass of the driver loaded the anatomy of his neck which resulted in the cervical spine contusion at C3-C4. His left shoulder contacted the roof resulting in a contusion. The driver came to rest in an unknown orientation on the roof of the Ford. The medical records indicated that he was able to exit the vehicle under his own power, but he was not ambulatory at the scene. He was transported by ambulance to a local hospital and hospitalized for seven days.

Front-Row Right Occupant Demographics

Age/sex:	Unknown age/female
Height:	Unknown
Weight:	Unknown
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 system available
Usage source:	Vehicle inspection, EDR
Air bags:	CAC frontal, seat-mounted side-impact and IC air bags available; all deployed
Alcohol/drug data:	Unknown
Egress from vehicle:	Exited under own power
Transport from scene:	Ambulance to a local hospital
Type of medical treatment:	Treated and released

Front-Row Right Occupant Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Head contusion, NFS	110402.1	Isolated IPC - Roof or convertible top	Probable
2	Hand lacerations, NFS	710600.1	Isolated IPC Front - Windshield	Probable
3	Lip abrasions	210202.1	Isolated IPC Right air bag – Right top instrument panel	Certain

Source: police report.

Front-Row Right Occupant Kinematics

The adult female was seated in the front-row right position with her seat adjusted in the full-rear track position. She was not restrained by the vehicle's manual 3-point lap and shoulder seat belt. As the Ford traveled north in the right-most lane, its driver applied an aggressive left steering input in an attempt to take the left exit ramp from the interstate highway. This occupant initiated a right trajectory in response to the centrifugal force of the turn and possibly moved into contact with the door panel.

The Ford departed the roadway and entered the gore. The vehicle's right fender/forward aspect struck the support post of the road sign. The magnitude of the impact was insufficient to affect the kinematics of the occupant.

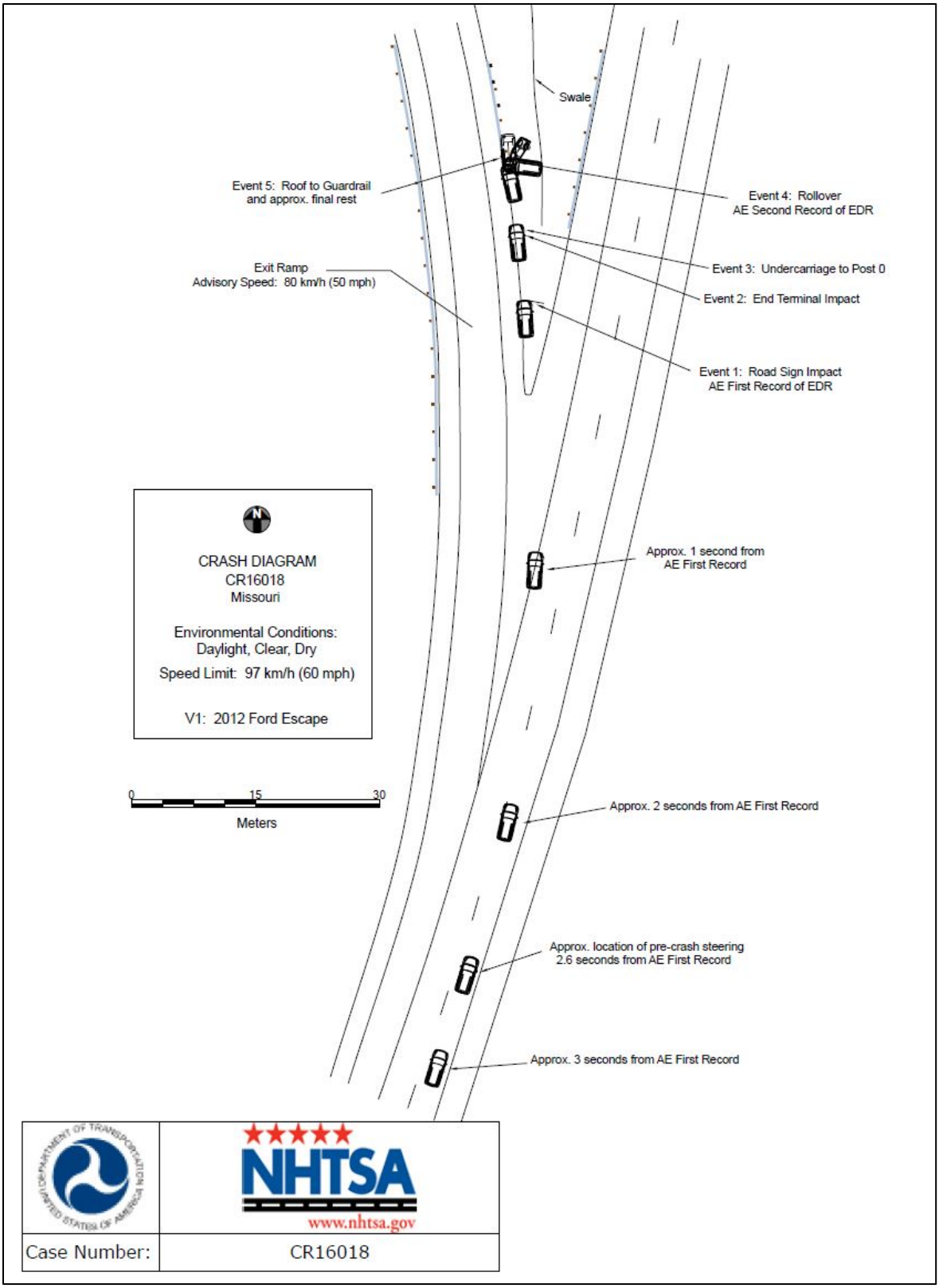
The front plane/center aspect of the Ford then struck the end terminal, resulting in the deployment of the frontal air bags. The front-row right occupant initiated a forward trajectory in response to the 12 o'clock direction of the impact. As the Ford displaced the end-treatment, she

contacted the deployed air bag and rode down the force of the impact. The make-up transfer to the air bag fabric evidenced this contact, which resulted in abrasions to her lips. Her right hand probably struck and fractured the windshield.

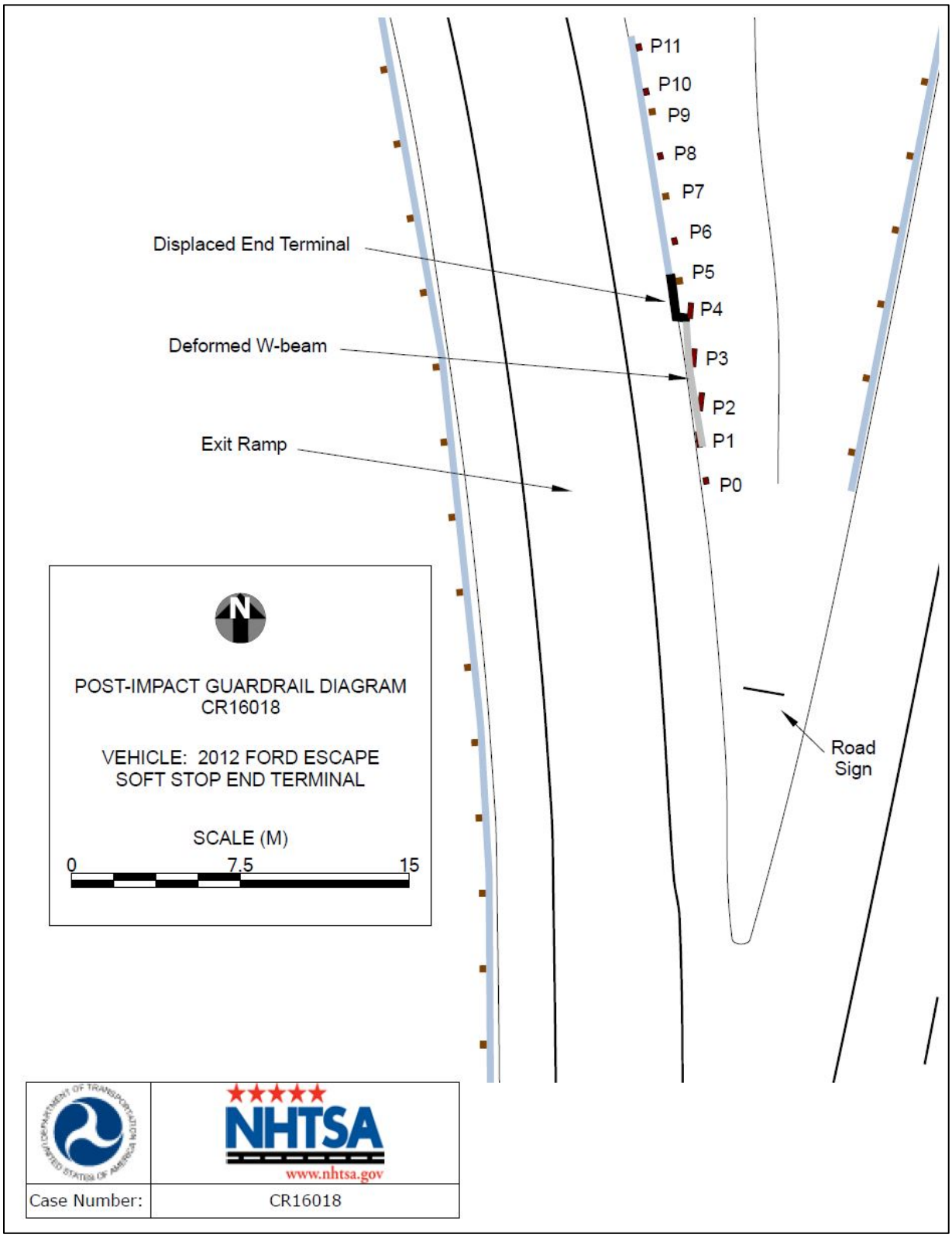
The vehicle maintained its counterclockwise rotation and tripped into a two-quarter turn, right-side-leading rollover. The unbelted occupant was displaced from her seat in an uncontrolled manner. Her head probably contacted the roof above her seat position, which may have resulted in a head contusion. This contact was evidenced by a scuff to the headliner. The occupant came to rest on the roof in an unknown orientation due to the inverted position of the vehicle.

According to the driver's medical records, the occupants were able to exit the vehicle under their own power and then waited for the responding police and EMS personnel. The front row right occupant was transported by ambulance to the hospital, where she was treated and released. The narrative of the police report described the investigating officer's interview of this occupant at the crash scene and the nature of her injuries; however, the report did not identify her name, age, or any contact information to facilitate a follow-up interview.

CRASH DIAGRAM



POST-CRASH GUARDRAIL DIAGRAM



APPENDIX A: Federal Highway Administration Guardrail Forms

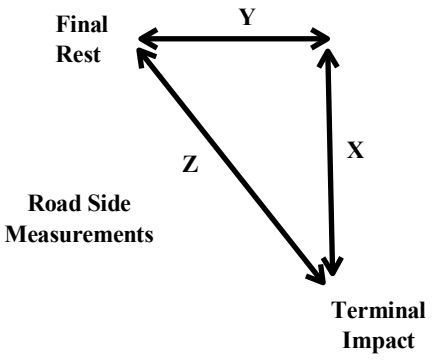
Case No.: CR16018

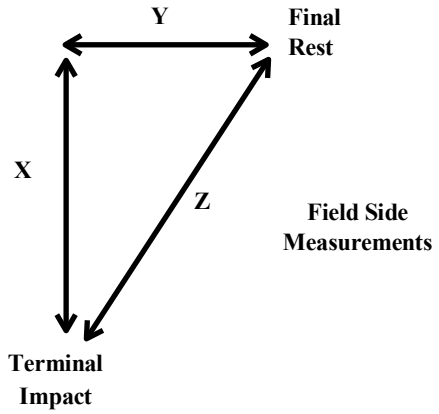
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	July 2016	**TIME OF CRASH (MILITARY)**	Afternoon
Case Number	CR16018	**State**	MO
Traffic Route	Interstate at exit ramp	**Direction (Southbound = SB)**	NB
Ambient Conditions (at time of crash)			
Temperature (°F)	80 °F	**Lighting**	Daylight
Atmospheric	Clear		

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 mph (EDR)
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 35.8 ft ☒Road side ❒Field Side
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 33.5 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 12.1 ft
Super elevation	❒+2% ☒-2% ❒ NONE or FLAT
Curve Radius (ft.)	820 ft

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: CR16018

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							

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	Steel	6 x 4	N/A	N/A	No	N/A	0 ft 8 in	N/A	5 ft 0 in
1	Steel	6 x 4	N/A	N/A	Unknown	N/A	0 ft 3 in	N/A	5 ft 5 in
2	Steel	6 x 4	Composite	7.5 x 4	Unknown	N/A	1 ft 0 in	N/A	6 ft 4 in

Case No.: CR16018

GUARDRAIL INSTALLATION									
Post No.	Post		Block-Out		Pre-Existing Damage		Offset to Post or Post Hole (ft.)		Spacing to Next Post (ft. -in.)
	Type Steel Wood Other	Dim. D x W (in.) or Dia. (in.)	Type Steel Wood Composite	Dim. D x W (in.)	Yes No Unknown	Describe	Travel Way	Curb	
3	Steel	6 x 4	Composite	7.5 x 4	Unknown	N/A	1 ft 1 in	N/A	6 ft 4 in
4	Steel	6 x 4	Composite	7.5 x 4	No	N/A	1 ft 0 in	N/A	5 ft 10 in
5	Steel	6 x 4	Composite	7.5 x 4	No	N/A	1 ft 0 in	N/A	6 ft 4 in
6	Steel	6 x 4	Composite	7.5 x 4	No	N/A	0 ft 11 in	N/A	6 ft 7 in
7	Steel	6 x 4	Composite	7.5 x 4	No	N/A	0 ft 9 in	N/A	5 ft 11 in
8	Steel	6 x 4	Composite	7.5 x 4	No	N/A	0 ft 9 in	N/A	6 ft 4 in

Case No.: CR16018

GUARDRAIL INSTALLATION									
Post No.	Post		Block-Out		Pre-Existing Damage		Offset to Post or Post Hole (ft.)		Spacing to Next Post (ft. -in.)
	Type Steel Wood Other	Dim. D x W (in.) or Dia. (in.)	Type Steel Wood Composite	Dim. D x W (in.)	Yes No Unknown	Describe	Travel Way	Curb	
9	Steel	6 x 4	Composite	7.5 x 4	No	N/A	0 ft 9 in	N/A	3 ft 2 in
10	Steel	6 x 4	Composite	7.5 x 4	No	N/A	0 ft 10 in	N/A	6 ft 7 in
11	Steel	6 x 4	Composite	7.5 x 4	No	N/A	0 ft 10 in	N/A	N/A
12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Additional Comments:
Two additional pre-existing impacts in guardrail system downstream from this crash, near post 35 and post 60.

Case No.: CR16018

EXTRUDER			
Feeder Channel Width at impact head	❒4inches ❒5 inches ☒Other 5.625”		
Guide Chute Exit Height (in.)	4.75 in		
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.)	26.3 ft
Rail Extrusion Direction	❒Traffic Side ❒Field Side ☒Soft Stop N/A		
Total Length of Rail Damaged (ft.) [total length would include extruded rail plus damaged rail downstream from head.]	**Total = 63.9 ft** *From Post 0 to Post 11*		

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

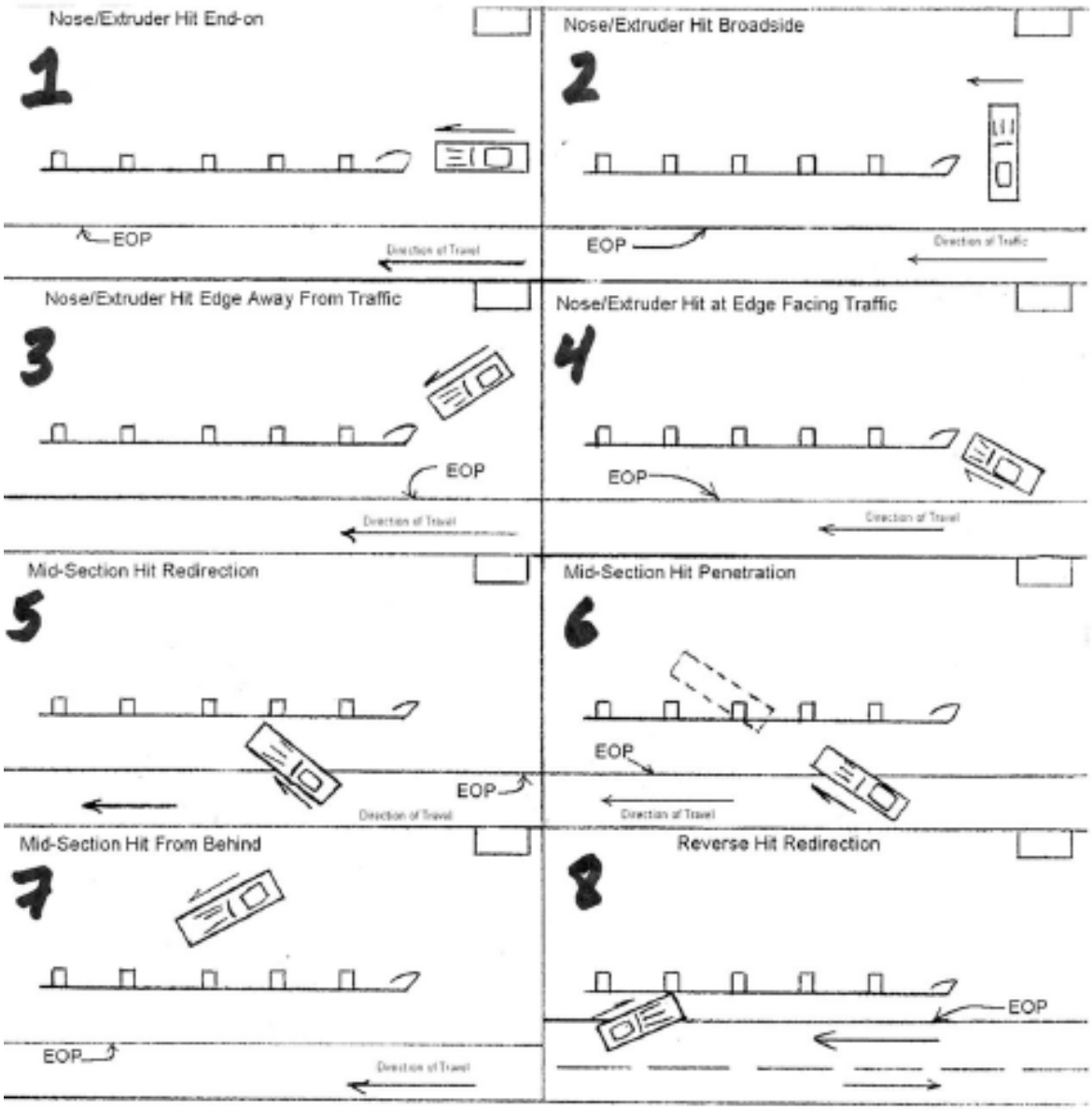
ALL-SYSTEM PERFORMANCE			
Railkinks Downstream of Head?	☒No	❒Yes;	No. of Kinks in Rail: N/A
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	❒No ☒Yes: Post 5/Roof		
Did vehicle impact other objects after impact with terminal?	☒No ❒Yes		
Object Contacted	N/A		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in Advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	0.0%	Unknown	Unknown
Adjacent Lane Width (ft)	17.4 ft		
Lane Type (NAS EDS Variable: Sur. Type)	Asphalt		
Shoulder Type	Concrete		
Shoulder Width (ft)	7.9 ft		
Guardrail Height (in)	30.5 in		

Case No.: CR16018

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	2012 Ford Escape	
Vehicle Identification Number (VIN)	1FMCU0C72CKxxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	3,289 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	N/A	
Collision Deformation Classification	Event 2: 12FCEN2	
Delta-V	25 mph	
Occupant Compartment Penetration of rail	❒ No	☒ Yes; Describe: Vehicle rotated ~180 degrees and rolled two quarter turns. Post 5 of guardrail impacted and penetrated roof. Roof impacted W-beam. Vehicle came to rest overturned on top of guardrail system.
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)	Impact to guardrail w/ counterclockwise rotation	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	Trip-Over (right side tires)	

Case No.: CR16018



APPENDIX B: 2012 Ford Escape Event Data Recorder Report[1]

[1] 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.

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	1FMCU0C72CK******
User	
Case Number	
EDR Data Imaging Date	07/07/2016
Crash Date	
Filename	CR16018_V1_ACM.CDRX
Saved on	Thursday, July 7 2016 at 12:13:24
Imaged with CDR version	Crash Data Retrieval Tool 16.4
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
ACM Adapter Detected During Download	No
Event(s) recovered	locked frontal event locked side event locked rollover 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 Thursday, July 7 2016 at 12:13:24.

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 two deployment events.

Airbag 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.
- Event Recording Complete will indicate if data from the recorded event has been fully written to the RCM memory or if it has been interrupted and not fully written.
- If power to the Airbag Module is lost during a crash event, all or part of the crash record may not be recorded.
- For 2011 Ford Mustangs, the Steering Wheel Angle parameter indicates the change in steering wheel angle from the previously recorded sample value and does not represent the actual steering wheel position.

Airbag 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.

02007_RCM-RC6_r002

System Status at Time of Retrieval

VIN as programmed into RCM at factory	1FMCU0C72CK******
Current VIN from PCM	1FMCU0C72CK******
Ignition cycle, download (first record)	16,888
Ignition cycle, download (second record)	16,888
Restraints Control Module Part Number	BL84-14B321-AD
Restraints Control Module Serial Number	7170937200000000
Restraints Control Module Software Part Number (Version)	BL84-14C028-AB
Left/Center Frontal Restraints Sensor Serial Number	148675CE
Left Side Restraint Sensor 1 Serial Number	1486AFEB
Left Side Restraint Sensor 2 Serial Number	148A88CB
Right Frontal Restraints Sensor Serial Number	14843F58
Right Side Restraint Sensor 1 Serial Number	14864FA6
Right Side Restraints Sensor 2 Serial Number	1487FAB3

System Status at Event (First Record)

Recording Status	Locked Record
Complete file recorded (yes,no)	Yes
Multi-event, number of events (1,2)	1
Time from event 1 to 2 (msec)	N/A
Lifetime Operating Timer at event time zero (seconds)	14,209,395
Key-on Timer at event time zero (seconds)	860
Vehicle voltage at time zero (Volts)	13.851
Energy Reserve Mode entered during event (Y/N)	No

Faults Present at Start of Event (First Record)

No Faults Recorded

Deployment Data (First Record)

Frontal airbag deployment, time to first stage deployment, driver (msec)	583.0
Frontal airbag deployment, time to 2nd stage, driver (msec)	733.0
Frontal airbag deployment, time to first stage deployment, front passenger (msec)	583.0
Frontal airbag deployment, time to 2nd stage, front passenger (msec)	613.0
Maximum delta-V, longitudinal (MPH [km/h])	-2.97 [-4.77]
Time, maximum delta-V longitudinal (msec)	241
Maximum delta-V, lateral (MPH [km/h])	-2.16 [-3.47]
Time, maximum delta-V lateral (msec)	236
Left or center front, satellite Sensor discriminating deployment	Yes
Left or center, front satellite Sensor safing	Yes
Right, front satellite sensor safing	Yes
RCM, front sensor discriminating deployment	Yes
RCM, front sensor safing	Yes
Longitudinal Delta-V Time Zero Offset	9.5 ms
Lateral Delta-V Time Zero Offset	9.5 ms
Roll Angle Time Zero Offset	69.5 ms

Pre-Crash Data -1 sec (First Record)

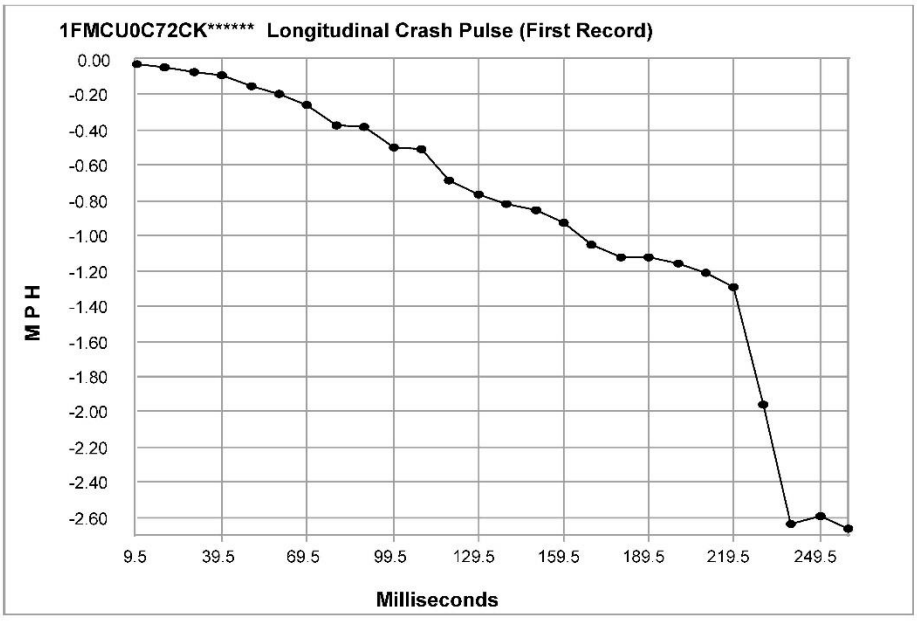
Ignition cycle, crash	16,880
Frontal air bag warning lamp, on/off	Off
Occupant size classification, front passenger (Child size Yes/No [Hex value])	No [$08]
Safety belt status, driver	Driver Not Buckled
Seat track position switch, foremost, status, driver	Not Forward
Safety belt status, front passenger	Passenger Not Buckled
Brake Telltale	Off
ABS Telltale	Off
Stability Control Telltale	Off
Speed Control Telltale	Off
Powertrain Wrench Telltale	Off
Powertrain Malfunction Indicator Lamp (MIL)Telltale	Off

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

Times (sec)	Speed vehicle indicated MPH [km/h]	Accelerator pedal, % full	Service brake, on/off	Engine RPM	ABS activity (engaged, non-engaged)	Stability control (engaged, non-engaged)	Traction Control via Brakes (engaged, non-engaged)	Traction Control via Engine (engaged, non-engaged)
- 5.0	68.4 [110.0]	0	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
- 4.5	69.0 [111.0]	7	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
- 4.0	68.4 [110.0]	7	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
- 3.5	68.4 [110.0]	7	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
- 3.0	68.4 [110.0]	8	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
- 2.5	68.4 [110.0]	8	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
- 2.0	67.7 [109.0]	5	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
- 1.5	68.4 [110.0]	0	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
- 1.0	67.7 [109.0]	0	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
- 0.5	67.7 [109.0]	0	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
0.0	67.1 [108.0]	0	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged

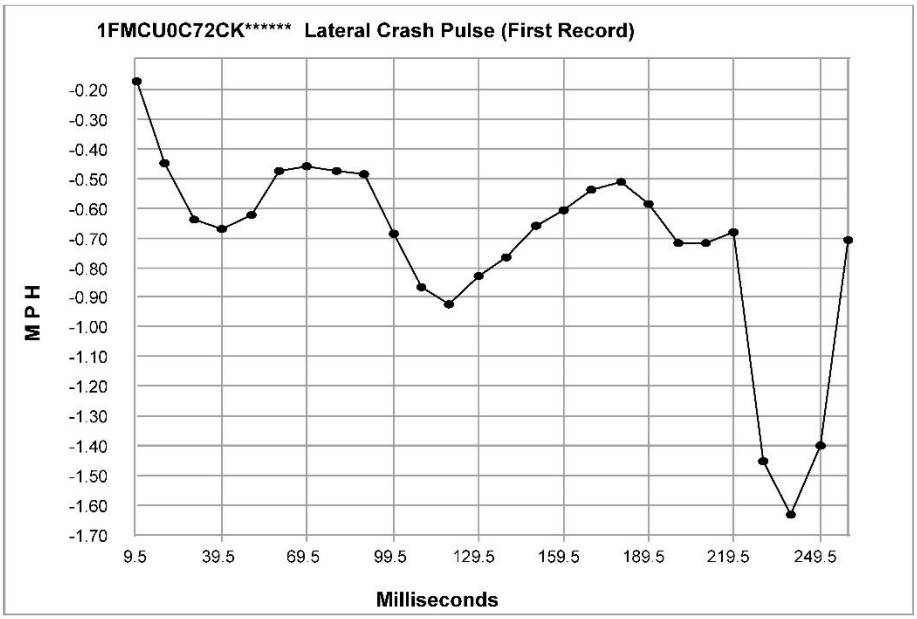
Pre-Crash Data -5 to 0 sec [10 samples/sec] (First Record)

Times (sec)	Steering Wheel Angle (degrees)	Stability Control Lateral Acceleration (g)	Stability Control Longitudinal Acceleration (g)	Stability Control Yaw Rate (deg/sec)	Stability Control Roll Rate (deg/sec)
- 5.0	Invalid	0.059	-0.06	1.37	0.5
- 4.9	Invalid	0.053	-0.072	1.62	0.87
- 4.8	Invalid	0.027	-0.096	0.87	0.75
- 4.7	Invalid	0.009	-0.072	1.0	-0.12
- 4.6	Invalid	0.024	-0.07	1.12	0.87
- 4.5	Invalid	-0.005	-0.072	1.5	1.0
- 4.4	Invalid	0.024	-0.072	1.62	1.5
- 4.3	Invalid	0.034	-0.098	1.0	2.37
- 4.2	Invalid	0.018	-0.072	1.75	1.25
- 4.1	Invalid	0.024	-0.072	1.0	1.0
- 4.0	Invalid	0.018	-0.091	1.25	1.0
- 3.9	Invalid	0.024	-0.091	1.37	0.87
- 3.8	Invalid	0.024	-0.065	1.5	1.12
- 3.7	Invalid	0.053	-0.055	1.5	0.87
- 3.6	Invalid	0.044	-0.072	1.62	0.75
- 3.5	Invalid	0.024	-0.091	1.25	1.12
- 3.4	Invalid	0.04	-0.072	1.25	1.12
- 3.3	Invalid	0.044	-0.067	1.37	0.0
- 3.2	Invalid	0.053	-0.091	1.25	0.75
- 3.1	Invalid	0.026	-0.091	1.37	0.75
- 3.0	Invalid	0.024	-0.063	1.12	1.25
- 2.9	Invalid	0.03	-0.084	0.75	1.25
- 2.8	Invalid	0.055	-0.116	1.37	1.37
- 2.7	Invalid	0.044	-0.053	1.87	1.0
- 2.6	Invalid	0.103	-0.053	1.87	2.0
- 2.5	Invalid	0.1	-0.077	2.5	1.37
- 2.4	Invalid	0.109	-0.094	3.5	1.75
- 2.3	Invalid	0.156	-0.091	2.75	-0.12
- 2.2	Invalid	0.179	-0.072	3.12	0.37
- 2.1	Invalid	0.183	-0.098	3.75	0.5
- 2.0	Invalid	0.178	-0.091	4.25	1.12
- 1.9	Invalid	0.266	-0.113	5.75	5.25
- 1.8	Invalid	0.227	-0.065	7.25	3.62
- 1.7	Invalid	0.339	-0.091	6.75	0.37
- 1.6	Invalid	0.279	-0.096	5.62	-1.0
- 1.5	Invalid	0.303	-0.129	4.37	2.0
- 1.4	Invalid	0.257	-0.111	5.0	-0.12
- 1.3	Invalid	0.295	-0.125	5.0	4.37
- 1.2	Invalid	0.256	-0.084	7.0	9.0
- 1.1	Invalid	0.334	-0.118	9.0	13.75
- 1.0	Invalid	0.489	-0.129	11.5	14.37
- 0.9	Invalid	0.54	-0.149	13.25	5.5
- 0.8	Invalid	0.737	-0.142	13.25	-1.0
- 0.7	Invalid	0.689	-0.123	11.5	3.0
- 0.6	Invalid	0.636	-0.149	9.12	-1.12
- 0.5	Invalid	0.591	-0.129	7.37	-2.25
- 0.4	Invalid	0.659	-0.129	9.75	1.75
- 0.3	Invalid	0.619	-0.132	14.0	7.12
- 0.2	Invalid	0.593	-0.127	15.62	4.62
- 0.1	Invalid	0.566	-0.116	16.25	-6.12
0.0	Invalid	0.354	0.106	14.37	18.75



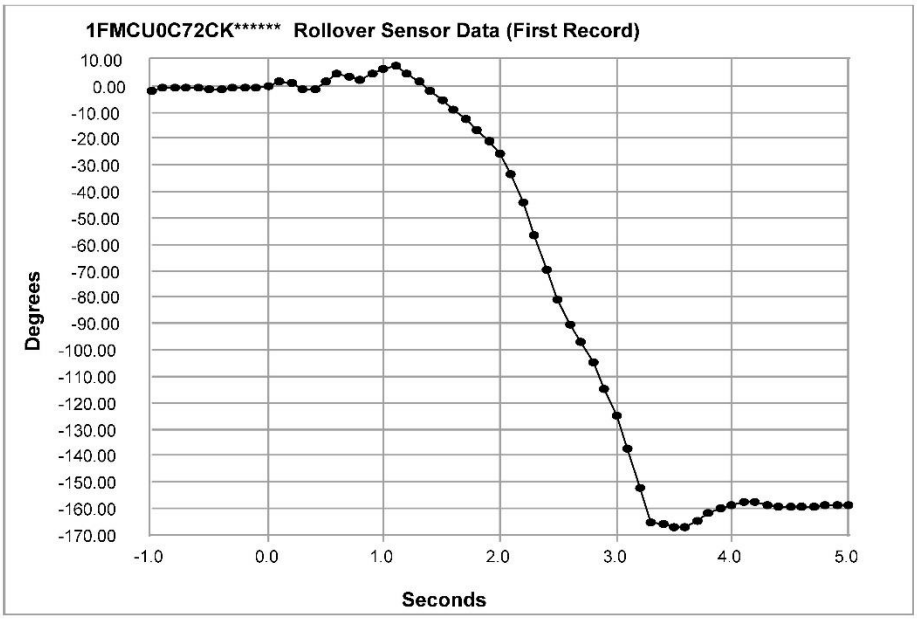
Longitudinal Crash Pulse (First Record)

Time (msec)	Delta-V, longitudinal (MPH)	Delta-V, longitudinal (km/h)
9.5	-0.03	-0.04
19.5	-0.04	-0.07
29.5	-0.07	-0.12
39.5	-0.09	-0.14
49.5	-0.15	-0.24
59.5	-0.20	-0.32
69.5	-0.26	-0.42
79.5	-0.38	-0.61
89.5	-0.38	-0.61
99.5	-0.50	-0.80
109.5	-0.51	-0.82
119.5	-0.69	-1.11
129.5	-0.77	-1.24
139.5	-0.82	-1.32
149.5	-0.86	-1.38
159.5	-0.93	-1.50
169.5	-1.05	-1.70
179.5	-1.13	-1.81
189.5	-1.12	-1.81
199.5	-1.16	-1.86
209.5	-1.21	-1.95
219.5	-1.29	-2.08
229.5	-1.96	-3.15
239.5	-2.64	-4.25
249.5	-2.60	-4.18
259.5	-2.66	-4.29



Lateral Crash Pulse (First Record)

Time (msec)	Delta-V, lateral (MPH)	Delta-V, lateral (km/h)
9.5	-0.17	-0.28
19.5	-0.45	-0.72
29.5	-0.64	-1.03
39.5	-0.67	-1.08
49.5	-0.62	-1.00
59.5	-0.48	-0.77
69.5	-0.46	-0.74
79.5	-0.47	-0.76
89.5	-0.49	-0.78
99.5	-0.69	-1.11
109.5	-0.86	-1.39
119.5	-0.92	-1.48
129.5	-0.83	-1.33
139.5	-0.76	-1.23
149.5	-0.66	-1.06
159.5	-0.61	-0.98
169.5	-0.54	-0.86
179.5	-0.51	-0.83
189.5	-0.59	-0.94
199.5	-0.72	-1.16
209.5	-0.72	-1.16
219.5	-0.68	-1.09
229.5	-1.45	-2.34
239.5	-1.63	-2.62
249.5	-1.40	-2.25
259.5	-0.71	-1.14



Rollover Sensor Data (First Record)

Time (sec)	Vehicle roll angle (degrees)
-1.0	-1.61
-0.9	-0.98
-0.8	-0.95
-0.7	-0.94
-0.6	-0.96
-0.5	-1.1
-0.4	-1.11
-0.3	-0.89
-0.2	-0.53
-0.1	-0.67
0.0	-0.32
0.1	1.68
0.2	1.08
0.3	-1.19
0.4	-1.42
0.5	1.51
0.6	4.56
0.7	3.22
0.8	2.03
0.9	4.73
1.0	6.56

Time (sec)	Vehicle roll angle (degrees)
1.1	7.6
1.2	4.68
1.3	1.51
1.4	-1.72
1.5	-5.19
1.6	-8.84
1.7	-12.73
1.8	-16.78
1.9	-21.0
2.0	-25.43
2.1	-33.26
2.2	-43.83
2.3	-56.27
2.4	-69.7
2.5	-80.93
2.6	-90.61
2.7	-96.69
2.8	-104.73
2.9	-114.78
3.0	-125.09
3.1	-137.38

Time (sec)	Vehicle roll angle (degrees)
3.2	-152.42
3.3	-165.38
3.4	-165.82
3.5	-166.9
3.6	-166.89
3.7	-164.6
3.8	-161.53
3.9	-159.87
4.0	-158.57
4.1	-157.49
4.2	-157.79
4.3	-158.56
4.4	-159.38
4.5	-159.6
4.6	-159.51
4.7	-159.19
4.8	-158.86
4.9	-158.75
5.0	-158.75

System Status at Event (Second Record)

Recording Status	Locked Record
Complete file recorded (yes,no)	Yes
Multi-event, number of events (1,2)	2
Time from event 1 to 2 (msec)	2,000
Lifetime Operating Timer at event time zero (seconds)	14,209,395
Key-on Timer at event time zero (seconds)	860
Vehicle voltage at time zero (Volts)	11.988
Energy Reserve Mode entered during event (Y/N)	No

Faults Present at Start of Event (Second Record)

B1193-00

Deployment Data (Second Record)

Side curtain airbag deployment, time to deploy, driver side (msec)	45.5
Side curtain airbag deployment, time to deploy, right side (msec)	45.5
Side (thorax) airbag deployment, time to deploy, right front passenger (msec)	45.5
Maximum delta-V, longitudinal (MPH [km/h])	12.80 [20.59]
Time, maximum delta-V longitudinal (msec)	300
Maximum delta-V, lateral (MPH [km/h])	-8.71 [-14.02]
Time, maximum delta-V lateral (msec)	300
Left, rear, side satellite sensor safing	Yes
Right, rear, side satellite sensor discriminating deployment	Yes
Right, rear, side satellite sensor safing	Yes
RCM, rollover sensor discriminating deployment	Yes
RCM, vertical sensor safing	Yes
Longitudinal Delta-V Time Zero Offset	7.5 ms
Lateral Delta-V Time Zero Offset	7.5 ms
Roll Angle Time Zero Offset	67.5 ms

Pre-Crash Data -1 sec (Second Record)

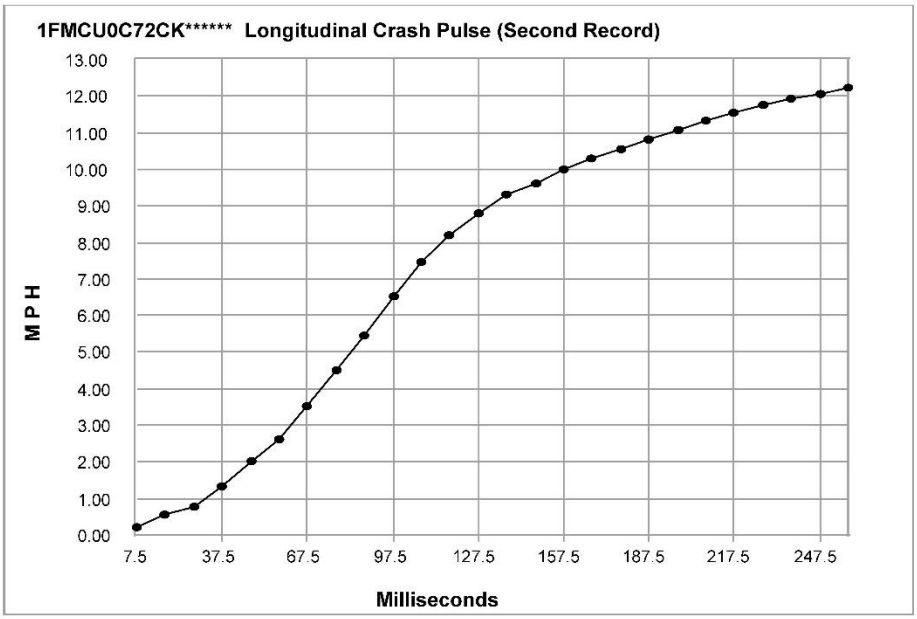
Ignition cycle, crash	16,880
Frontal air bag warning lamp, on/off	On
Occupant size classification, front passenger (Child size Yes/No [Hex value])	No [$04]
Safety belt status, driver	Driver Not Buckled
Seat track position switch, foremost, status, driver	Not Forward
Safety belt status, front passenger	Passenger Not Buckled
Brake Telltale	Off
ABS Telltale	Off
Stability Control Telltale	Flashing 2 Hz
Speed Control Telltale	Off
Powertrain Wrench Telltale	Off
Powertrain Malfunction Indicator Lamp (MIL)Telltale	Off

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

Times (sec)	Speed vehicle indicated MPH [km/h]	Accelerator pedal, % full	Service brake, on/off	Engine RPM	ABS activity (engaged, non-engaged)	Stability control (engaged, non-engaged)	Traction Control via Brakes (engaged, non-engaged)	Traction Control via Engine (engaged, non-engaged)
-5.0	68.4 [110.0]	8	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
-4.5	68.4 [110.0]	8	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
-4.0	67.7 [109.0]	5	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
-3.5	68.4 [110.0]	0	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
-3.0	67.7 [109.0]	0	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
-2.5	67.7 [109.0]	0	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
-2.0	67.1 [108.0]	0	Off	2,100	non-engaged	non-engaged	non-engaged	non-engaged
-1.5	66.5 [107.0]	0	Off	2,000	non-engaged	engaged	non-engaged	non-engaged
-1.0	57.8 [93.0]	0	Off	1,600	non-engaged	engaged	non-engaged	non-engaged
-0.5	8.1 [13.0]	0	On	0	engaged	engaged	non-engaged	non-engaged
0.0	0.6 [1.0]	N/A	Off	0	engaged	engaged	non-engaged	non-engaged

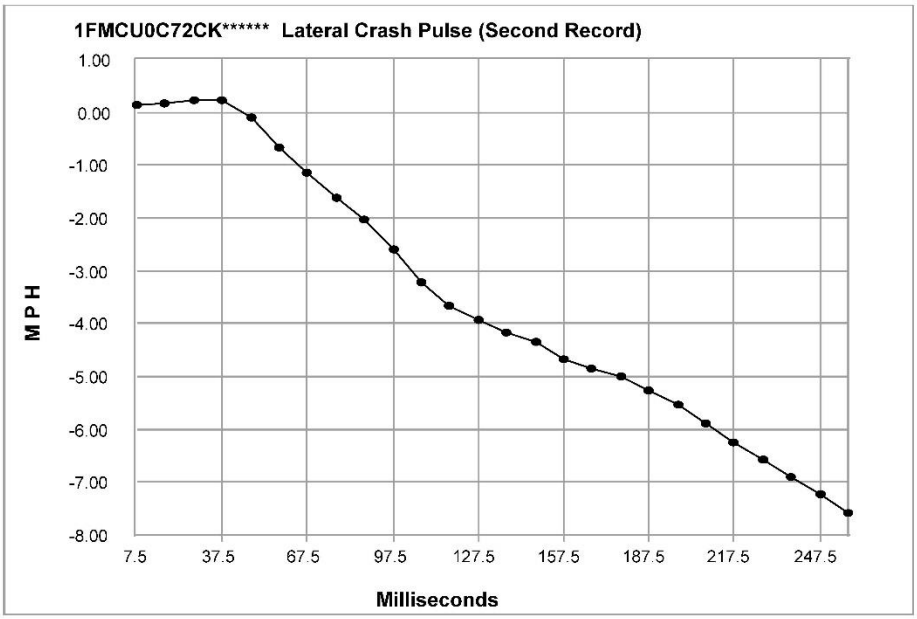
Pre-Crash Data -5 to 0 sec [10 samples/sec] (Second Record)

Times (sec)	Steering Wheel Angle (degrees)	Stability Control Lateral Acceleration (g)	Stability Control Longitudinal Acceleration (g)	Stability Control Yaw Rate (deg/sec)	Stability Control Roll Rate (deg/sec)
- 5.0	Invalid	0.024	-0.063	1.12	1.25
- 4.9	Invalid	0.03	-0.084	0.75	1.25
- 4.8	Invalid	0.055	-0.116	1.37	1.37
- 4.7	Invalid	0.044	-0.053	1.87	1.0
- 4.6	Invalid	0.103	-0.053	1.87	2.0
- 4.5	Invalid	0.1	-0.077	2.5	1.37
- 4.4	Invalid	0.109	-0.094	3.5	1.75
- 4.3	Invalid	0.156	-0.091	2.75	-0.12
- 4.2	Invalid	0.179	-0.072	3.12	0.37
- 4.1	Invalid	0.183	-0.098	3.75	0.5
- 4.0	Invalid	0.178	-0.091	4.25	1.12
- 3.9	Invalid	0.266	-0.113	5.75	5.25
- 3.8	Invalid	0.227	-0.065	7.25	3.62
- 3.7	Invalid	0.339	-0.091	6.75	0.37
- 3.6	Invalid	0.279	-0.096	5.62	-1.0
- 3.5	Invalid	0.303	-0.129	4.37	2.0
- 3.4	Invalid	0.257	-0.111	5.0	-0.12
- 3.3	Invalid	0.295	-0.125	5.0	4.37
- 3.2	Invalid	0.256	-0.084	7.0	9.0
- 3.1	Invalid	0.334	-0.118	9.0	13.75
- 3.0	Invalid	0.489	-0.129	11.5	14.37
- 2.9	Invalid	0.54	-0.149	13.25	5.5
- 2.8	Invalid	0.737	-0.142	13.25	-1.0
- 2.7	Invalid	0.689	-0.123	11.5	3.0
- 2.6	Invalid	0.636	-0.149	9.12	-1.12
- 2.5	Invalid	0.591	-0.129	7.37	-2.25
- 2.4	Invalid	0.659	-0.129	9.75	1.75
- 2.3	Invalid	0.619	-0.132	14.0	7.12
- 2.2	Invalid	0.593	-0.127	15.62	4.62
- 2.1	Invalid	0.566	-0.116	16.25	-6.12
- 2.0	Invalid	0.354	0.106	14.37	18.75
- 1.9	Invalid	-0.24	-0.32	18.75	24.75
- 1.8	Invalid	0.151	-0.442	12.62	-23.75
- 1.7	Invalid	-1.976	-0.243	-2.62	-14.37
- 1.6	Invalid	-1.138	-0.958	-3.12	20.25
- 1.5	Invalid	-0.37	-0.541	4.5	46.25
- 1.4	Invalid	0.175	-0.723	6.12	12.37
- 1.3	Invalid	0.795	-2.0	3.0	-23.37
- 1.2	Invalid	-1.598	-2.0	18.75	0.12
- 1.1	Invalid	0.412	-2.0	28.25	34.87
- 1.0	Invalid	1.017	-2.0	12.12	25.5
- 0.9	Invalid	-0.368	-2.0	12.75	-4.37
- 0.8	Invalid	-0.046	-0.75	26.37	-35.25
- 0.7	Invalid	0.238	-0.346	33.0	-34.0
- 0.6	Invalid	0.006	-0.373	39.0	-33.87
- 0.5	Invalid	0.003	-0.417	45.62	-36.5
- 0.4	Invalid	-0.044	-0.437	52.0	-39.25
- 0.3	Invalid	-0.071	-0.437	58.0	-40.87
- 0.2	Invalid	-0.1	-0.417	65.5	-42.62
- 0.1	Invalid	-0.092	-0.399	73.0	-44.25
0.0	Invalid	-0.096	-0.399	79.75	-46.75



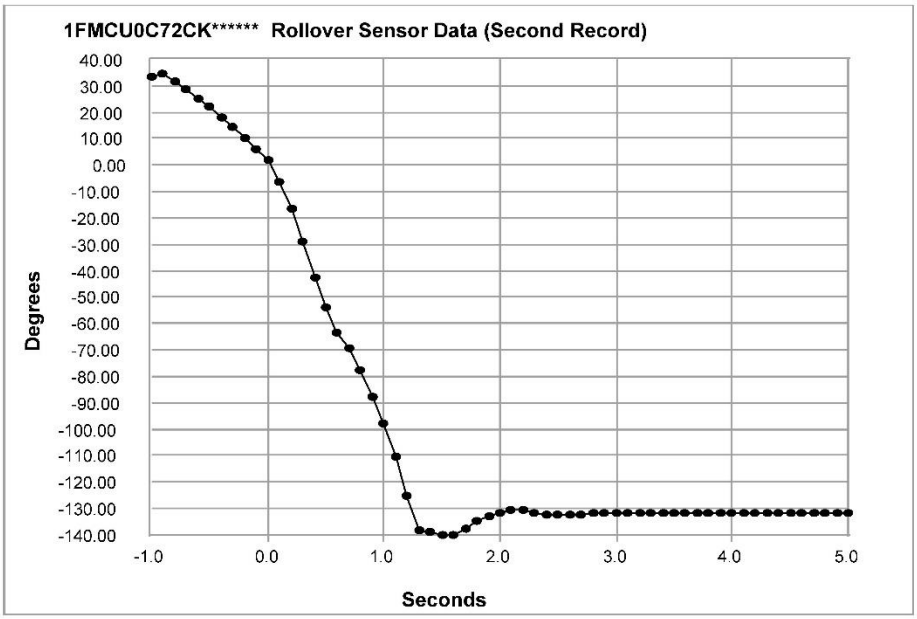
Longitudinal Crash Pulse (Second Record)

Time (msec)	Delta-V, longitudinal (MPH)	Delta-V, longitudinal (km/h)
7.5	0.21	0.33
17.5	0.54	0.87
27.5	0.76	1.23
37.5	1.33	2.13
47.5	2.04	3.28
57.5	2.61	4.20
67.5	3.52	5.67
77.5	4.50	7.23
87.5	5.43	8.74
97.5	6.51	10.48
107.5	7.47	12.02
117.5	8.19	13.18
127.5	8.80	14.16
137.5	9.32	15.00
147.5	9.62	15.47
157.5	10.00	16.10
167.5	10.30	16.58
177.5	10.56	16.99
187.5	10.82	17.42
197.5	11.06	17.81
207.5	11.31	18.21
217.5	11.54	18.57
227.5	11.74	18.89
237.5	11.91	19.16
247.5	12.07	19.42
257.5	12.21	19.66



Lateral Crash Pulse (Second Record)

Time (msec)	Delta-V, lateral (MPH)	Delta-V, lateral (km/h)
7.5	0.13	0.21
17.5	0.18	0.29
27.5	0.23	0.37
37.5	0.23	0.37
47.5	-0.09	-0.15
57.5	-0.67	-1.08
67.5	-1.14	-1.84
77.5	-1.63	-2.62
87.5	-2.03	-3.26
97.5	-2.60	-4.18
107.5	-3.22	-5.18
117.5	-3.67	-5.91
127.5	-3.93	-6.33
137.5	-4.16	-6.69
147.5	-4.36	-7.02
157.5	-4.66	-7.50
167.5	-4.86	-7.83
177.5	-5.01	-8.07
187.5	-5.26	-8.47
197.5	-5.54	-8.92
207.5	-5.90	-9.50
217.5	-6.25	-10.06
227.5	-6.57	-10.57
237.5	-6.90	-11.11
247.5	-7.24	-11.64
257.5	-7.59	-12.21



Rollover Sensor Data (Second Record)

Time (sec)	Vehicle roll angle (degrees)
-1.0	33.69
-0.9	34.73
-0.8	31.81
-0.7	28.64
-0.6	25.41
-0.5	21.94
-0.4	18.29
-0.3	14.4
-0.2	10.35
-0.1	6.13
0.0	1.7
0.1	-6.13
0.2	-16.7
0.3	-29.14
0.4	-42.57
0.5	-53.8
0.6	-63.48
0.7	-69.56
0.8	-77.6
0.9	-87.65
1.0	-97.96
1.1	-110.25
1.2	-125.29
1.3	-138.25
1.4	-138.69
1.5	-139.77
1.6	-139.76
1.7	-137.47
1.8	-134.4
1.9	-132.74
2.0	-131.44
2.1	-130.36
2.2	-130.66
2.3	-131.43
2.4	-132.25
2.5	-132.47
2.6	-132.38
2.7	-132.06
2.8	-131.73
2.9	-131.62
3.0	-131.62
3.1	-131.68
3.2	-131.68
3.3	-131.66
3.4	-131.53
3.5	-131.45
3.6	-131.45
3.7	-131.45
3.8	-131.45
3.9	-131.45
4.0	-131.43
4.1	-131.42
4.2	-131.42
4.3	-131.42
4.4	-131.42
4.5	-131.41
4.6	-131.41
4.7	-131.41
4.8	-131.41
4.9	-131.41
5.0	-131.41

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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Event Record 1

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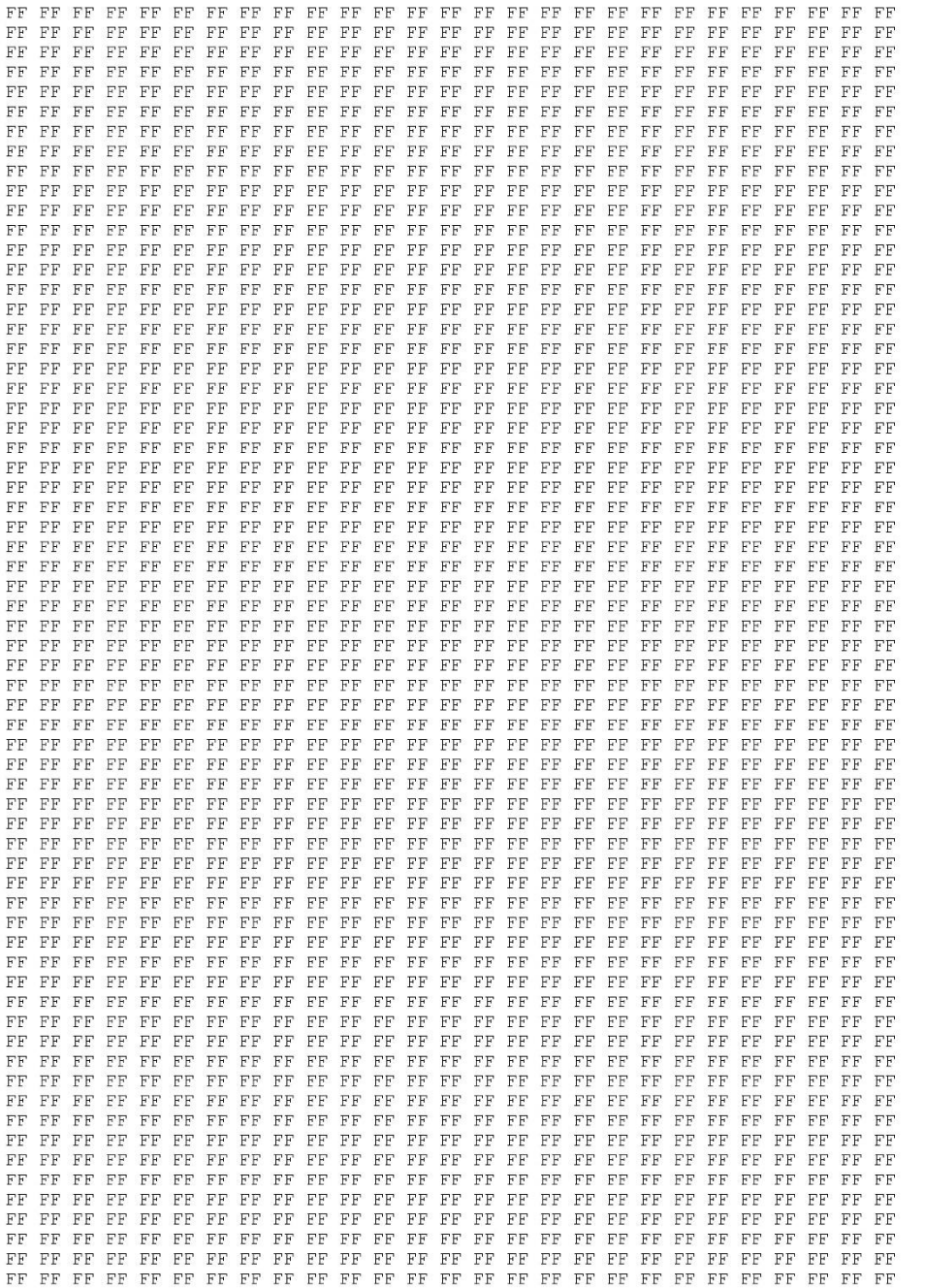

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Event Record 2

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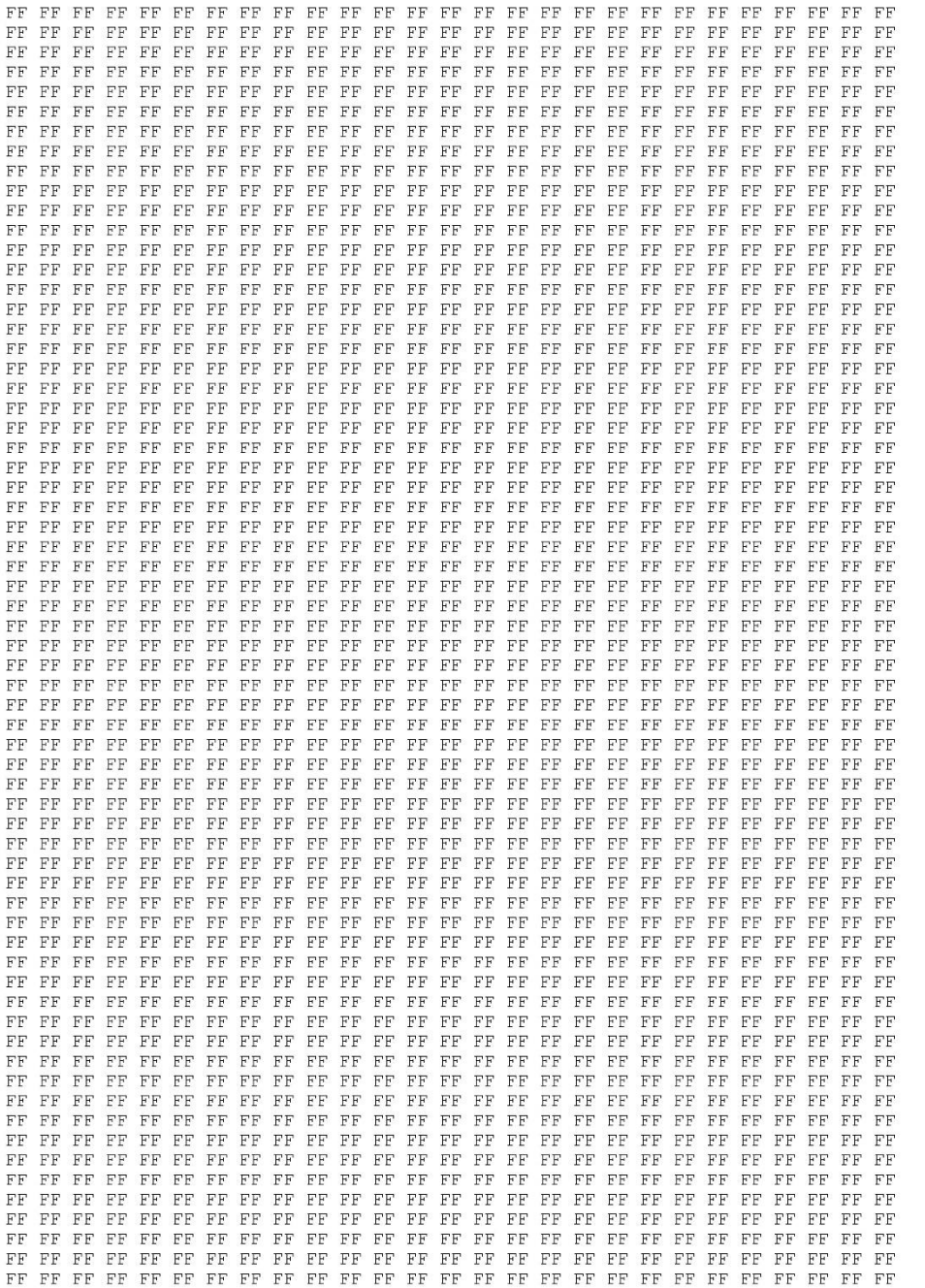

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**National Highway
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