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Special Crash Investigations On-Site Guardrail End Terminal Crash Investigation Vehicle: 2003 Ford Focus Location: Missouri Crash Date: March 2017

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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 passenger car impact to an ET-2000 guardrail end terminal that is of interest to the Federal Highway Administration (FHWA). This crash occurred in an interchange on the south side of the eastbound lanes of a four-lane, divided, interstate highway. The Ford Focus was a 4-door sedan equipped with dual-stage frontal air bags. The vehicle was not equipped with an event data recorder (EDR) supported by a commercially available tool. A belted 17-year-old female driver, belted 18-year-old male front row passenger, unbelted 17-year-old female second row left passenger, and unbelted 17-year-old female second row right passenger occupied the vehicle. The Ford was traveling southeast in the left eastbound through lane. The driver told police she lost control of the vehicle on the wet roadway as she was changing lanes to the right through lane. The vehicle departed the south side of the road in a clockwise yaw and the left plane struck the end terminal (Event 1). The vehicle rotated counterclockwise (counterclockwise) from the impact, crossed a ditch, then rolled over (Event 2), right side leading, two quarter turns, coming to final rest on its top plane heading northwest. The two unbelted second row passengers were ejected through the disintegrated backlight during the rollover. The driver and second row right passenger sustained police reported “B” (non- incapacitating) injuries. The front row right and second row left passengers sustained “C” (possible) and “A” (incapacitating) injuries, respectively. All the occupants were transported by ambulance to a trauma center. The Ford was towed from the crash scene due to damage.

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On-Site Guardrail End Treatment Investigation
Case Number: IN17018
Location: Missouri
Vehicle: 2003 Ford Focus
Crash Date: May 2017

BACKGROUND

This report documents the on-site investigation of a passenger car impact to an ET-2000 guardrail end terminal (**Figure 1**) that is of interest to the Federal Highway Administration (FHWA). This crash was identified by an engineer with the Missouri Department of Transportation, who submitted information about the crash and the involved guardrail end terminal to the FHWA. The FHWA determined that the guardrail end terminal and crash type were of interest. This crash investigation was then initiated by the National Highway Traffic Safety Administration on May 2017 and assigned to the Special Crash Investigation team at the Indiana University Transportation Research Center. This single-vehicle crash involved a 2003 Ford Focus (**Figure 2**). The crash occurred in Missouri in April 2017 during the morning and was investigated by a local police agency. The guardrail, crash scene, and vehicle were inspected and the investigating police officer interviewed in May 2017. A telephone interview was conducted with the driver in June 2017.

Figure 1. The damaged end terminal and guardrail, view southeast.

Figure 2. The damaged 2003 Ford Focus.

This crash occurred in an interchange on the south side of the eastbound lanes of a four-lane, divided, interstate highway. The Ford was a 4 -door sedan equipped with dual-stage frontal air bags. The vehicle was not equipped with an event data recorder (EDR) supported by a commercially available tool. A belted 17-year-old female driver, belted 18-year-old male front row passenger, unbelted 17-year-old female second row left passenger, and unbelted 17-year-old female second row right passenger occupied the vehicle. The Ford was traveling southeast in the left eastbound through lane. The driver told police that she lost control of the vehicle on the wet roadway as she was changing lanes to the right through lane. The vehicle departed the south side of the road in a clockwise yaw and the left plane struck the end terminal (Event 1). The vehicle rotated counterclockwise from the impact, crossed a ditch, then rolled over (Event 2), right side leading, two quarter turns, coming to final rest on its top plane heading northwest. The two

unbelted second row passengers were ejected through the disintegrated backlight during the rollover. The driver and second row right passenger sustained police reported "B" (non-incapacitating) injuries. The front row right and second row left passengers sustained "C" (possible) and "A" (incapacitating) injuries, respectively. All the occupants were transported by ambulance to a trauma center. The Ford was towed from the crash scene due to damage.

SUMMARY

Crash Site

This crash occurred during daylight hours in an interchange area on the south side of the southeastbound lanes of a four-lane, divided, interstate highway. The weather conditions were rain with clear visibility, southeast winds at 19 km/h (15 mph), a temperature of 11.7 °C (53 °F), and a dew point of 11.1 °C (52 °F), according to local weather reports. The interstate highway was curved and traversed in a slightly northwest/southeast direction and had two concrete through lanes in each direction that were divided by a grass median. The roadways were bordered by 1.3 m (4.3 ft) wide concrete median shoulders and 2.6 m (8.5 ft) wide concrete outside shoulders. The right eastbound lane was 4.3 m (14.1 ft) wide and the left eastbound lane was 3.3 m (10.8 ft) wide. A blocked-out W-beam guardrail equipped with an ET-2000 end treatment was located on the right side of the road adjacent to the shoulder. The guardrail was protecting the approach to the concrete support pillars of an overpass. The grade for southeastbound traffic was +3 percent. The calculated radius of curvature of the roadway was 1,134 m (3,719.5 ft). The speed limit was 97 km/h (60 mph). The crash diagram is included at the end of this report.

Figure 3. Police photo showing southeast approach of the Ford to impact with the ET-2000.

Pre-Crash

The Ford was traveling east in the left eastbound lane during rainy conditions. The driver told police that as she was changing lanes to the right through lane, the vehicle began to "hydroplane" on the wet roadway and she lost control of the vehicle. The tire mark evidence documented on the right shoulder during the SCI crash scene inspection showed that the vehicle was in a clockwise yaw as it approached impact with the end terminal (**Figure 3**). The tire mark evidence showed that the vehicle was rotated clockwise 150 degrees from its original heading on the roadway as it approached impact with the end terminal.

Figure 4. Left plane damage to the Ford from impact with the ET-2000.

Crash

The left plane of the Ford (**Figure 4**) struck the end terminal (**Figure 5**, Event 1). The impact speed is not known. The force direction on the vehicle was in the 8 o'clock sector and neither frontal air bag deployed. WinSMASH could not be used to calculate delta V since an impact with a yielding object is out-of-scope for the program. However, WinSMASH was used to calculate a barrier equivalent speed (BES) of 29 km/h (18 mph) based on the damage to the left plane. The impact damaged 7.6 m (25 ft) of guardrail and three posts.

Figure 5. Face of the ET-2000.

The impact with the end terminal occurred to the left rear door, which crushed the door 81 cm (31.9 in) into the second seating row and pulled the striker from its C-pillar mount. The vehicle rotated counterclockwise and separated from the end terminal. The vehicle traveled approximately 9 m (30 ft) in a southeast direction from this impact and was rotated counterclockwise about the longitudinal axis less than 90 degrees. The damage to the left rear wheel, left rear door, and left rear quarter panel was moderate (**Figure 6**). Gray plastic fragments from the vehicle's taillight housing and black plastic fragments from the rear bumper fascia bracket were located in and around the divots (**Figures 7** and **8**). The rapid counterclockwise rotation likely resulted in the ejection of the second row left and second row right occupants. The vehicle's right rear wheel then furrowed into the ground and the vehicle rolled over, right side leading. This was evidenced by the mud and grass in the right rear wheel and a second series of divots in the ground on the back slope of the ditch (**Figure 7**). The vehicle rolled over two quarter turns a distance of approximately 6 m (20 ft), coming to final rest on its top plane heading northwest. The two unbelted second row occupants were ejected from the vehicle through the disintegrated backlight during the crash. They came to final rest approximately 11 m (36 ft) south of the final rest position of the Ford based on the police crash schematic.

Figure 6. Police on-scene photo showing damage to the Ford's left rear wheel and quarter panel from ET-2000 impact.

Figure 7. Police on-scene photo showing divots from the Ford's rollover point, view southeast.

Post-Crash

The driver and front row passenger exited the vehicle without assistance through the right front window. The police were notified of the crash and arrived on scene six minutes after being notified. The police took photographs of the crash scene and marked the crash induced physical evidence. The driver and second row right passenger sustained police reported "B" (non-incapacitating) injuries. The front row right and second row left passengers sustained "C" (possible) and "A" (incapacitating) injuries, respectively. All the occupants were transported by ambulances to a hospital. The driver, front row right, and second row right occupants were treated in the emergency room for minor injuries and released. The second row left occupant was hospitalized for two weeks. The vehicle was towed from the crash scene due to damage.

Figure 8. Close view of divots shown in Fig. 7.

END TERMINAL AND GUARDRAIL DAMAGE

Figure 9. Guardrail extruded to field side from end terminal.

The left plane impact of the Ford to the end terminal extruded 2.5 m (8.2 ft) of guardrail to the field side (**Figure 9**) and damaged 7.6 m (25 ft) of guardrail and three posts. The direct damage involved the full width and height [51 cm (20.0 in) and 51 cm (20.0 in)] of the face of the ET-2000. Posts 1 and 2, and the posts and offset blocks for posts 3 - 7 were constructed of the wood. Posts 8 - 12 were constructed of steel and their offset blocks were constructed of wood. Posts 1 and 2 were fractured and displaced from the ground. Post 3 was damaged and displaced approximately 15 degrees off vertical in the downstream direction. The offset block was fractured and the rail bolt bent but remained attached to the post. Post 4 was not damaged or displaced; however, the rail bolt was pulled through the guardrail and the guardrail was slightly bent. The remaining posts were undamaged. Post 5 was not bolted to the guardrail during installation and the offset block and post were tightly bolted together by the rail bolt. The offset blocks at posts 7 and 8, and 10 - 12 were rotated off vertical in the downstream direction at various angles ranging from 10 to 80 degrees. This probably occurred during installation. The offset block at post 11 had minor damage that appeared to be related to installation. The guardrail sustained one kink, which was located at post 3. The width of the feeder channel was 12.7 cm (5.0 in) and the guide chute exit height was 39.4 cm (15.5 in). The connection of the feeder channel to the head was not damaged and no welds were broken. The anchor cable was present but disconnected from its anchor and was found between posts 3 and 4 at the SCI scene inspection. The FHWA In-Service End Treatment Evaluation Data Collection Form is attached to the end of this report as **Appendix A**.

2003 FORD FOCUS

Description

The Ford was a front-wheel-drive, 5-occupant, 4-door sedan with the Vehicle Identification Number 1FAFP34PX3Wxxxxxx that was manufactured in March 2003. The vehicle was equipped with a 2.0-liter, I-4 engine, 4-speed automatic transmission, front disc and rear drum brakes with electronic brake force distribution, and advanced dual-stage frontal air bags. The specified wheelbase was 262 cm (103.1 in).

The vehicle manufacturer's recommended tire size was P195/60R15. The vehicle was equipped with Douglas All Season tires of the recommended size on the front wheels and Achilles tires of the recommended size on the rear wheels. The manufacturer's recommended cold tire pressure for the front and rear tires was 220 kPa (32 psi). The front tires were in good condition. The tire tread on the rear tires was in poor condition and was 2 mm (2/32 in) in depth on the left rear and 3 mm (2/32) on the right rear.

The front row was equipped with driver and passenger cloth-covered bucket seats with adjustable head restraints. The second row was equipped with a cloth-covered bench seat with folding backs and no head restraints. The driver's seat track was adjusted between the forward-most and middle positions and the seat back was upright. The front row passenger's seat track was adjusted between the middle and rear-most positions. The recline position of the seat back at the time of the crash is not known. The second-row seat was not adjustable.

Exterior Damage

Exterior Damage Event 1

The Ford sustained damage to the left plane during the impact with the end terminal. The imprint of the face of the end terminal was stamped in the sheet metal of the left rear door. The direct damage began 150 cm (59.1 in) rear of the left front axle and extended 173 cm (68.1 in) rearward on the left plane. The Field L was 173 cm (68.1 in). Crush measurements were taken at the mid-door level and on the sill. The maximum residual crush occurred at the mid-door level was 49 cm (19.3 in) occurring 75 cm (29.5 in) forward of the left rear axle. The crush values at the two levels were averaged since there was a separation of the striker. The averaged crush values were C_1 = 5 cm (2.0 in), C_2 = 11 cm (4.3 in), C_3 = 16 cm (6.3 in), C_4 = 18 cm (7.1 in), C_5 = 36 cm (14.2 in), and C_6 = 8 cm (3.1 in).

Damage Classification Event 1

The Collision Deformation Classification (CDC) was 08LZAW3 (240 degrees).

Exterior Damage Event 2

Damage from the rollover involved the right and top planes. The direct damage on the right plane consisted of scratches on the side of the right roof side rail and A-pillar. The quarter panel was dented and there were scratches on the right side of the back-bumper fascia, which was partially displaced off the vehicle. The direct damage on the top plane consisted of scratches and dents on the hood. There was a dent in the top of the right fender and scratches on the top of the right roof side rail and A-pillar. Grass was embedded in the windshield header near the right A-

pillar and the windshield was cracked. The vehicle sustained no lateral of vertical crush to the greenhouse related to the rollover.

Damage Classification Event 2
The CDC was 00TYDO1. The extent of the damage was minor.

Event Data Recorder
The Ford was not equipped with an EDR that was supported by a commercially available tool.

Interior Damage
The interior of the Ford sustained severe damage from eight intruding components into the second row as a result of the end terminal impact. The most severe intrusions involved the rear lower quadrant of the left rear door, which intruded laterally 48 cm (18.9 in) and 33 cm (13.0 in) into the second row left and center portions of the seat, respectively. The damage to the left plane also indicated that the end terminal intruded into the second row as the door was crushed. The estimated end terminal intrusion into the second row was 48 cm (18.8 in) and 28 cm (11.0 in) into the left and center portions of the seat, respectively.

Evidence of occupant contact consisted of a displaced arm rest from the left front door, probably from contact by the driver's left thigh. There was a spider web-shaped fracture to the right aspect of the windshield, probably from contact by an unknown body region of the front row passenger. The plastic belt guide of the second-row center safety belt located on the package shelf, the left backlight header, and roof were scuffed from contact by unknown body regions of the second row left occupant. The left, center, and right, backlight header and roof were also scuffed with hair adhering to the roof from probable contact by the second-row right passenger's body and head. This evidence indicated that the path of ejection for the second-row occupants was through the disintegrated backlight glazing. The left front door was jammed shut. The left rear door was crushed into the occupant compartment by the impact with the end terminal. The impact pulled the striker from its mounting surface on the C-pillar. The right front and rear doors remained closed and operational.

Manual Restraint Systems
The front and second row seating positions were equipped with lap and shoulder safety belts. The driver's safety belt had a locking latch plate. The remaining safety belts had sliding latch plates. The driver's and front row passenger's safety belts were equipped with adjustable upper anchors that were adjusted to the full-up and middle positions, respectively. The second-row safety belts had fixed upper anchors.

Inspection of the front row safety belts revealed no evidence of loading. However, the driver was considered to be belted at the time of the crash since she stated during the SCI interview that she was using the lap and shoulder belt and described contusions to her left neck and across her abdomen that were consistent with an injury from the belt webbing during the crash. The front right passenger was considered to be belted based on the driver's interview and SCI interview with the investigating police officer. The second row left passenger was not belted since the safety belt was found locked in the retracted position during the SCI vehicle inspection and the occupant was ejected from the vehicle during the rollover. The second-row right passenger was also not belted and was ejected from the vehicle during the crash.

Supplemental Restraint Systems
The Ford was equipped with multi-stage frontal air bags, neither of which deployed during the crash. However, it was determined through the investigation that the crash configuration did not appear to warrant air bag deployment.

2003 FORD FOCUS OCCUPANTS

Driver Demographics

Age/sex:	17 years/female
Height:	158 cm (62 in)
Weight:	57 kg (125 lbs)
Eyewear:	Glasses
Seat type:	Bucket
Seat track position:	Between forward-most and middle
Manual restraint usage:	Lap and shoulder safety belt
Usage source:	Interview and injury descriptions
Air bags:	Frontal, not deployed
Alcohol/drug data:	No
Egress from vehicle:	Exited without assistance through right front window
Transport from scene:	Ambulance
Medical treatment:	Treated in trauma center emergency room and released

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Contusion, 5 cm (2.0 in) in diameter base left neck	310402.1	Isolated Interior - Shoulder portion of belt restraint	Certain
2	Contusion lower back, not further specified	410402.1	Isolated Interior - This occupants seat back	Probable
3	Abrasion over right anterior hip, not further specified	510202.1	Isolated Interior - Lap portion of belt restraint	Certain
4 5	Contusions across abdomen, not further specified	510402.1 510402.1	Isolated Interior - Lap portion of belt restraint	Certain

Sources: Emergency room records and interviewee data–same person. Injury number 3 came only from emergency room records. Injury numbers 1, 2, 4, and 5 came only from interviewee data.

Driver Kinematics
The driver was restrained by a lap and shoulder safety belt and her seat track was adjusted to between the forward-most and middle positions. The seatback was in the upright position. The driver was probably displaced slightly to the left in the safety belt as the Ford rotated clockwise

and decelerated as it approached impact with the end terminal. The impact redirected the driver further to the left and the left side of her body contacted the left front door resulting in a displaced arm rest, probably from contact by her left thigh, which resulted in no reported injury. The driver was then redirected down into the seat during the ground impact and in multiple directions during the rollover. She loaded the safety belt, resulting in a 5 cm (2.0 in) diameter contusion on the base of her left neck and a contusion across her abdomen and hip. She also sustained a contusion to her lower left back from contact with the seatback. The driver was transported by ambulance to a trauma center where she was treated in the emergency room for minor injuries and released.

Front Row Right Occupant Demographics

Age/sex:	18 years/male
Height:	163 cm (64 in)
Weight:	61 kg (135 lbs)
Eyewear:	Glasses
Seat type:	Bucket
Seat track position:	Between middle and rear-most
Manual restraint usage:	Lap and shoulder safety belt
Usage source:	Driver interview
Air bags:	Frontal, not deployed
Alcohol/drug data:	Not reported
Egress from vehicle:	Exited without assistance through right front window
Transport from scene:	Ambulance
Medical treatment:	Treated in trauma center emergency room and released

Front Row Right Occupant Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Contusion right side of head, not further specified	110402.1	Isolated Roof - Roof right side rail	Probable
2	Abrasion over right shoulder, not further specified	710202.1	Isolated Interior - Shoulder portion of belt restraint	Probable
3	Contusion, 13 to 15 cm (5.0-6.0 in) in diameter, back of left shoulder	710402.1	Isolated Interior - This occupant seatback	Probable
4	Lacerations, small area, 13 to 15 cm (5.0-6.0 in) in diameter on back of left shoulder	710602.1	Isolated Noncontact Injury - Flying glass	Probable

Sources: Emergency room records and interviewee data–driver. Injury number 2 came only from emergency room records. Injury numbers 1, 3, and 4 came only from interviewee data.

Front Row Right Occupant Kinematics

The front right occupant was restrained by a lap and shoulder safety belt. His seat track was adjusted between the middle and rear-most positions. The recline position of the seatback is not known. The front row right occupant was probably displaced slightly to the left in his safety belt as the Ford rotated clockwise and decelerated as it approached impact with the end terminal. The impact redirected the occupant to the left. The occupant was then redirected down into the seat during the ground impact and toward the roof and in multiple directions during the rollover. He loaded the safety belt causing an abrasion on his left shoulder. He also sustained a contusion on the right side of his head, probably from contact with the right roof side rail. He sustained an approximate 13 - 15 cm (5.0 - 6.0 in) diameter area of small lacerations and a contusion on the back of his left shoulder from contact with glass fragments and the seatback, respectively. The occupant was transported by ambulance to a trauma center where he was treated in the emergency room for minor injuries and released.

Second Row Left Occupant Demographics

Age/sex:	17 years/female
Height:	160 cm (63 in)
Weight:	70 kg (154 lbs)
Eyewear:	None
Seat type:	Bench seat with folding back
Seat track position:	Fixed
Manual restraint usage:	None
Usage source:	Vehicle inspection, driver interview
Air bags:	None
Alcohol/drug data:	Not tested
Egress from vehicle:	Ejected through disintegrated backlight glazing
Transport from scene:	Ambulance
Medical treatment:	Hospitalized 15 days

Second Row Left Occupant Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Injury, traumatic brain, GCS=9 on scene; in ER pupils were fixed and dilated with minimal reaction and right eye deviated outward; there were significant cognitive defects with regards to attention and memory	100099.9	ICS 1: Isolated IPC Roof - Roof left side rail	Probable
			ICS 2: Isolated IPC Other Vehicle or Object - Ground	Probable
2	Contusions, lungs, left and right upper lobes, extensive, with left upper lobe the worst	441412.4	ICS 1: Isolated IPC Left Door Panel - Left rear upper quadrant	Probable
			ICS 2: Isolated IPC Other Vehicle or Object - Ground	Probable

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
3	Fractured ribs: comminuted left 1st rib and nondisplaced fractures of right 1st and 2nd ribs, left 2nd rib, anteriorly, and left 3rd rib, not further specified	450203.3	ICS 1: Isolated IPC Left Door Panel - Left rear upper quadrant	Probable
			ICS 2: Isolated IPC Other Vehicle or Object - Ground	Probable
4	Tiny/trace right apical pneumothorax	442202.2	ICS 1: Isolated IPC Left Door Panel - Left rear upper quadrant	Probable
			ICS 2: Isolated IPC Other Vehicle or Object - Ground	Probable
5	Pneumothorax, moderate left with near complete collapse of left upper lobe	442203.4	ICS 1: Isolated IPC Left Door Panel - Left rear upper quadrant	Probable
			ICS 2: Isolated IPC Other Vehicle or Object - Ground	Probable
6	Laceration liver, grade 1, involving segment IV, not further specified	541822.2	ICS 1: Isolated IPC Left Door Panel - Left rear upper quadrant	Probable
			ICS 2: Isolated IPC Other Vehicle or Object - Ground	Probable
7	Laceration spleen, grade 2, with hemoperitoneum, not further specified	544222.2	Isolated IPC Left Door Panel - Left rear upper quadrant	Certain
8	Laceration (injury) ovarian	542620.1	Isolated IPC Left Door Panel - Left rear upper quadrant	Certain
9	Hemorrhage involving left fallopian tube	542400.2	Isolated IPC Left Door Panel - Left rear upper quadrant	Certain
10	Fracture pelvic ring with comminution and displacement of left inferior and superior pubic rami, left pubic body, and left sacrum, non- displaced (diastasis) and oblique, with extension into and minimal widening of left sacroiliac joint requiring ORIF[1]	856163.4	ICS 1: Isolated IPC Left Door Panel - Left hardware/armrest rear upper quadrant	Probable
			ICS 2: Isolated IPC Other Vehicle or Object - Ground	Probable

[1] ORIF: Open Reduction and Internal Fixation (ORIF). For reference, see https://www.ncbi.nlm.nih.gov /pubmed/23569694.

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
11	Fracture, comminuted, displaced, left intra-articular acetabulum (both columns) involving anterior and superior acetabular walls, left ilium and iliac wing	856271.2	ICS 1: Isolated IPC Left Door Panel - Left hardware/armrest rear upper quadrant	Probable
			ICS 2: Isolated IPC Other Vehicle or Object - Ground	Probable
12	Fracture, nondisplaced, right acetabular roof and anterior column, not further specified	856251.2	ICS 1: Isolated IPC Left Door Panel - Left hardware/armrest rear upper quadrant	Probable
			ICS 2: Isolated IPC Other Vehicle or Object - Ground	Probable
13	Fracture, with displacement, left radial head, not further specified	752111.2	Isolated IPC Left Door Panel - Left forward upper quadrant	Certain
14	Fracture, comminuted, displaced, left femoral diaphysis, requiring ORIF	853271.3	Isolated IPC Left Door Panel - Left forward upper quadrant	Certain
15	Fracture right ankle, not further specified	852002.2	Isolated Other Vehicle or Object - Ground	Probable
16	Fractured, avulsion, of left distal tibia (medial malleolus) with swelling over lateral malleolus, not further specified	840700.1	Isolated Left Door Panel - Left forward lower quadrant	Probable
17	Contusion (soft tissue injury) with subcutaneous emphysema over left superior chest wall, extending to left shoulder, not further specified	710402.1	Isolated Other Vehicle or Object - Ground	Probable
18	Laceration on right lower back, not further specified	410600.1	Isolated Other Vehicle or Object - Ground	Possible
19	Laceration right flank, not further specified	510600.1	Isolated Other Vehicle or Object - Ground	Probable
20	Laceration, 15 by 15 cm (5.9 x 5.9 in), left calf, with damage to superficial and deep muscle compartments with posterior compartment syndrome not further specified	812006.3	Isolated IPC Left Door Panel - Left forward lower quadrant	Certain
21	Laceration lesser saphenous vein, not further specified	821202.1	Isolated IPC Left Door Panel - Left forward lower quadrant	Certain

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
22	Laceration, superficial, over left tibia, not further specified	810602.1	Isolated IPC Left Door Panel - Left forward lower quadrant	Certain
23	Abrasions over right medial and lateral malleoli, not further specified	810202.1	Isolated Interior - Other seating position seat back	Probable
24	Laceration, 3 cm (1.2 in) over left dorsal foot	810602.1	Isolated Interior - Other seating position seat back	Probable

Sources: Emergency room records, hospitalization records, and interviewee data-driver. Injury number 15 came only from interviewee data. Injury number 18 came only from emergency room data. Injury numbers 6, 13, 16, and 21 came only from hospitalization records, Injury numbers 8 and 9 came from a combination of interviewee data and hospitalization records. Injury numbers 1 through 5, 17, 19, and 22 through 24 came from a combination of emergency room and hospitalization records. Finally, injury numbers 7, 10 to 12, 14, and 20 came from a combination of all sources.

Second Row Left Occupant Kinematics

The second row left occupant was not restrained by a lap and shoulder safety belt. She was probably displaced slightly to the left as the Ford rotated clockwise and decelerated as it approached impact with the end terminal. The left rear door impact to the end terminal displaced the occupant further to the left and the left side of her body contacted the intruding door causing extensive left lung contusions, three left rib fractures with pneumothorax, grade 1 liver laceration, grade 2 spleen laceration, ovarian laceration involving the left fallopian tube, comminuted pelvic ring fracture, left acetabulum fracture, displaced fracture of the left radial head, comminuted and displaced fracture of the left femoral diaphysis, and a fracture and avulsion of the left distal tibia. The lung contusions, rib fractures with pneumothorax, liver laceration, pelvic ring fracture, and left acetabulum fractures may also have been caused by contact with the ground during the rollover event. Contact with the left rear door also resulted in a 15 x 15 cm (5.9 x 5.9 in) laceration to the left calf, a laceration of the lesser saphenous vein, and a laceration over the left tibia. Contact with the left roof rail or roof during the impact with the guardrail probably caused the traumatic brain injury, but contact with the ground during the rollover event may also have caused the injury. She sustained abrasions over the right medial and lateral malleoli and a 3 cm (1.2 in) long laceration to the left foot, probably from contact with the driver's seatback.

The occupant was redirected down into the seat and in multiple directions during the rollover and was ejected through the disintegrated backlight glazing. Ground contact also probably caused a fracture of the right ankle, contusion of the left chest, and a laceration on the right lower back and right flank. The second row left occupant came to final rest in the grass south of the final rest position of the vehicle. The occupant was transported by ambulance to a trauma center where she was hospitalized for 15 days for treatment of severe injuries then transferred to a rehabilitation facility.

Second Row Right Occupant Demographics

Age/sex:	17 years/female
Height:	158 cm (62 in)

Weight:	64 kg (140 lbs)
Eyewear:	None
Seat type:	Bench with folding back
Seat track position:	Fixed
Manual restraint usage:	None
Usage source:	Vehicle inspection
Air bags:	Frontal, not deployed
Alcohol/drug data:	Not reported
Egress from vehicle:	Ejected through disintegrated backlight glazing
Transport from scene:	Ambulance
Medical treatment:	Treated in trauma center emergency room and released

Second Row Right Occupant Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Contusion, 5.1 cm, (2 in) in length, right side of head	110402.1	Isolated Other Vehicle or Object - Ground	Probable
2	Contusion/hematoma left supraorbital area, not further specified	210402.1	Isolated Other Vehicle or Object - Ground	Probable
3	Contusion over right mandible (jaw), not further specified	210402.1	Isolated Other Vehicle or Object - Ground	Probable
4	Laceration, 3.0 cm (1.2 in), transversely oriented on right eyebrow requiring ten stitches, not further specified	210602.1	Isolated Other Vehicle or Object - Ground	Probable
5	Contusion mid-sternal area of chest wall, not further specified	410402.1	Isolated Other Vehicle or Object - Ground	Probable
6	Abrasion, small, left ankle, not further specified	810202.1	Isolated Other Vehicle or Object - Ground	Probable

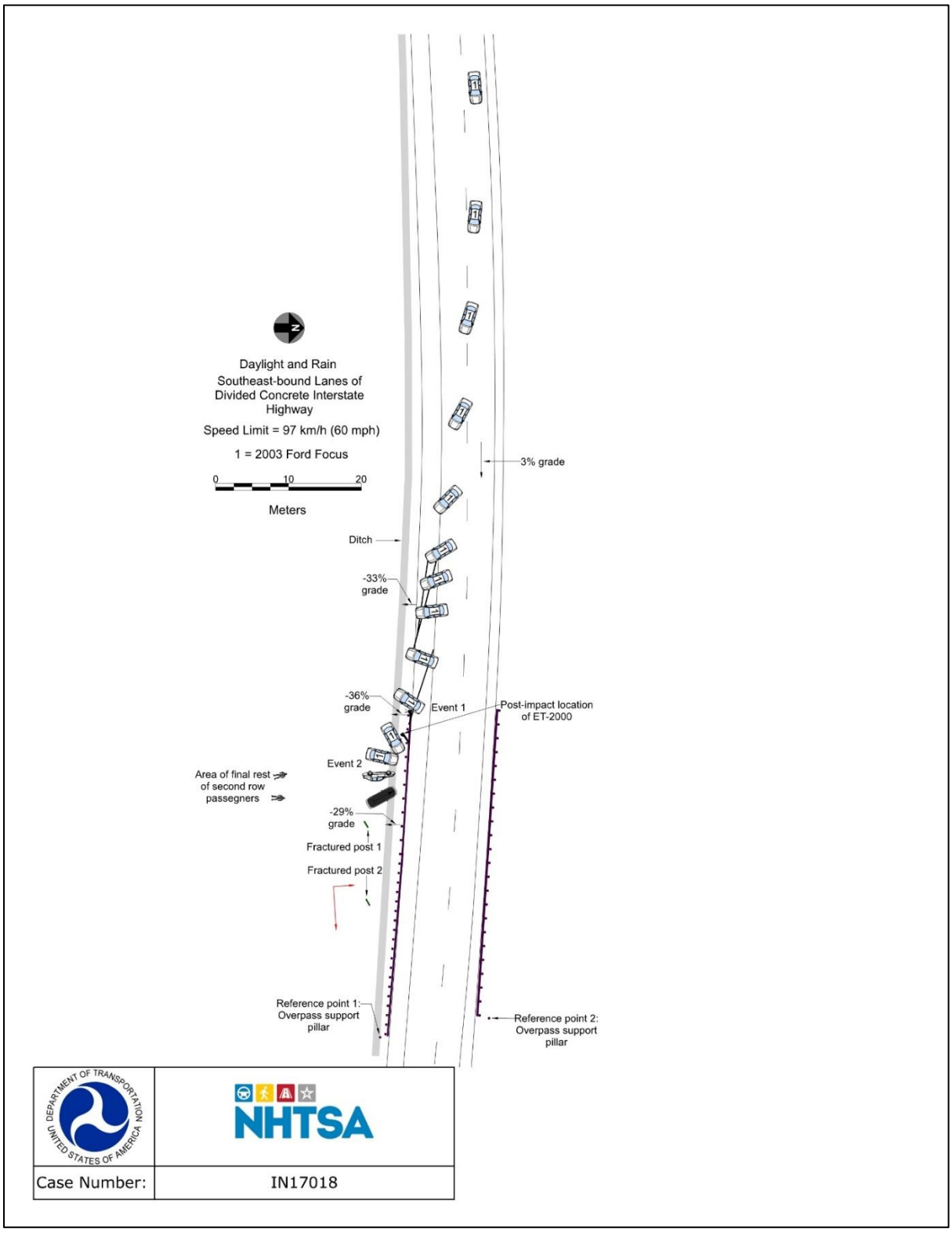
Sources: Emergency room records and interviewee data–driver. Injury numbers 2, 3, and 5 came only from emergency room records. Injury numbers 1 and 6 came only from interviewee data. Injury number 4 came from a combination of interviewee data and emergency room records.

Second Row Right Occupant Kinematics

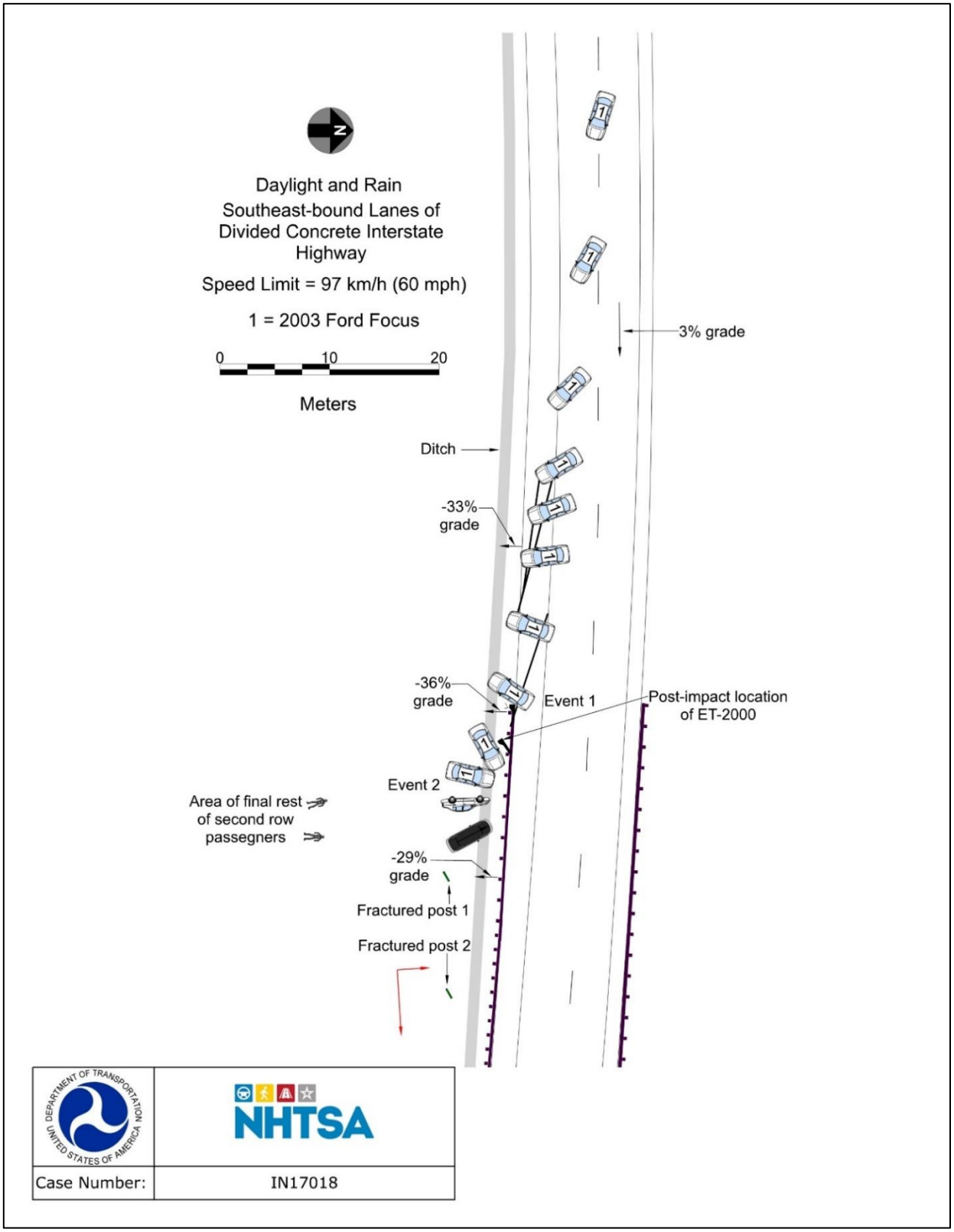
The second-row right occupant was not restrained by a lap and shoulder safety belt. She was probably displaced slightly to the left as the Ford rotated clockwise and decelerated. The left rear door impact to the end terminal displaced the occupant to the left. The second-row right occupant was then redirected down into the seat during the ground impact and in multiple directions during the rollover and was ejected through the disintegrated backlight glazing. She came to final

rest in the grass south of the final rest position of the vehicle. She sustained a 3 cm (1.2 in) long laceration to her right eyebrow, abrasion to her left ankle, and contusions to her head, face, and chest, probably from contact with the ground. The occupant was transported by ambulance to a trauma center where she was treated in the emergency room and released for minor injuries.

CRASH DIAGRAM



CRASH DIAGRAM: DETAILED VIEW



APPENDIX A: FHWA Guardrail Form

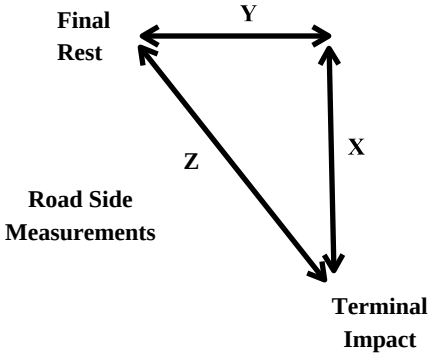
Case No.: IN17018

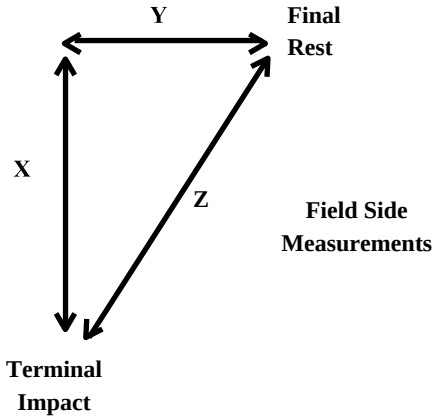
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	April 2017	**TIME OF CRASH (MILITARY)**	Morning
Case Number	IN17018	**State**	Missouri
Traffic Route	Interstate	**Direction (Southbound = SB)**	SEB
Ambient Conditions (at time of crash)			
Temperature (°F)	53	**Lighting**	Daylight
Atmospheric	Rain		

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)	Unknown
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 40.7 ft
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 38.1 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 18.4 ft
Super elevation	❒+2% ❒-2% ☒ -3.5% at post 1
Curve Radius (ft.)	3,719.5 (calculated from chord & middle ordinate)

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: IN17018

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

GUARDRAIL INSTALLATION									
Post No.	Post		Offset Block		Pre-Existing Damage		Offset to Post or Post Hole (ft.)		Spacing to Next Post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel Way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
0	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A
1	Wood	7 x 5.5	N/A	N/A	Unk		9.4	N/A	6’ 2”
2	Wood	7.5 x 5	N/A	N/A	Unk		9.2	N/A	6’ 4”

Case No.: IN17018

Post No.	Post		Offset Block		Pre-Existing Damage		Offset to Post or Post Hole (ft.)		Spacing to Next Post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel Way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
3	Wood	7.75 x 6	Wood	Unk	Unk		9.8	N/A	6’ 2”
4	Wood	7.75 x 6	Wood	7.75 x 6	No		9.7	N/A	6’ 3”
5	Wood	7.75 x 6	Wood	8 x 6.5	No	Note: Rail bolt was not through rail, only tightly through post and offset block	9.6	N/A	6’ 3”
6	Wood	8 x 6	Wood	8 x 5.5	No	Note: Rail bolt was not through rail, only tightly through post and offset block	9.4	N/A	6’ 0”
7	Wood	7.75 x 6	Wood	7.75 x 6	No		9.3	N/A	6’ 2”
8	Steel	6 x 4	Wood	7.5 x 6	No		9.3	N/A	6’ 4”

Case No.: IN17018

Post No.	Post		Offset Block		Pre-Existing Damage		Offset to Post or Post Hole (ft.)		Spacing to Next Post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel Way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
9	Steel	5.75 x 4	Wood	7.5 x 5.75	No		9.3	N/A	6’ 2”
10	Steel	6 x 4	Wood	7.25 x 6	No		9.2	N/A	6’ 3”
11	Steel	6 x 4	Wood	7.75 x 6.5	Yes	Minor damage to offset block that probably occurred during installation	9.1	N/A	6’ 3”
12	Steel	6 x 4	Wood	7.5 x 6	No		9.2	N/A	6’ 3”

Additional Comments:

Case No.: IN17018

EXTRUDER			
Feeder Channel Width at impact head	❒ 4inches ☒ 5 inches ❒ Other_____		
Guide Chute Exit Height (in.)	15.5 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.)	8 ft 2 in
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.]	25 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 in Rail: 1 (at post 3)
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	❒ No ☒ Yes Guardrail		
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 - %	-33%	-36%	-29%
Adjacent Lane Width (ft)	14.1 ft		
Lane Type (NAS EDS Variable: Sur. Type)	Concrete		
Shoulder Type	Concrete		

Case No.: IN17018

Shoulder Width (ft)	8.5 ft
Guardrail Height (in)	28 in

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	Passenger vehicle	
Vehicle Identification Number (VIN)	1FAFP34PX3Wxxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	2,564 lbs	
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	08LZAW3	
Delta-V	Unknown (Barrier Equivalent Speed = 18 mph)	
Occupant Compartment Penetration of rail	❒No	☒Yes Describe: LR door was pushed into 2nd row by impact with ET-2000 and side of extruder head intruded as rail bent.
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)	Ground	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	Trip Over	

DOT HS 812 899
March 2020

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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