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Special Crash Investigations On-Site Guardrail End Treatment Impact Investigation Vehicle: 2008 Mercury Mariner Location: Pennsylvania Crash Date: November 2016

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants. Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicles or their safety systems.

This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was published.

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15. Supplementary Note An investigation of the impact to an ET-Plus guardrail end treatment by a 2008 Mercury Mariner, in which a section of the W-beam penetrated the left toe pan of the vehicle and entered the occupant compartment.			
16. Abstract The interest in this on-site investigation was the impact to an ET-Plus guardrail end treatment by a 2008 Mercury Mariner. The crash occurred when the eastbound Mercury traveling the limited-access interstate highway departed the right side of the road and struck the guardrail end treatment during early morning hours. The Mercury was occupied by a 19-year-old female driver and a 20-year-old female in the front row right occupant position. The driver reported to the police that she fell asleep, precipitating the crash. The ET-Plus end terminal was displaced along a portion of the guardrail and deformed the W-beam. A section of the W-beam guardrail penetrated the left toe pan of the vehicle and breached the occupant compartment to the rear seats. The two occupants in the vehicle were transported by ambulance from the scene with police-reported C-level "possible" injuries. The crash was identified by the Pennsylvania Turnpike Commission (PTC), which in turn submitted notification to the Federal Highway Administration (FHWA). The FHWA determined that the crash type and guardrail end treatment met the criteria for further research and subsequently forwarded the notification to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration in November 2016. The CID assigned an on-site investigation of the crash to the Special Crash Investigations (SCI) team at Crash Research & Analysis, Inc., the same day. In turn the SCI team initiated contact with the PTC for the on-site investigation.			
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TABLE OF CONTENTS

SPECIAL CRASH INVESTIGATIONS

CASE NO.: CR16028

ON-SITE GUARDRAIL END TREATMENT IMPACT INVESTIGATION

LOCATION: PENNSYLVANIA

VEHICLE: 2008 MERCURY MARINER

CRASH DATE: NOVEMBER 2016

BACKGROUND

The interest in this on-site investigation was the impact to an ET-Plus guardrail end treatment (**Figure 1**) by a 2008 Mercury Mariner. The crash occurred when the eastbound Mercury traveling the limited-access interstate highway departed the right side of the road and struck the guardrail end treatment during early morning hours. The Mercury was occupied by a 19-year- old female driver and a 20-year-old female in the front row right occupant position. The driver reported to the police that she fell asleep, precipitating the crash. The ET-Plus end terminal was displaced along a portion of the guardrail and deformed the W-beam. A section of the W-beam guardrail penetrated the left toe pan of the vehicle and breached the occupant compartment to the rear seats. The two occupants in the vehicle were transported by ambulance from the scene with police-reported C-level "possible" injuries. The crash was identified by the Pennsylvania Turnpike Commission (PTC), which in turn submitted notification to the Federal Highway Administration (FHWA). The FHWA determined that the crash type and guardrail end treatment met the criteria for further research and subsequently forwarded the notification to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration in November 2016. The CID assigned an on-site investigation of the crash to the Special Crash Investigations (SCI) team at Crash Research & Analysis, Inc., the same day. In turn the SCI team initiated contact with the PTC for the on-site investigation.

Figure 1: On-scene image of the Mercury and crash site. Image supplied by the PTC.

The on-site investigation documented the guardrail system, the damage it sustained during the crash and assessed its performance. The roadway environment and the guardrail were also documented. The inspection of the Mercury included the measurement of its exterior and interior deformation, documentation of the guardrail penetration, identification of interior occupant contact, assessment of manual restraint systems, and an evaluation and inspection of the supplemental restraint deployment/actuation. The Mercury was equipped with an event data recorder (EDR), however, the 2008 model year Mercury Mariner was not supported by the Bosch Crash Data Retrieval (CDR) tool. Recorded crash event data was not available.

CRASH SUMMARY

Crash Site

This single-vehicle crash occurred during the dark morning hours of November 2016 in the eastbound lanes of a divided interstate highway. The posted speed limit was 113 km/h (70 mph). Police-reported environmental conditions at the time of the crash were dark, clear, and dry. The National Weather Service reported a temperature in the locale of 0 ˚C (32 ˚F), with 94 percent relative humidity, calm winds, and clear skies.

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 vicinity of the crash site, the roadway descended with a 3 percent grade from a hillcrest that was located approximately 0.3 miles to the west. The interstate was three lanes wide at the hillcrest and narrowed to two lanes along the approach (**Figure 2**). In the area of the crash, the travel lanes were separated by broken white lines. The width of the right lane measured 5.1 m (16.7 ft) and the width of the left lane measured 3.7 m (12.1 ft). The right shoulder was 3.8 m (12.5 ft) wide and was separated from the right travel lanes by a solid white line. A 41 cm (16.0 in) wide rumble strip was embedded in the right shoulder. The 1.8 m (5.9 ft) wide left shoulder was delineated by a solid yellow line. The ET-Plus end-treatment and guardrail was installed adjacent to the right shoulder (**Figure 3**). This guardrail protected traffic from entering the roadside along the approach to the right curve. A Crash Diagram is included at the end of this technical report on **Page 15**.

Figure 2: East-looking view of the crash site 93 m (150 ft) from post 1.

Figure 3: Southeast-looking oblique view of the crash site.

Pre-Crash

The Mercury was traveling east in the right lane of the interstate at an estimated speed of 113 km/h (70 mph) based on SCI field experience. It was occupied by a belted 19-year-old female driver and an unbelted 20-year-old female in front row right position. Medical record documents for the front right passenger reported that she was asleep at the time of the crash. The driver stated to the investigating police officer that she had also fallen asleep, which precipitated the crash. While the Mercury traveled eastbound, it began to drift to the right and departed its travel lane.

The vehicle traversed across the shoulder at a shallow angle and approached the guardrail end treatment. The reconstructed departure angle was estimated to be between 5 and 10 degrees, based on the combination of the location of the damage to the vehicle and the nature of the damage to both the vehicle and guardrail system. There were no tire marks at the scene related to the Mercury's pre-crash trajectory.

Crash

The front right corner of the Mercury impacted the end terminal located at Post 1 (Event 1, **Figure 4**) and began to displace it to the east. The frontal air bags within the Mercury deployed. The force of the impact accelerated the end terminal along the guardrail, and 3.7 m (12.0 ft) of W-beam was extruded from the impact head. The right bias of the crash force caused the Mercury to initiate a clockwise rotation. As the displaced end terminal detached the W-beam from Post 3, the end terminal separated from its contact with the Mercury and the vehicle's front plane began to engage the face of the guardrail between Post 3 and 4. This separated the bumper fascia from the vehicle.

Figure 4: East-looking image depicting the point of impact.

Figure 5: East-looking image depicting the final rest position of the displaced end terminal and extruded rail.

The Mercury continued along its errant trajectory and began to deflect the guardrail system toward the field side. A kink formed at Post 4 as the combined mass of the end terminal and extruded rail was accelerated to the southeast (thrown forward ahead of the vehicle). The W-beam deformed into a U-pattern and sheared as it separated from Post 4. The combined mass of the end terminal and extruded rail were displaced onto the road side 29.8 m (97.8 ft) from Post 1, in the vicinity of Post 16 (**Figure 5**). This section of damaged guardrail measured 5.9 m (19.5 ft) in length.

The exposed end of the kinked and sheared W-beam then engaged the left front corner of the Mercury (Event 2). As the vehicle maintained its momentum, the guardrail system speared the Mercury. The W-beam entered through the space behind the left front suspension, penetrated through the driver's toe pan into the occupant compartment 229 cm (80 in). The left bias of the penetration and the corresponding engagement caused the Mercury to rotate rapidly counterclockwise into the road side.

The vehicle progressed beyond the plane of the guardrail system into the roadside, but the exposed W-beam remained penetrated into the vehicle. This bent the W-beam around Post 7 as the vehicle came to rest. At final rest, the Mercury (**Figure 6**) was facing the northwest, 13.6 m (44.6 ft) from Post 1 of the end treatment. **Figure 7** is an image of the vehicle's final rest position (represented by the small yellow and blue evidence marking cones) taken during the SCI site inspection.

Figure 6: On-scene east-facing image of the Mercury at final rest. Image supplied by PTC.

Figure 7: East-facing image depicting the final rest position of the Mercury represented by the yellow and blue evidence cones.

Post-Crash

The front right passenger stated in medical record that she awoke to the sounds of the driver screaming and the force of the crash. She was able to exit the Mercury under her own power and then assisted the driver from the vehicle. Police, fire department, and emergency medical services (EMS) personnel responded to the crash scene. Both Mercury occupants were transported to local hospitals for evaluation and treatment of police-reported C-level "possible" injuries. A towing and recovery service used a portable saw to cut the W-beam immediately forward of its penetration into the Mercury. The vehicle was then removed from the scene and towed to a nearby maintenance facility, where it was secured for this SCI Investigation with a portion of the guardrail remaining penetrated inside the vehicle.

ET-PLUS END TREATMENT AND GUARDRAIL

The ET-Plus End Treatment, manufactured by Trinity Highway Products, was an energy absorbing end terminal used to terminate W-beam guardrail installations. The end treatment met the requirements of the National Cooperative Highway Research Program (NCHRP) 350 Test Level 3. The end terminal was designed to be displaced along the W-beam by the force of the impact and dissipate the impact force by flattening the W-beam during its movement. The flattened and deformed beam was projected out of the impact head toward the field (off-traffic) side. The chute of the end terminal involved in this crash was 10 cm (4.0 in) wide.

The ET-Plus end terminal and guardrail treatment system were inspected post-crash and documented by the SCI Investigator through a combination of measurements and photographs. A diagram depicting the deformed guardrail is included on **Page 16** of this technical report. The completed FHWA Guardrail Forms can be found at the end of this technical report as Attachment A. For visual and comparison purposes, an exemplar ET-Plus installation is depicted in **Figure 8**. The manufacturer's literature and installation manuals can be found at www.highwayguardrail.com/products/etplus.html.

Figure 8: Oblique view of an exemplar 10 cm (4 in) ET-Plus installation.

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

Inspection of the installation determined that the crash resulted in an approximate overall damage length of 13.4 m (44.0 ft) which extended to the area of Post 8. **Figure 9** provides and overall oblique view of the damaged guardrail system. The HBA-Post 1 separated from its foundation on impact. The post was displaced to the southeast coming to rest within the swale adjacent to Post 11. SYT-Post 2 was deformed 70 degrees to the east, bending at ground level. The I-beam was partially torn through the weakening holes on its field side. A block-out was used with the carriage bolt at this post to support the W-beam. SYT Posts 3 to 6 were deformed approximately 50 to 80 degrees in the vehicle's direction of travel, bending at ground level. Composite block-outs and carriage bolts were used at each post.

Figure 9: Oblique view of the crash site looking to the southeast.

Posts 2 to 6 were installed such that the weakening holes were approximately 8 to 10 cm (3 to 4 in) above ground level. Post 7 deflected approximately 15 degrees to the east and Post 8 twisted (rotated along its length) counterclockwise approximately 20 degrees due to forces transmitted through the deformed W-beam. The guardrail at Post 9 and beyond was not damaged. It was noted that Posts 1to 6 were embedded into the roadside adjacent to the pavement edge. The posts at location 7 and beyond were embedded through the asphalt of the road shoulder. The height of the W-beam at an undamaged location between Posts 11 and 12 measured 71 cm (28.0 in).

Figure 10: Southeast-facing image depicting the ET-Plus 10 cm (4 in) end terminal and the extruded guardrail.

During the crash sequence, the Mercury departed the right road edge and the right corner of the vehicle struck the face of the end terminal. The impact face measured 38x71 cm (15x28 in) width by height and was abraded at its upper left corner. The force of the impact displaced the end terminal to the east extruding the W-beam. The length of the extruded rail measured 3.7 m (12.0 ft). The end terminal separated from the Mercury and was accelerated forward as the front plane of the vehicle engaged the face of the W-beam between Posts 3 and 4. The W-beam kinked at Post 4 and tore adjacent to post. The end terminal and a 5.9 m (19.3 ft) section of the W-beam was then projected to the east, coming to rest on the road side (**Figure 10**).

The torn end of the W-beam then engaged the left corner of the Mercury (**Figure 11**). The eastward momentum of the vehicle directed the exposed end of the W-beam through the open space between the left frame and left front wheel assembly. The guardrail pierced the toe pan, entered the driver's floor space and intruded to the second row (**Figure 12**). In total, 229 cm (80 in) of guardrail entered the vehicle as the Mercury rotated counterclockwise to its final rest position.

Figure 11: Image of the left aspect of the Mercury's front plane and intruded guardrail.

Figure 12: Interior image of the Mercury depicting the intruded guardrail.

2008 MERCURY MARINER

Description

The Mercury (**Figure 13**) was a four-door SUV manufactured in March 2007 and was identified by Vehicle Identification Number 4M2CU39H28Kxxxxxx. It was built on a 262 cm (103.1 in) wheelbase and equipped with a hybrid powertrain that used a 2.3 liter four-cylinder gasoline engine linked to two electric motor/generators. Power was transferred to the front-wheel drive platform by a continuously variable transmission (CVT) with a console-mounted shifter. A placard declared that the gross vehicle weight rating was 2,177 kg (4,800 lb), with gross axle weight ratings of 1,116 kg (2,460 lb) front and 1,098 kg (2,420 lb) rear.

Figure 13: Left front oblique view of the 2008 Mercury Mariner.

The Mercury's curb weight was 1522 kg (3,630 lb). Standard equipment included electric power rack and pinion steering, power-assisted four- wheel disc brakes with ABS and electronic brakeforce distribution, and indirect tire pressure monitoring system. The vehicle's manufacturer recommended tire size P235/70R16 at a cold pressure of 240 kPa (35 PSI) for all four positions. The Mercury was equipped with Continental ContiTrac all-season tires, with matching Tire Identification Numbers of A308 46KW 1313 and mounted on OEM alloy wheels. Specific tire data at the time of the SCI vehicle inspection were as follows.

Position	Pressure	Tread Depth	Restriction	Damage
LF	Tire Flat	8 mm (10/32 in)	Yes	Outer sidewall cut
LR	293 kPa (42.5 PSI)	6 mm (8/32 in)	None	None
RR	262 kPa (38 PSI)	8 mm (10/32 in)	No	None
RF	Tire Flat	9 mm (11/32 in)	Yes	Outer sidewall cut

The interior of the Mercury was configured with two rows for the seating of up to five occupants (2/3), with a rear cargo area. Front bucket seats featured cloth upholstery, reclining seat backs and adjustable head restraints. Both head restraints were adjusted 3 cm (1.0 in) above the seat backs. The at-crash position of the driver's seat remains unknown. The seat was deformed and displaced by the intrusion of the guardrail section. The front row right seat was adjusted to the full-rear track position. The second row seat was a cloth-surfaced split-bench seat. Both second row head restraints were removed from the vehicle. Manual restraint systems consisted of 3-point lap and shoulder seat belts for all seat positions. Supplemental restraint systems included front seat belt pretensioners, Certified Advanced 208-Compliant (CAC) driver and passenger frontal air bags, front seat-mounted side impact air bags, and dual-sensing (side impact and rollover) roof side rail-mounted inflatable curtain (IC) air bags.

Exterior Damage

The front corners of the vehicle exhibited impact damage as a result of the road-departure impact. The Mercury (**Figure 14**) impacted the end terminal with its front plane (Event 1). The direct contact damage began 48 cm (19.0 in) right of centerline and extended 30 cm (12.0 in) to the right corner. The crush of the unsupported end of the front bumper reinforcement measured 3 cm (1.0 in). There was no deformation of the right frame rail. The right fender crushed 30 cm (12.0 in) rearward and deformed 28 cm (11.0 in) outward. The right front tire was displaced into the hinge pillar of the front door and was debeaded from the rim. The right wheel base was shortened 13 cm (5.1 in). The Collision Deformation Classification representing this damage pattern was 12FREE3. The corner impact and yielding properties of the guardrail were outside the scope of the WinSMASH program for analysis.

Figure 14: Front view of the Mercury depicting the two regions of damage.

During the prolonged engagement with the guardrail and its deformation, the front bumper fascia separated from the vehicle. The deformed guardrail engaged the left corner of the Mercury and speared the vehicle (Event 2). This engagement occurred in the open space between the left frame rail and the inner aspect of the left front tire (**Figure 15**). The end of the left frame rail was deformed approximately 3 cm (1 in). The guardrail pierced the driver toe pan and entered the occupant compartment. The side wall of the left front tire was cut, the suspension fractured and the wheel assembly was displaced rearward 25 cm (9.8 in). Contact with the guardrail support posts extended rearward to the mid aspect of the left front door. All four doors and the rear lift gate remained closed during the crash and were operational at the time of the SCI inspection. The CDC assigned to this damage pattern was 12FLEE8. A reconstruction analysis of this impact was beyond the scope of the WinSMASH program.

Figure 15: Left view of the Mercury at the left front axle.

Event Data Recorder

The Mercury was equipped with an event data recorder, however, it was not supported by the Bosch Crash Data Retrieval (CDR) tool. No recorded crash data was available for this investigation.

Interior Damage

The interior damage to the Mercury consisted of the intrusion of the W-beam guardrail with associated deformation of the driver seat, fracture of the windshield, and deployment of the frontal air bags. The guardrail entered the occupant compartment through the left aspect of the driver's toe pan. The hole in the toe pan measured 43 cm x 30 cm (13.0 in x 12.0 in) width by height. The guardrail traveled along the floor pan and under the right aspect of the driver seat (**Figure 16**). The guardrail contacted and forced the driver seat vertically from the seat track and rotated the seat approximately 60 degrees CW. The driver seatback angle was near vertical and in contact with the left B-pillar. The guardrail deformed the center console to the right and entered the interior second row at its mid-point (**Figure 17**). The intrusion measured 229 cm (80.0 in) from the toe pan. The front row right seat was in a full-rear track position. The seatback was reclined 30-degrees.

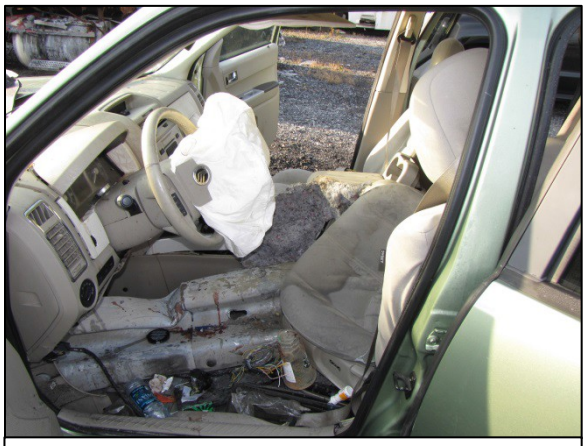


Figure 16: Left interior view of the Mercury depicting the intruded W-beam guardrail.

Figure 17: Right interior view of the Mercury's second row and the intruded guardrail.

The Mercury was configured with an AS1 laminated windshield, AS2 front door glazing, AS3 rear door, quarter window, backlight, and roof glazing. The laminated windshield maintained full bond retention. There were two distinct fracture points to the interior aspect of the glazing that were located directly forward of the front row occupant positions. The first fracture was located forward of the driver's position and consisted of a star-like fracture pattern with an associated large fluid spill from a metal drink container held by the driver at the time of the crash (**Figure 18**). The drink container was found on the floor space forward of the driver seat. This fracture was located 37 cm (14.5 in) right of the left A-pillar and 30 cm (12.0 in) below the windshield header.

Figure 18: Image depicting the fluid spill patterns and fracture site to the left aspect of the Mercury's windshield.

The associated spill pattern from the drink measured 23 cm x 36 cm (9.0 in x 14.0 in). It began at the fracture site and extended toward the left A-pillar. The location of the fracture site and spill pattern was consistent with the driver holding the drink container in her left hand.

A second fluid spill pattern was observed on the left half of the windshield. This second fluid was darker in color and was presumed to be coffee-based. This pattern began at the fracture site and extended to the right measuring 25 cm x 54 cm (10.0 in x 23.0 in) width by height. The fabric of the deployed air bags was also stained by the fluid. Chocolate chips were observed within the spill on the windshield and on the top of the instrument panel forward of the driver position. The fluid spill was present on the center aspect of the instrument panel running down onto the right aspect of the driver's lower instrument panel and knee bolster. A brand name plastic drink container was found on the floor forward of the driver seat. The location of the spill was consistent with the front right occupant holding the drink in her left hand. The right half of the windshield was fractured directly forward of the front right seat position (**Figure 19**). This fracture site was located 40 cm (15.8 in) left of the right A-pillar and 46 cm (18.0 in) below the windshield header. The fracture was attributed to probable contact from the unbelted front row right occupant as she loaded through the deployed air bag.

Figure 19: Interior view of the Mercury depicting the fracture site at the right aspect of the windshield.

Manual Restraint Systems

The Mercury was equipped 3-point lap and shoulder seat belts for the five designated seat positions. All seat belts were equipped with continuous loop and sliding latch plates. The front row belts incorporated adjustable D-rings. Both were adjusted to the full-up positions. The driver's seat belt retracted onto an emergency locking retractor (ELR) while the other four seat belts used switchable ELR/automatic locking retractors (ALRs). Both front row seat belts were configured with retractor and buckle pretensioners.

The driver was restrained by the seat belt at the time of the crash. Use of the seat belt system was evidenced by the actuation of the pretensioners, loading evidence on the webbing, and frictional abrasions on the polymer surface of the latch plate. The belt webbing was captured between the deformed seat back and the left B-pillar with 171 cm (67.5 in) of exposed webbing, a length consistent with driver usage. Vertical striations consistent with driver loading were present over a 23 cm (9.0 in) section of the lap belt and a 20 cm (8.0 in) section on the shoulder belt, 36 cm to 56 cm (14 in to 22 in) below the D-ring.

The front row right occupant was unbelted at the time of the crash. The retractor and buckle pretensioners did not actuate. At inspection, the webbing was stowed on the retractor and freely extended. There was no evidence of occupant loading on the webbing, latch plate, or D-ring.

Supplemental Restraint Systems

The Mercury was equipped with a Certified Advanced 208-Compliant frontal air bag system for the driver and front row right occupant, front row seat-mounted side impact air bags and dual sensing (side impact and rollover) IC air bags. The CAC air bag system consisted of dual-stage air bags, seat track positioning sensors, seat belt buckle switches, and a front row right occupant weight sensor. Both frontal air bags deployed during the frontal crash sequence. The seat-mounted and the IC air bags did not deploy.

The driver's frontal air bag deployed from an I-configuration module mounted within the center hub of the steering wheel. The symmetrical I-configuration cover flaps were 12 cm (4.7 in) in height and 13 cm (5.3 in) in width. The driver air bag (**Figure 20**) was 61 cm (24.0 in) in diameter in its deflated stated and was vented by two 3 cm (1.2 in) diameter ports located at the 11 and 1 o'clock sectors on the back side of the air bag. Internal tethering was sewn to the face of the air bag with an oval-shaped stich pattern that measured 14 cm (5.5 in) in height and 8 cm (3.0 in) in width. The following nomenclature was stamped onto the air bag at the top aspect of the module assembly: 607930300CC02 FORD U377 EWPU2FOHGSI. There was no residual evidence of occupant contact to the deployed air bag. The right and top aspects of the air bag fabric were stained a brown color from the presumed coffee-based beverage associated to the front row right occupant.

Figure 20: View of the deployed driver's frontal air bag within the Mercury.

Figure 21: View of the deployed passenger's frontal air bag within the Mercury.

The passenger's frontal air bag (**Figure 21**) deployed from a mid-mount module through H-configuration cover flaps. In its deflated state, the air bag measured 41 cm (16.0 in) in width and 61 cm (24.0 in) in height with 58 cm (23.0 in) of rearward excursion. The air bag was not tethered. Venting was achieved via two 6 cm (2.5 in) diameter ports located on the lateral aspects of the air bag. A barcode label identified the air bag as 08454800 AA 02 F2TTYNSDA/V.

The unbelted front row right occupant engaged the deployed air bag during her forward trajectory. There was no direct evidence associated with occupant contact; however, a large, brown-colored fluid stain was present of the left aspect of the air bag consistent with the presumed coffee-based beverage.

2008 MERCURY MARINER OCCUPANT DATA

Driver Demographics

Age/Sex:	19 years / female
Height:	Unknown
Weight:	79 kg (174 lb)
Eyewear:	Unknown
Seat Type:	Forward-facing bucket seat with adjustable head restraint
Seat Track Position:	Unknown
Manual Restraint Usage:	3-point lap and shoulder seat belt
Usage Source:	SCI vehicle inspection, PAR
Air Bags:	Front, seat-mounted, and IC air bags available, Front deployed
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Exited vehicle with assistance
Transport from Scene:	Ambulance to a local hospital
Type of Medical Treatment:	Treated and released

Driver Injuries

Injury No.	Injury	AIS 2015	Involved Physical Component	IPC Confidence
1	Irregular (X-shaped) full thickness right leg laceration, medial aspect, 5x3 cm, requiring 11-suture repair	810602.1	Intruding W-beam guardrail	Certain

Source – Emergency room records

Driver Kinematics

The 19-year-old female driver of the Mercury was seated in an unknown-track position with the seat back reclined within normal range and the head restraint adjusted 3 cm (1.0 in) above the seat back. She was restrained by the manual seat belt system, based on the observations of the SCI vehicle inspection. The driver was holding a metal beverage container in her left hand. Her posture was unknown, as she reported to the investigating law enforcement officer that she had fallen asleep immediately prior to the crash.

The Mercury drifted to the right and departed the right side of the interstate roadway at a shallow angle. At impact with the end terminal of the guardrail system, the driver's seat belt pretensioners actuated and the frontal air bag system deployed. The driver initiated a forward trajectory in response to the 12 o'clock direction of force impact. She loaded the seat belt system, evidenced by frictional abrasions to the polymer surface of the latch plate and creasing of the belt webbing. She likely contacted the deployed air bag with her torso.

During the driver's forward motion, she lost her grip on the beverage container. It became displaced about the vehicle's interior, and subsequently struck and fractured the windshield. A star-like fracture to and beverage residue on the windshield evidenced these dynamics.

During the impact sequence, the W-beam guardrail section penetrated into the occupant compartment through the left toe pan of the Mercury. As the W-beam entered the occupant compartment, it traveled between the legs of the driver and lacerated the medial aspect of her right leg. Blood evidence was observed on the W-beam. The corresponding laceration required suture repair at the treating medical facility. The guardrail remained low (at the level of the floor) and traveled beneath the right aspect of the driver's seat frame. It sheared the seat's mounts, and rotated and displaced the driver's seat clockwise and upward. The driver remained restrained within the driver's seat as the guardrail penetrated beyond her seat and into the second row. She rebounded and came to rest in her deformed seat as the Mercury rotated counterclockwise to its final rest position. The front right occupant assisted the driver from the vehicle. Upon the arrival of EMS personnel, she was transported by ambulance to a local hospital for treatment and released within hours of the crash.

Front Row Right Occupant Demographics

Age/Sex:	20 years / female
Height:	Unknown
Weight:	93 kg (205 lb)
Eyewear:	Unknown
Seat Type:	Forward-facing bucket seat with adjustable head restraint
Seat Track Position:	Rearmost
Manual Restraint Usage:	None; 3-point lap and shoulder seat belt available
Usage Source:	SCI vehicle inspection, PAR
Air Bags:	Front, seat-mounted, and IC air bag available, Front deployed
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Exited vehicle under her 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	AIS 2015	Involved Physical Component	IPC Confidence
1	Right-sided anterior subcutaneous soft tissue contusion of abdomen	510402.1	Center instrument panel	Possible
2	Erythematous soft tissue swelling of right distal and medial aspect of the thigh	810402.1	Unknown	Unknown
3	Abrasion on the medial aspect of the proximal right lower leg	810202.1	Unknown	Unknown

Source – Emergency Room Records

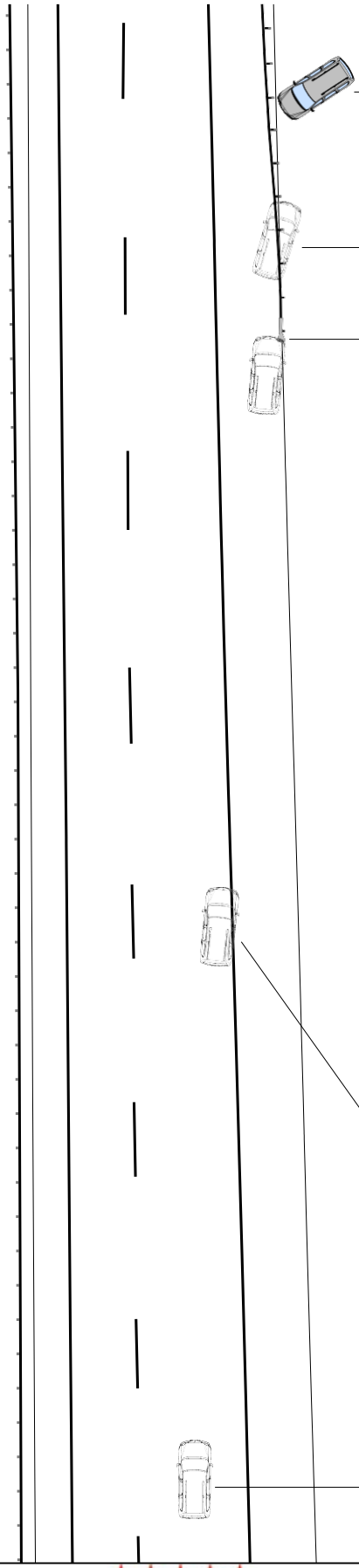
Front Row Right Occupant Kinematics

The front row right occupant was asleep at the time of the crash, positioned in an unknown posture. Her seat track was adjusted full rear, with the seatback reclined 30 degrees aft of vertical. The head restraint was adjusted 3 cm (1.0 in) above the seat back. Based on the observations of the SCI vehicle inspection, the front row right occupant was not restrained by the manual seat belt system and was most-likely holding a plastic cup with a presumed coffee-based beverage in her left hand.

At impact with the guardrail end terminal, the frontal air bag deployed. The front row right occupant initiated a forward trajectory in response to the 12 o'clock direction of force. The beverage container was displaced from her hand, spilling the contents on the fabric of both air bags and onto the center and left aspects of the windshield. The front row right occupant contacted and loaded through the deployed air bag with her torso. She likely contacted the instrument panel with her abdomen and the windshield with her head. The abdominal contact to the instrument panel resulted in the identified contusion. The windshield contact was evidenced by the star fracture, but did not produce a documented injury. The sources of the soft tissue injuries to her right leg remain unknown.

The front row right occupant exited the vehicle under her own power, then assisted the driver from the vehicle. She was then transported by ambulance to a local hospital, where she was treated and released within hours of the crash.

CRASH DIAGRAM



V1 FINAL REST WITH RAIL PENETRATING INTO VEHICLE

V1 ENGAGES AND DEFORMS SYSTEM, BEGINS COUNTERCLOCKWISE ROTATION

EVENT #1: V1 IMPACTS ET-PLUS END TREATMENT

N

CRASH DIAGRAM
CR16028

PENNSYLVANIA
NOVEMBER 2016

ILLUMINATION: DARK, NOT LIGHTED
ATMOSPHERIC: CLEAR
ROADWAY: BITUMINOUS, DRY
SPEED LIMIT: 113 KM/H (70 MPH)

V1: 2008 MERCURY MARINER

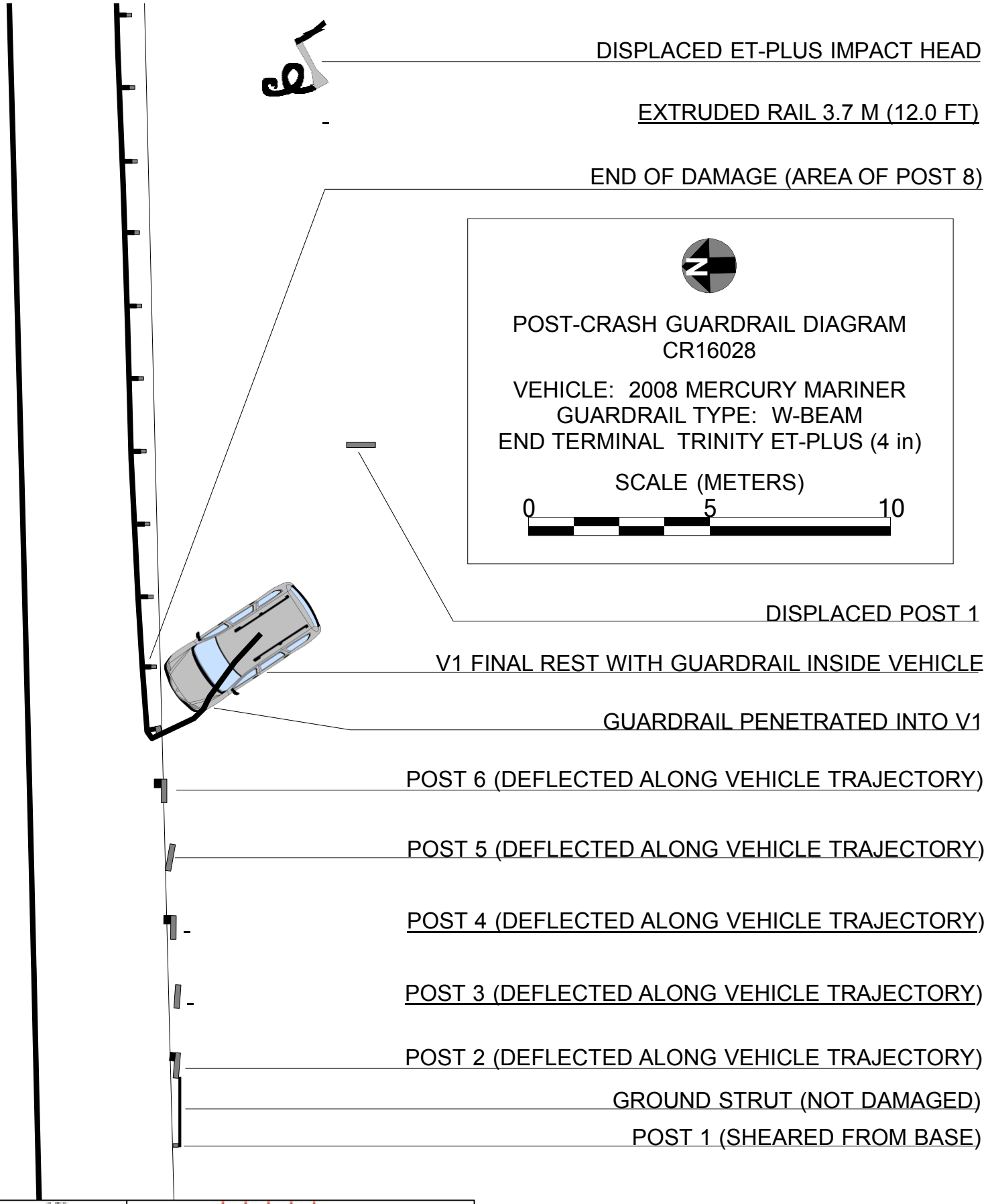
SCALE (METERS)

0 10 20

APPROXIMATE LOCATION ONE SECOND PRIOR TO IMPACT, V1 DRIFTING RIGHT

V1 TRAVELS EAST APPROXIMATELY TWO SECONDS PRIOR TO CRASH

POST-IMPACT GUARDRAIL DIAGRAM



	NHTSA www.nhtsa.gov
Case Number:	CR16028

APPENDIX A: Federal Highway Administration Guardrail Forms

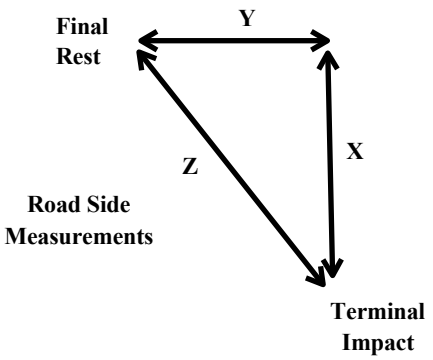
Case No.: CR16028

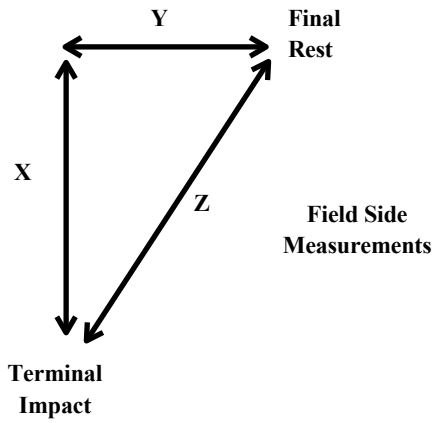
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	November 2016	**Time of Crash (Military)**	Evening
Case Number	CR16028	**State**	PA
Traffic Route	Limited Access	**Direction (Southbound = SB)**	EB
Ambient Conditions (at time of crash)			
Temperature (°F)	32 °F	**Lighting**	Dark
Atmospheric	Clear		

SCENE INFORMATION	
Type of area where crash occurred	❒Urban ■Rural ❒Suburban
Terminal on a horizontal curve?	■No ❒Curve/LT ❒Curve/RT
Estimated Speed at Impact (mph)	Highway Speed (70 mph); No EDR
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 45 ft 11 in ❒Road side ■Field Side
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X= 45 ft 0 in
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 9 ft 2 in
Super elevation	❒+2% ❒-2% ■NONE or FLAT
Curve Radius (ft.)	N/A

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: CR16028

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	-	-	-	-	-	-	-	-	-
1	Steel	6 x 4	None	N/A	No	N/A	12 ft 4 in	N/A	6 ft 4 in
2	Steel	6 x 4	Composite	5.4 x 14	No	N/A	12 ft 6 in	N/A	6 ft 4 in

Case No.: CR16028

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.)					
3	Steel	6 x 4	Composite	5.4 x 14	No	N/A	12 ft 7 in	N/A	6 ft 2 in
4	Steel	6 x 4	Composite	5.4 x 14	No	N/A	12 ft 1 in	N/A	6 ft 3 in
5	Steel	6 x 4	Composite	5.4 x 14	No	N/A	12 ft 0 in	N/A	6 ft 2 in
6	Steel	6 x 4	Composite	5.4 x 14	No	N/A	11 ft 5 in	N/A	6 ft 4 in
7	Steel	6 x 4	Composite	5.4 x 14	No	N/A	11 ft 1 in	N/A	6 ft 3 in
8	Steel	6 x 4	Composite	5.4 x 14	No	N/A	10 ft 11 in	N/A	6 ft 2 in

Case No.: CR16028

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.)					
9	Steel	6 x 4	Composite	5.4 x 14	Yes	W-beam abraded (by snow plow?)	10 ft 11 in	N/A	N/A
10	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-

Additional Comments:

NONE

Case No.: CR16028

EXTRUDER			
Feeder Channel Width at impact head	■4inches ❒5 inches ❒Other _____		
Guide Chute Exit Height (in.)	20 in		
Connection of feeder channels to head damaged?	■No ❒Yes	Are Welds Broken?	■No ❒Yes
Anchor Cable Present?	❒No ■Yes	Connected?	❒No ■Yes
Rail Extrusion?	❒No ■Yes	Length (ft. in.)	12 ft
Rail Extrusion Direction	❒Traffic Side ■Field Side		
Total Length of Rail Damaged (ft.) [total length would include extruded rail plus damaged rail downstream from head.]	**Total = 38.4 ft** *[12 ft (extruded) + 7.5 ft (in terminal) + 12.8 ft (in vehicle) + 6.1 ft (to seam at Post 7)]*		

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

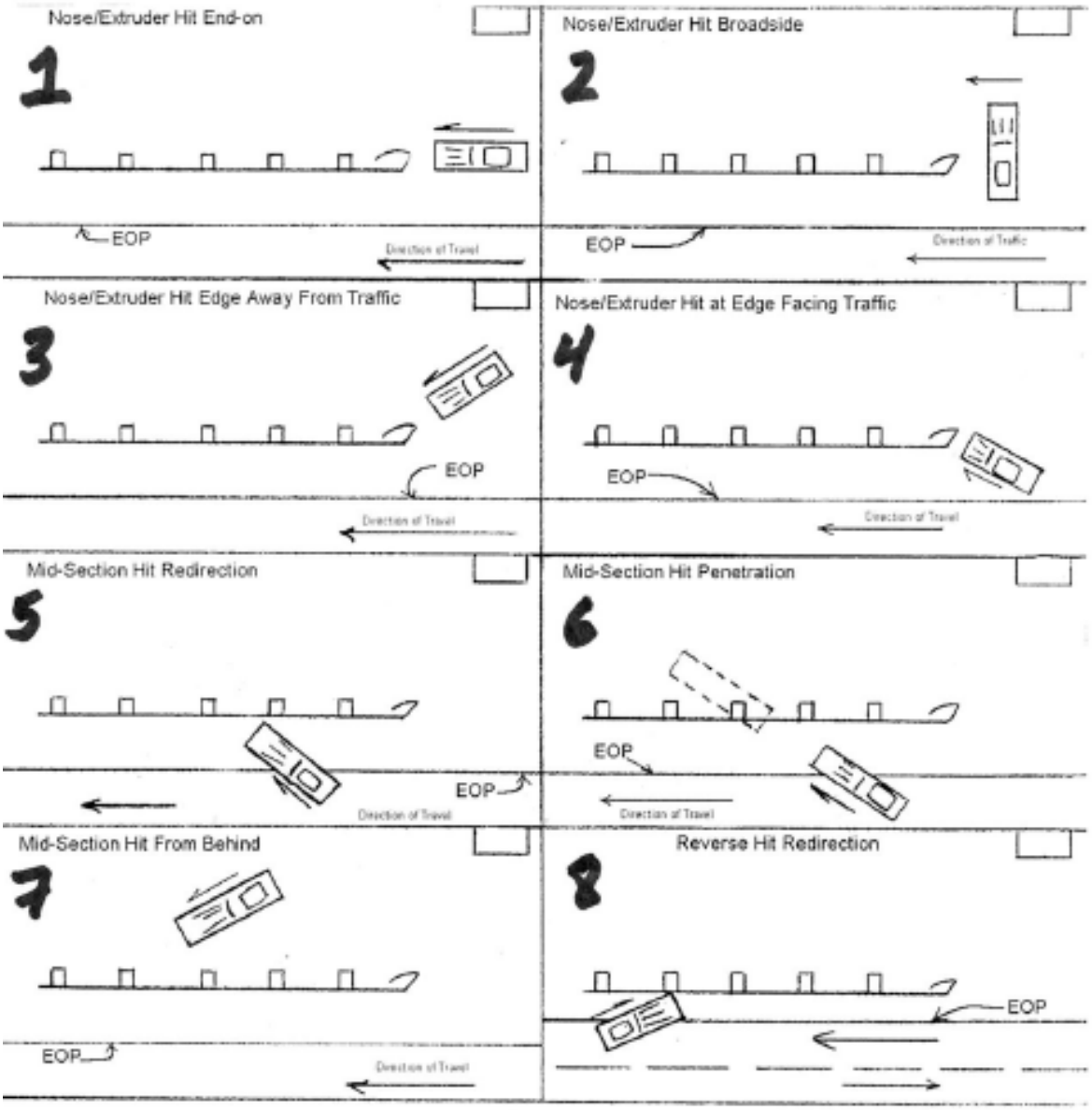
ALL-SYSTEM PERFORMANCE			
Railkinks Downstream of Head?	❒No	■Yes; No. of Kinks:	Two (~Post4, ~Post 7)
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	❒No ■Yes		
Did vehicle impact other objects after impact with terminal?	■No ❒Yes		
Object Contacted	N/A		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	14.4%	7.3%	9.8%
Adjacent Lane Width (ft)	17.1 ft		
Lane Type (NAS EDS Variable: Sur. Type)	Asphalt		
Shoulder Type	Asphalt		
Shoulder Width (ft)	12.2 ft		
Guardrail Height (in)	28 in (*measured between Posts 11 and 12*)		

Case No.: CR16028

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	2008 Mercury Mariner	
Vehicle Identification Number (VIN)	4M2CU39H28Kxxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	3,355 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	12FREE3, 12FLEE8	
Delta-V	15-25 mph (ESTIMATED)	
Occupant Compartment Penetration of rail	❒No	■Yes; Describe: Penetration through LF corner behind LF wheel, through left toe pan and into vehicle. Total penetration measured 90.2 in, extending from right toe pane beneath driver's seat and into second row
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)	N/A	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	N/A	

Case No.: CR16028



DOT HS 812 561
July 2018

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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