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Administration**

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Special Crash Investigations On-site Guardrail End Treatment Impact Investigation Vehicle: 1990 Ford Tempo Location: Missouri Crash Date: January 2017

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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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16. Abstract The interest in this on-site investigation was the performance of an X-Lite guardrail end treatment during impact with a 1990 Ford Tempo. The crash occurred when the 53-year-old male driver of the Ford allowed the vehicle to drift right from its eastbound travel lane on a rural, two-lane roadway. As he approached an overpass over a waterway, the Ford departed the right roadway edge and struck the X-Lite end treatment. As it deformed the guardrail system, the Ford rotated counterclockwise into a rollover sequence before coming to rest at the bottom of an embankment on its left plane. The 53-year-old male sustained police-reported non-incapacitating (B-level) injuries in the crash. Although he refused medical transport, he was taken later by private vehicle to a local hospital for treatment. The driver was treated and released from the hospital within hours of the crash.			
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INVESTIGATION VEHICLE: 1990 FORD TEMPO
LOCATION: MISSOURI
CRASH DATE: JANUARY 2017

BACKGROUND

The interest in this on-site investigation was the performance of an X-Lite guardrail end treatment (**Figure 1**) during impact with a 1990 Ford Tempo. The crash occurred when the 53- year-old male driver of the Ford allowed the vehicle to drift right from its eastbound travel lane on a rural, two-lane roadway. As he approached an overpass over a waterway, the Ford departed the right roadway edge and struck the X-Lite end treatment. As it deformed the guardrail system, the Ford rotated counterclockwise, then fell into a rollover sequence before coming to rest at the bottom of an embankment on its left plane. The 53-year-old male sustained police-reported non-incapacitating (B-level) injuries in the crash. Although he refused medical transport, he was later taken by private vehicle to a local hospital for treatment. The driver was treated and released from the hospital within hours of the crash.

Figure 1: East-facing view of the crash site and damaged X-Lite guardrail system.

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 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 January of 2017. The CID assigned an on-site investigation of the crash to the Special Crash Investigations (SCI) team at Crash Research & Analysis, Inc. The SCI team established cooperation with the MODOT, and the on-site portion of this investigation took place during January of 2017. The on-site investigation focused on the documentation of the X-Lite guardrail system, the damage it sustained during the crash, and an assessment of its performance. The physical environment of the roadway and the guardrail were documented using a total station. An inspection of the Ford documented its exterior and interior damage, and included measurement of the structural deformation, identification of occupant contact points, and an evaluation of manual restraint use. The Ford was not equipped with any supplemental restraints systems or an event data recorder (EDR) due to its age; therefore, recorded crash data was not available.

CRASH SUMMARY

Crash Site

This single-vehicle crash occurred on a two-lane east/west roadway in a rural setting during late afternoon in January 2017. Daylight was fading as sunset approached, and there was no artificial lighting in the area. Environmental conditions in the locale included clear skies and a temperature of 3 °C (37 °F), with calm winds. The asphalt-surfaced roadway was dry. During the SCI crash site inspection, a Nikon Nivo 5.M+ total station was used to document the physical environment of the roadway and crash site.

The lanes of the two-lane roadway were both 3.2 m (10.5 ft) wide, and were separated by yellow centerlines that permitted passing for westbound traffic. There were no edge lines or shoulders bordering the roadway. Speed was regulated by a posted limit of 89 km/h (55 mph). The roadway was bordered to the north and south by agricultural fields and grass/tree vegetation. A guardrail system was located along the south roadside and provided protection to traffic along the inclined approach to a bridge crossing over a ravine and creek. It consisted of W-beam guardrail with steel beam posts, and was installed with the X-Lite end treatment system (see X-Lite End Treatment and Guardrail section of this report). In the area of the crash, the two-lane roadway was straight and level. **Figure 2** shows an east-facing view of the Ford's pre-crash trajectory on approach to the crash location. A crash diagram is included at the end of this technical report.

Figure 2: View of the Ford's eastbound pre-crash travel trajectory 45.7 m (150.0 ft) west of the point of impact.

Pre-Crash

The 53-year-old male operated the Ford eastbound on the two-lane roadway. He was restrained by the automatic passive shoulder portion of the seat belt, but did not use the lap belt portion for manual restraint. Specifics concerning the driver's activities preceding the crash remain unknown due to the driver's lack of cooperation for interview. Regardless, he operated the vehicle along the roadway on approach to the overpass. According to the police accident report (PAR), the driver later stated to the investigating law enforcement agency that he had begun to violently cough while operating the vehicle, which precipitated his loss of direction control of the Ford. Based on the evidence gathered during the SCI inspection of the crash site and the SCI reconstruction, the driver allowed the vehicle to drift right from its travel lane and depart the south roadway. There was no evidence or indication of any avoidance braking or steering input. The Ford remained eastbound in a tracking attitude as its front plane approached the guardrail end treatment.

Crash

The first crash event occurred as the Ford's front plane struck the face of the X-Lite end treatment. Direct contact to the Ford's front plane was located to the left of the vehicle's centerline. As the vehicle engaged the end treatment, a counterclockwise rotation about the vehicle's vertical axis was induced. Crash forces began deforming the X- Lite end treatment as the first section was displaced downstream. The combination of the Ford's rotation and its off-center alignment and engagement with the end treatment deformed the end terminal in such a manner that the impact head of the X-Lite system deflected off the end of the second section of W-beam. This affected the ability of the system to perform as designed, and although crash forces continued to deform the end treatment, it did not collapse in a telescopic manner. **Figure 3** shows the damaged end treatment and roadside at the area of impact.

Figure 3: East-facing view of the damaged end treatment viewed from the area of initial impact.

The Ford achieved 90-degrees of total counterclockwise rotation between Post-3 and Post-4 as it continued eastbound with its center of mass along the field side of the end treatment. The steep roadside and pitch of the vehicle contributed to a fall-over rollover sequence (Event #2). The vehicle rolled one quarter turn uninterrupted onto its right plane. An impression in the loose gravel of the embankment from the right roof side rail evidenced the vehicle's 90-degree (perpendicular) north-facing orientation to the roadway between Post-5 and Post-6.

Figure 4: West-facing view of the crash site from beyond the Ford's final rest position in the roadside.

The vehicle continued to rotate counterclockwise about the vertical axis and, due to the combination of the steep slope of the roadside and gravity, began to translate backward down the embankment. Still on its right plane, the Ford's right rear wheel furrowed into the soft soil surface near the bottom of the embankment. The front of the vehicle translated toward the west as a result of the sustained counterclockwise rotation, and the Ford then fell back onto its wheels. It continued to roll onto its left plane and came to final rest on its left plane facing west, after completing two uninterrupted quarter-turns. During this movement, the front plane of the vehicle narrowly missed a wooden utility pole that was located at

the base of the embankment. **Figure 4** shows the steep roadside and area of the Ford's final rest position, as well as the pre-crash approach of the Ford, in a west-facing view from beyond final rest.

Post-Crash

Local law enforcement, fire department, and emergency medical services (EMS) personnel responded to the crash scene. First arriving emergency personnel located the driver walking around outside of the overturned vehicle after he had climbed up and out of the vehicle through the right front door. The driver refused medical treatment/transport at the crash scene, but was taken directly from the crash scene to a local hospital by private vehicle for evaluation and treatment of his reported non-incapacitating injuries. He was treated and released from the hospital's emergency department within hours of the crash. A local recovery service removed the Ford from the crash site and towed it to a local yard, where it was held pending completion of the law enforcement investigation. It remained at that yard at the time of the SCI vehicle inspection.

X-LITE END TREATMENT AND GUARDRAIL

The X-Lite system end terminal was a re-directive, gating end piece designed for encasing the ends of W-beam guardrail systems. The system was manufactured by Barrier Systems, Inc., a division of the Lindsay Corporation, and could be configured in a seven-post or nine-post installation with either a tangent or flared design. Installation manuals and the manufacturer's literature can be found at www.barriersystemsinc.com/xlite-end-terminal.

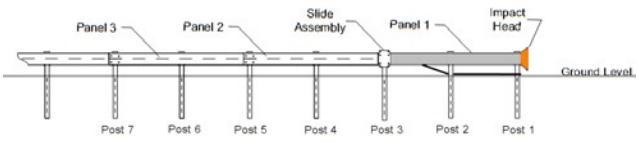


Figure 5: Schematic showing the pre-crash arrangement of the X-Lite end terminal's design.

The X-Lite system was comprised of an impact head, specially designed crimped posts, tension rods, a cable assembly, a slider assembly, and other standard guardrail components. It had energy-absorbing capabilities during head-on impacts, was re-directive starting at Post 3, and had been tested in accordance with the Test Level 3 (TL3) conditions of the National Cooperative Highway Research Project Report 350 (NCHRP Report 350). The end terminal's design absorbed energy through the slide assembly during telescopic movement of the impact head along up to three panels of standard W-beam guardrail. **Figure 5** is a schematic of a seven-post installation showing the pre-crash arrangement of the end terminal.

The installed X-Lite was a tangent system, comprised of seven 15 x 10 cm (6 x 4 in) steel I-beam posts with 193 cm (76.0 in) nominal spacing. Measured at an undamaged section of guardrail, the W-beam's height measured 74 cm (29.0 in). The impact face measured 34 x 61 cm (13.4 x 24.0 in), width by height, and was attached to the leading edge of the W-beam. The first panel of W- beam spanned Post-1 through Post-3, and was bolted to slots in Post-1 and 2. No block-outs were required at Post-1 and 2. A slider assembly was attached to the end of Panel-1

and bolted to Post- 3 through a block-out with a slotted connection in the slider. The slots allowed the panel to separate from the posts during an impact so that the panel could telescope down along the guardrail system via the slider assembly.

Tensioned ground struts connected Post-1 and Post-2, with a tensioned cable between Post-2 and 3. Post-1 was weakened by slots cut into the flanges of the I-beam. Panel-2 of the W-beam spanned Post 3 to 5. This panel was bolted through the slot in the W-beam and a block-out to Post-4. Panel-3 of the W-beam spanned Posts 5 to 7 and was bolted through block-outs at Post-6 and 7. Four shear bolts, painted yellow by the manufacturer for identification, connected the adjacent sections of the W-beam. These bolts were designed to shear during a crash and allow the panels to telescope.

The SCI investigator inspected the damaged components and assessed the performance of the end terminal, impact head, and guardrail system. Data concerning the X-Lite system was documented on the FHWA Guardrail Forms, **Appendix A,** below. Post-1 was deformed 58 degrees to the east along the vehicle's eastbound crash trajectory (**Figure 6**). Post-2 was deformed 25 degrees to the east and fully displaced from the ground, projected along the vehicle's eastbound crash trajectory. The tension rods and spade remained attached to Post-2 (**Figure 7**), and the entire assembly was found at the base of the embankment. Post-3 was deformed 49 degrees to the east, and although the composite blockout remained attached, it was fractured. Post-4 was deformed approximately 20 degrees toward the south, evidentiary of engagement with the Ford as it maintained its crash trajectory through the roadside. Post-4's blockout remained in place and was undamaged. No damage was noted to Post-5 or any of the remaining posts in the system.

Figure 6: South-facing lateral view of the damaged end treatment and the locations of Post-1 and Post-2.

Figure 7: View of Post-2 at roadside, completely displaced from its original location.

Panel-1 was displaced downstream 6.2 m (20.3 ft), measured in reference to the pre-crash location of the slider assembly at Post-3 and the post-crash location of the slider assembly engaged against the blockout of Post-6. An approximate 90-degree bend was located immediately downstream of Panel-1's center aspect, 2.1 m (7.0 ft) downstream of the impact head.

During the impact, the Ford struck the impact-face of the end terminal and displaced Panel-1 of the W-beam downstream. The bolts at Post-1 and Post-2 pulled from the slots in the posts, and the slider assembly pulled from the bolt at Post-3. As the Ford continued eastbound and displaced Panel-1, it deformed Post-1 with its left front corner and completely displaced Post-2 with its front plane. Corresponding crash forces and the location of the impact engagement on the left front of the Ford induced a counterclockwise rotation to the vehicle.

The combination of the offset impact and the lateral component of the vehicle's counterclockwise rotation in this crash resulted in misalignment of the impact head with Panel-2 as the system was deformed. Instead of engaging Panel-2, the impact head deflected up and over Panel-2 and deformed toward the field side by the rotating vehicle. No damage to Panel-2 or Panel-3 of the system was visible. As the vehicle continued eastward and maintained counterclockwise rotation, it deformed Post-3 and Post-4 as it rotated and initiated the right side-leading rollover. The impact head, still engaged with the Ford's front plane, bent nearly 90 degrees as the vehicle reached approximately 80 degrees of counterclockwise rotation and began the rollover. **Figure 8** shows an oblique view of the damaged end treatment and the exposed end of Panel-2, while **Figure 9** shows a lateral view of the displaced and deformed Panel-1.

Figure 8: Overall view of the deformed X-Lite system at the time of the SCI inspection.

Figure 9: Lateral view of the displaced and deformed Panel-1 of the X-Lite guardrail end treatment system.

After the Ford rolled one quarter turn and achieved momentary rest, its front plane disengaged from the impact head as the vehicle began to slide down the steep slope of the embankment. No further deformation was sustained by the guardrail or X-Lite end treatment system, despite the occurrence of subsequent crash events involving the vehicle. Following the crash, a MODOT

representative used orange marking spray paint to highlight the damaged portion of the guardrail identified for replacement. A post-impact guardrail diagram showing the deformed system is included on **Page 14**.

1990 FORD TEMPO

Description

The 1990 Ford Tempo was identified by the VIN 1FAPP36X7LKxxxxxx. It was a five-passenger sedan manufactured in August 1989. A mechanical odometer read 104,685 km (65,048 mi) at the time of the SCI inspection. Given its age, it is possible the actual reading was underreported (the vehicle's mechanical odometer had only five available digits). The Ford (**Figure 10**) was configured on a 254 cm (100.0 in) wheelbase with front-wheel drive. It was powered by a 2.3 liter inline 4-cylinder gasoline engine that was linked to an automatic transmission. A placard located on the frame of the left front door indicated that the vehicle's gross vehicle weight rating (GVWR) was 1,670 kg (3,682 lb). The vehicle manufacturer's recommended tire sizes and pressures were P185/70R14 at 207 kPa (30 PSI) for all four axle positions. At the time of the SCI vehicle inspection, the Ford was equipped with various tires of the recommended size. All had ample tread and were not restricted. Only the left front tire was damaged, with a cut in its side wall. The remaining tires were undamaged and inflated.

Figure 10: Front left oblique view of the Ford.

The interior of the Ford was configured with two rows for the seating of up to five occupants (2/3). The front seats were bucket seats with manual seat track and seatback recline adjustments, and were equipped with adjustable head restraints. At the time of the SCI inspection, the driver's seat was adjusted to its full-rearward track position, with the seatback slightly reclined and the adjustable head restraint fully downward. The second row was a three-passenger bench seat. Manual restraint systems in the Ford consisted of 3-point lap and shoulder seat belts for all outboard positions, with a lap belt only for the second row center position. The Ford was not equipped with any supplemental restraint devices.

Exterior Damage

Damage associative to the multiple event crash was located on the Ford's front, right, and left planes. A distinct area of direct contact from impact with the X-Lite end terminal's impact face (Event 1) was located on the left aspect of the Ford's front plane. Within the damage pattern was longitudinal deformation to front plane components, including the hood, upper radiator support, lower radiator support, and surrounding body structure. The front bumper beam was constructed

of a polymer, and had fractured completely from the impact. The front bumper fascia and grille were also fractured, and the fractured portions of these components had separated from the Ford's front plane. Despite the loss of portions of these components, accurate documentation of the deformation and crush was made possible with reference to the lower radiator support and surrounding body structure.

Figure 11: Front plane damage pattern to the 1990 Ford Tempo.

Figure 12: Deformation to the 1990 Ford Tempo's front plane from an overhead perspective.

The direct contact damage began 9 cm (3.5 in) right of center and extended 53 cm (20.9 in) left to 44 cm (17.3 in) left of center (**Figure 11**). The left edge of the direct contact was 19 cm (7.5 in) right of the left front bumper corner. A direct and induced damage length (Field-L) of 126 cm (49.6 in) across the entire frontend width of the Ford was used to document a residual crush profile. Measurements were documented by the SCI investigator using a Nikon Nivo 5.M+ total station at the original height of the front bumper, and were adjusted to account for free-space. This profile produced the following measurements: C1 = 7 cm (2.8 in), C2 = 29 cm (11.4 in), C3 = 35 cm (13.8 in), C4 = 2 cm (0.8 in), C5 and C6 = 0 cm (0 in). Maximum crush was located just to the left of the vehicle's centerline (**Figure 12**). The Collision Deformation Classification (CDC) assigned to the Ford for the X-Lite end treatment impact damage was 12FYEW2.

The impact forces displaced the end treatment and translated to a non-horizontal direction during the later stages of engagement (due to the counterclockwise rotation of the vehicle and transition into the Event 2 rollover dynamics). Although these characteristics were beyond the scope of analysis for the WinSMASH program, its barrier algorithm was used to calculate an estimated delta-V for the impact. The calculated total delta-V was 17 km/h (11 mph), with respective longitudinal and lateral components of -17 km/h (-11 mph) and 0 km/h (0 mph). The results were a borderline reconstruction due to characteristics that were beyond the model's scope, and they appeared underestimated based on the visible damage sustained by the Ford and SCI expertise.

The rollover (Event 2) began as an uninterrupted right side-leading fall-over event. Damage included minor surface scratching and abrasions, with minor deformation to the side body paneling. The right side mirror was fractured from its mount and hung loosely from the side of the vehicle. All right side glazing remained intact, and all four doors were operational. Grass and soil were loosely embedded into the seams surrounding the body panels and doors of the right plane. There was no measurable residual deformation associated with the right side-leading roll.

Figure 13 shows the right plane of the Ford and the associated right-leading rollover damage, while **Figure 14** shows the Ford's left plane and the left-leading rollover damage.

Figure 13: Right plane damage to the Ford.

Figure 14: Left plane damage to the Ford.

There was also minimal damage visible to the Ford's left plane relative to the final two quarter-turns of the rollover. As previously described, the dynamics of the Ford's roll and its direction was reversed as the vehicle slid down the embankment. This caused the Ford to roll to the left, from its right plane back onto its wheels and then onto its left plane. These dynamics were evidenced by the displacement of numerous loose objects in the Ford's interior against the interior aspect of the left side doors as observed at the time of the SCI inspection. Minor surface scratches, minor deformation to body components, and soil/vegetation in the body panel seams evidenced the vehicle's bi-directional rollover sequence. All left plane glazing remained intact and undamaged, with both left side doors closed and operational. There was no measurable residual deformation associated with the left-directional roll. Due to the nature of the rollover dynamics and the direction of initial roll, the CDC assigned to the Ford 00RDAO2. No WinSMASH calculations could be performed for the rollover Event, because the non-horizontal nature of the forces was beyond the scope of the program's capabilities.

Event Data Recorder

The 1990 Ford Tempo was not equipped with any supplemental restraints. It did not have EDR capabilities. No crash data could be imaged from the Ford.

Interior Damage

The interior of the Ford sustained minor damage that consisted of occupant contact. There was no intrusion into the occupant compartment space of the Ford associative to the multiple-event crash. As previously stated, all doors remained closed during the crash and were operational at the time of the SCI inspection. All side plane glazing was intact and undamaged. However, the backlight glazing had disintegrated prior to the crash. The vehicle's owner had used a nylon tarpaulin and duct tape to cover the void created by the missing backlight. The windshield glazing was fractured along its bottom aspect. It remains unknown if this fracture occurred either as a result of or prior to the incident crash.

Other damage to the windshield included a circular area of fracture, located directly above the steering column. It was apparent that this fracture was resultant from contact by the driver's head during the crash sequence. **Figure 15** shows the fracture pattern to the windshield of the Ford. It likely occurred as the driver was displaced forward during the initial contact and engagement with the X-Lite end treatment during the first impact event. Other occupant contact included an area of scuffing to the left lower instrument panel/knee bolster, which also likely occurred in conjunction with the windshield fracture during Event 1. No further crash related damage or occupant contact in the Ford was discernable at the time of the SCI vehicle inspection.

Figure 15: Interior view of the Ford showing driver contact to the windshield.

Manual Restraint Systems

The Ford was equipped with 3-point lap and shoulder seat belts for the four outboard seat positions, with a lap belt only for the second row center position. Both front row seat belt systems consisted of a manual lap belt with automatic passive shoulder belt. The lap belt required the occupant to physically extend and buckle the latch plate, while the shoulder belt automatically moved into position across the occupant (or empty seat) position when the door was closed and the vehicle's ignition was activated. The shoulder belt's track was located in the frame of the front doors, along the respective upper A-pillar and roof side rail. None of the seat belts were equipped with pretensioners.

At the time of the SCI inspection, inoperability of the vehicle's electrical system prevented operation of the automatic shoulder portion of the driver's seat belt. It was locked in the B-pillar position, evidentiary that it was automatically in use at the time of the crash. The webbing itself was discolored, dirty, and worn, with various stains that evidenced its age. The lap belt portion of the system was found fully retracted into the retractor that was mounted on the left aspect of the driver's seat. The SCI investigator pulled the lap webbing from the retractor, exposing a distinct area of dirt and wear near the latch plate with clean webbing extending into the retractor (**Figure 16**). Based on this condition and the lack of loading evidence, it was apparent that the manual lap portion of the driver's seat belt was not in use at the time of the crash. Therefore, the SCI investigator categorized the driver as partially restrained: the automatic passive shoulder portion of the system restrained the driver, but he did not use the manual lap belt portion.

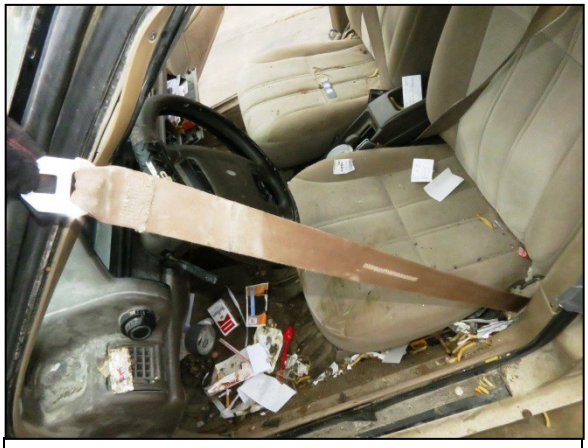


Figure 16: Driver's seat belt in the Ford at the time of the SCI vehicle inspection.

Supplemental Restraint Systems

The involved 1990 Ford Tempo was not equipped with any supplemental restraint devices. Based on internet research, it appeared that frontal air bags for the driver and front right passenger positions were optional equipment for the 1990 Ford Tempo.

1990 FORD TEMPO OCCUPANT DATA

Driver Demographics

Age/Sex:	53 years / male
Height:	180 cm (71 in)
Weight:	107 kg (236 lb)
Eyewear:	Unknown
Seat Type:	Forward-facing bucket seat with adjustable head restraint
Seat Track Position:	Rearmost
Manual Restraint Usage:	Partially restrained: automatic passive shoulder portion used, manual lap portion not used
Usage Source:	Vehicle inspection
Air Bags:	None available
Alcohol/Drug Involvement:	None
Egress from Vehicle:	Exited vehicle under own power
Transport from Scene:	Private vehicle to a local hospital
Type of Medical Treatment:	Treated and released on the same day as the crash

Driver Injuries

Injury No.	Injury	AIS 2015	Involved Physical Component (IPC)	IPC Confidence
1	Minor closed head injury	110009.1	Windshield	Certain
2	Abrasions on top of head	110202.1	Windshield	Certain
3	Chest wall contusion, NFS	410402.1	Steering wheel	Probable

Source – Emergency room records

Driver Kinematics

The 53-year-old male was seated in the driver's seat of the Ford. Based on the observations of the SCI inspection, the driver was only partially restrained by the vehicle's available 3-point lap and shoulder seat belt: the automatic passive shoulder portion was engaged, but the driver did not use the manual lap portion. The driver stated to the investigating law enforcement officer that he experienced an uncontrolled coughing fit while he operated the Ford eastbound on the local roadway, which precipitated a loss of control by the driver that lead to a right roadside departure by the Ford.

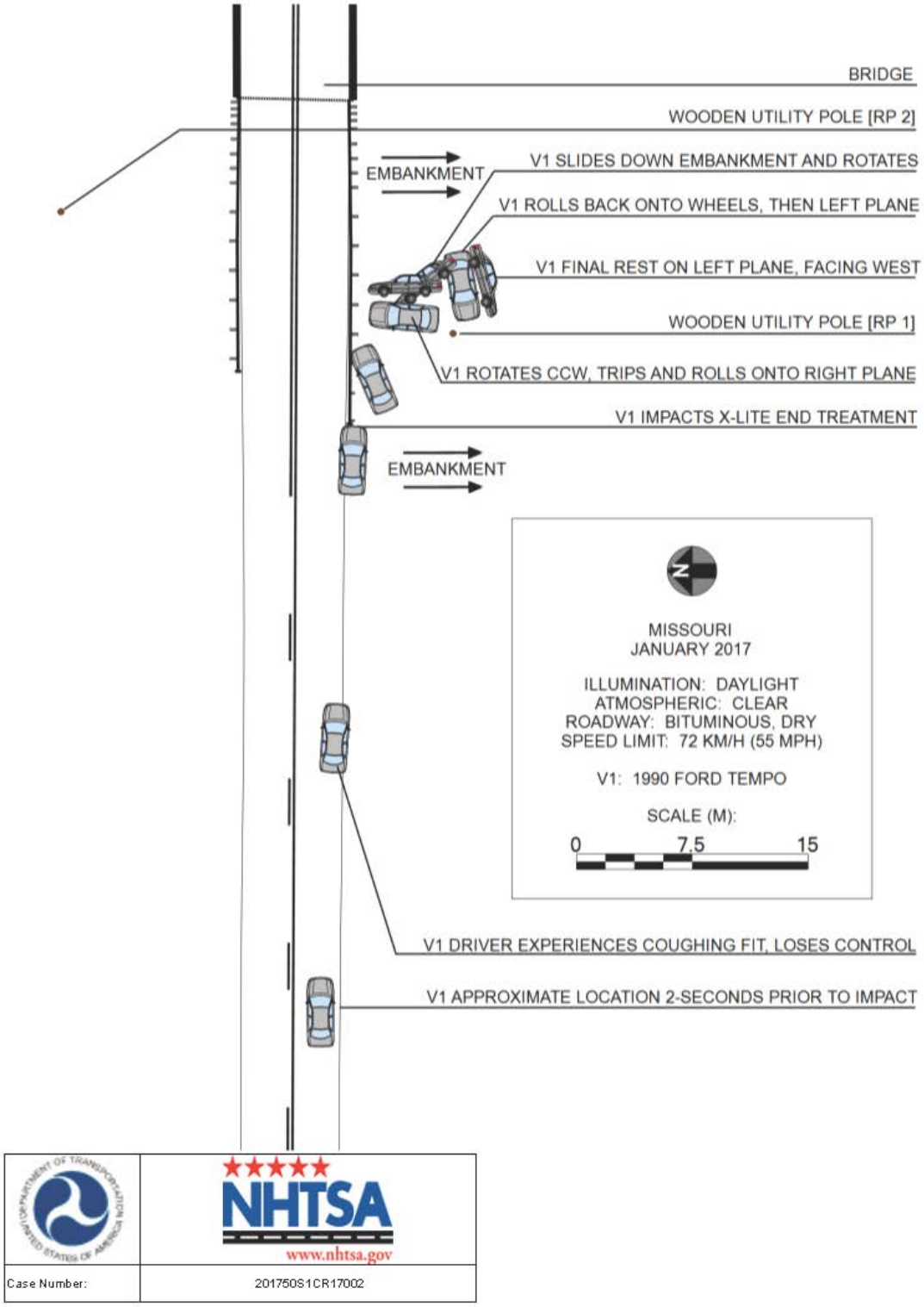
At impact with the X-Lite end treatment, the driver initiated a forward trajectory in response to the longitudinal component of the frontal crash forces. He loaded the automatic shoulder portion of the seat belt. However, his lack of use of the manual lap portion permitted his body to slide forward and over the shoulder portion of the seat belt.

The driver's knees contacted and scuffed the left lower instrument panel. His torso and chest probably contacted the steering wheel as he loaded the shoulder portion of the automatic seat belt. The combination of the loading of the seat belt and contact with the steering column produced chest wall contusions. In conjunction with these kinematics, the driver's head flexed forward and contacted the windshield glazing. This contact was evidenced by a distinct fracture pattern to the glazing and produced abrasions to the top of the driver's head and a closed head injury.

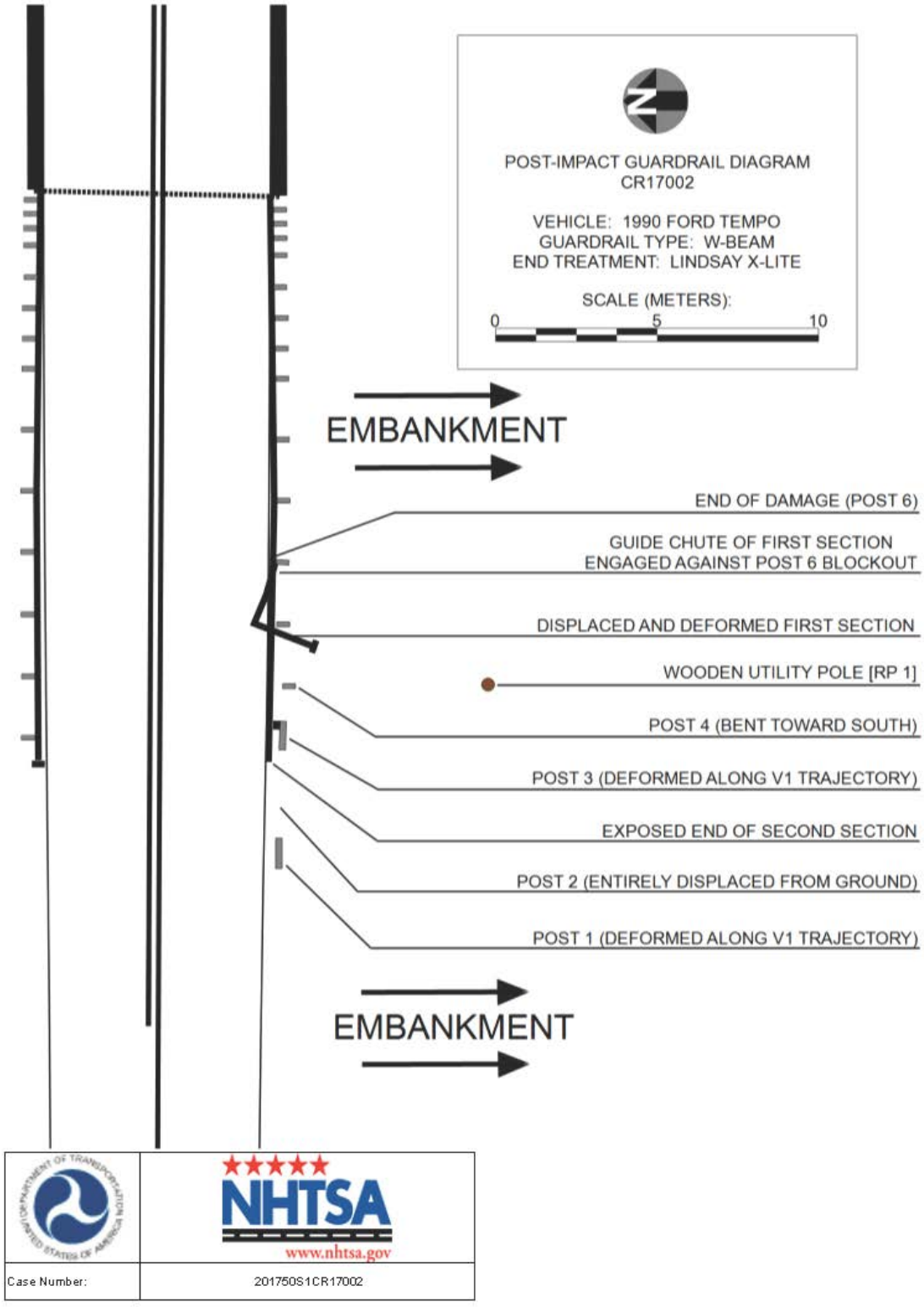
The driver remained forward and out of position as the Ford rotated counterclockwise. As the dynamics of the right side-leading rollover were initiated, the driver was momentary directed away from the vehicle's center of gravity. However, momentary rest and the force of gravity induced a right lateral trajectory to the displaced driver. His right lower leg likely contacted the short center console between the two front seat positions, but the shoulder belt portion restricted his overall lateral movement. After the Ford slid down the embankment, the driver was redirected left laterally as the vehicle began to roll back to the left. The slow rollover was of insufficient severity to significantly displace the driver or induce further injury. The driver contacted the left front door with his left flank as the Ford came to final rest on its left plane. However, there was no physical evidence discernable to support such contact. These dynamics did not result in additional occupant injuries.

The driver slid from beneath the automatic shoulder belt and stood upright on the left door of overturned vehicle. He reached upward and opened the right front door, then climbed upward and out of the vehicle. This was evidenced by footprints on the left door panel, right aspect of the driver's seat cushion, and right aspect of the center console/tunnel. He refused medical treatment/transport at the crash scene, but was taken by a private vehicle to a local hospital for evaluation. At the local hospital, he received treatment for his injuries and was discharged within hours of the crash.

CRASH DIAGRAM



POST-IMPACT GUARDRAIL DIAGRAM



APPENDIX A: Federal Highway Administration Guardrail Form

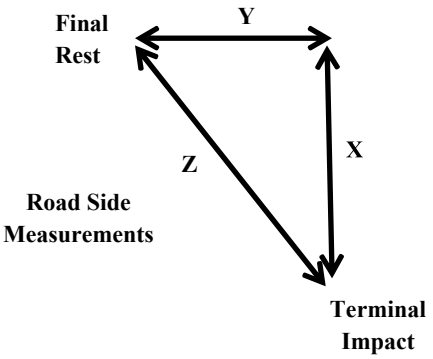
Case No.: CR17002

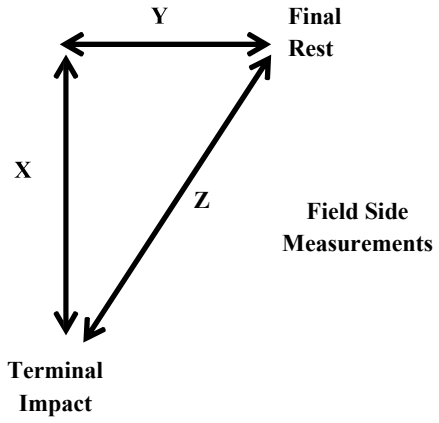
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	May 2017	**TIME OF CRASH (MILITARY)**	EVENING
Case Number	CR17002	**State**	MO
Traffic Route	LOCAL	**Direction (Southbound = SB)**	EB
Ambient Conditions (at time of crash)			
Temperature (°F)	37 °F	**Lighting**	DAYLIGHT
Atmospheric	OVERCAST		

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)	45 mph *(estimated)*
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 39 ft 0 in ❒Road side ■Field Side
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 27 ft 11 in
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 27 ft 2 in
Super elevation	❒+2% ■-2% ❒ NONE or FLAT
Curve Radius (ft.)	N/A

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





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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 Compo-site	D x W (in.)					
0	-	-	-	-	-	-	-	-	-
1	STEEL I-BEAM	6 in x 4 in	NONE	N/A	NO	NONE	2 ft 2 in	N/A	6 ft 3 in
2	STEEL I-BEAM	6 in x 4 in	NONE	N/A	NO	NONE	2 ft 0 in	N/A	6 ft 9 in

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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 Compo-site	D x W (in.)					
3	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	2 ft 8 in	N/A	6 ft 0 in
4	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	2 ft 6 in	N/A	6 ft 4 in
5	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	2 ft 4 in	N/A	6 ft 5 in
6	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	2 ft 0 in	N/A	6 ft 2 in
7	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	1 ft 8 in	N/A	6 ft 3 in
8	STEEL I-BEAM	6 in x 4 in	COMP.	8 in x 4 in	NO	NONE	1 ft 4 in	N/A	6 ft 3 in

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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 Compo-site	D x W (in.)					
9	STEEL I-BEAM	6 in x 4 in	WOOD	8 in x 6 in	NO	NONE	0 ft 10 in	N/A	3 ft 1 in
10	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-

Additional Comments

NONE

Case No.: CR17002

EXTRUDER			
Feeder Channel Width at impact head	❒4inches ❒5 inches ❒Other _____		
Guide Chute Exit Height (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.)	
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.]			

TELESCOPE				
Rail Displacement	❒No	■Yes Length: 20 ft 4 in	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		
Did vehicle impact other objects after impact with terminal?	❒No ■Yes		
Object Contacted	GROUND (ROLLOVER)		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	-54%	-49%	-58%
Adjacent Lane Width (ft)	10 ft 4 in		
Lane Type (NAS EDS Variable: Sur. Type)	ASPHALT		
Shoulder Type	NO SHOULDER		
Shoulder Width (ft)	N/A		
Guardrail Height (in)	16 – 29 in		

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VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	1990 FORD TEMPO	
Vehicle Identification Number (VIN)	1FAPP36X7LKxxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	2,756 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	12FYEW2	
Delta-V	17 mph *(WinSMASH est.)*	
Occupant Compartment Penetration of rail	■ No	❒ Yes; Describe:
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)	EMBANKMENT	
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	FALL-OVER	

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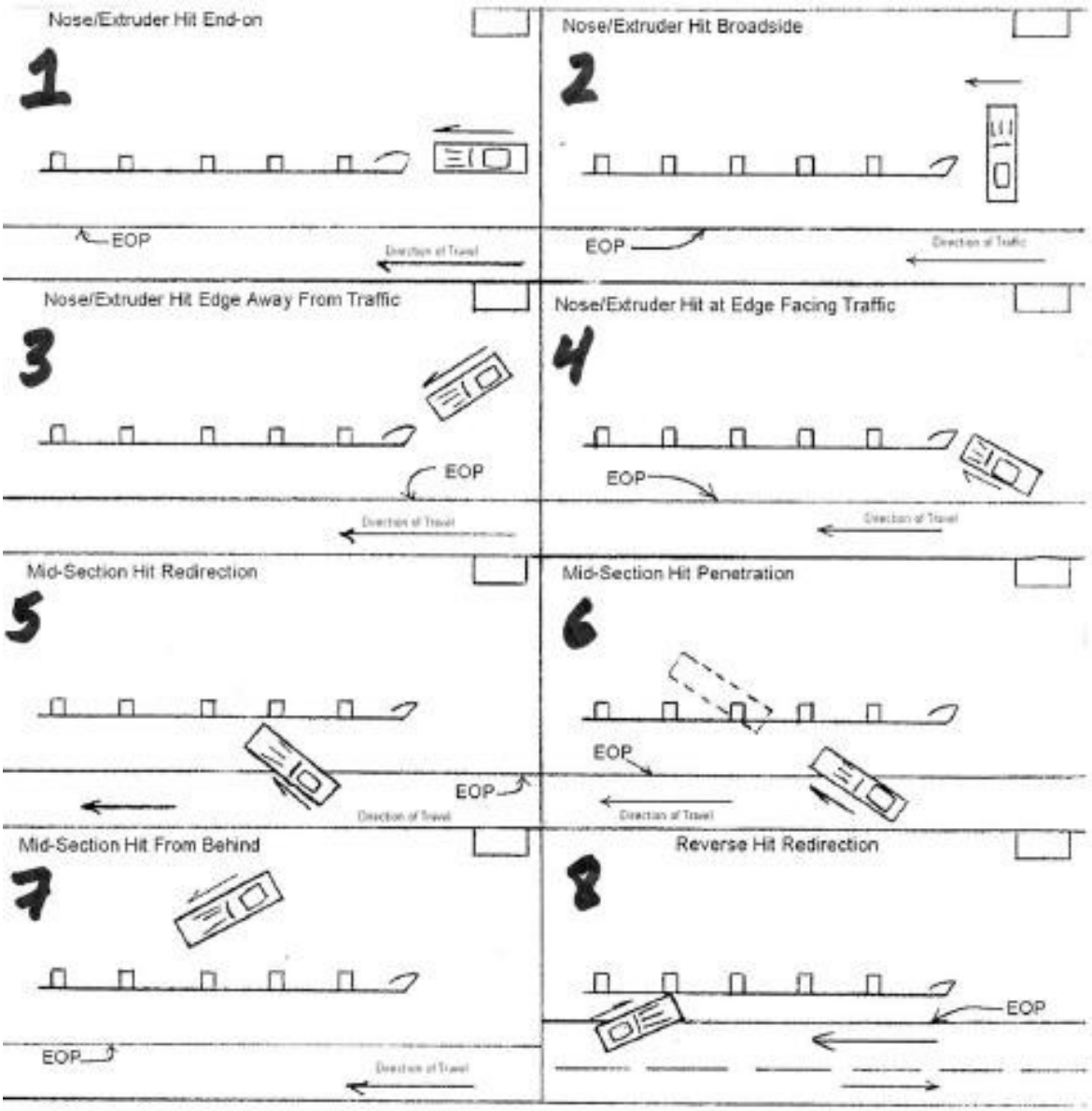

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U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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