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# Special Crash Investigations: On-Site ET-Plus Guardrail End Treatment Crash Investigation; Vehicle: 2003 Nissan Maxima; Location: Missouri; Crash Date: April 2016

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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 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.

**16. Abstract**

This report documents the on-site investigation of an ET-Plus guardrail end treatment that was struck by a 2003 Nissan Maxima. The investigation was conducted at the request of the Federal Highway Administration. The Nissan was traveling east on a divided roadway, driven by a belted 19-year-old male. While the driver negotiated a right curve, a deer entered the roadway. The driver took evasive left steering and braking action but overcorrected to the right, initiating a clockwise rotation. The driver lost control as the Nissan yawed across the travel lanes toward the right roadway edge, where it struck the ET-Plus end treatment. The guardrail system redirected the Nissan back onto the shoulder of the roadway, where it came to final rest. The driver exited the vehicle without assistance. He denied injury at the crash scene and was not medically treated or transported.

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## Background

This report documents the on-site investigation of an ET Plus guardrail end treatment struck by a 2003 Nissan Maxima (Figure 1). The Nissan was traveling east on a divided roadway, driven by a belted 19-year-old male. While the driver negotiated a right curve, a deer entered the roadway. The driver took evasive left steering and braking action but overcorrected to the right, which caused a clockwise rotation. The driver lost control of the Nissan as it yawed across the travel lanes toward the right roadway edge, where it struck the ET-Plus end treatment. The guardrail system redirected the Nissan back onto the shoulder of the roadway, where it came to final rest. The driver exited the vehicle without assistance. He denied injury at the crash scene and was not medically treated or transported.

*Figure 1. East-facing view of the Nissan and partial view of the struck guardrail system (on-scene image supplied by MoDOT)*

The crash was identified by a Missouri Department of Transportation (MoDOT) engineer who 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 forwarded the notification to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration in May 2016. The investigation was conducted at the request of the FHWA. The CID then assigned an on-site investigation of the crash to the Special Crash Investigations (SCI) team at Crash Research & Analysis, Inc. The SCI team initiated contact and cooperation with the MoDOT, and the on-site investigation occurred in May 2016. On-site activities consisted of the inspection of the crash site and the ET-Plus guardrail system, the damage it sustained during the crash, and an assessment of its performance. The Nissan was also inspected to assess its exterior

damage, interior damage, occupant contact, manual restraint systems, and supplemental restraint systems condition. Due to its age, the Nissan was not equipped with an Event Data Recorder (EDR) supported by a commercially available tool. Therefore, the SCI investigator had no means by which to image any data from the Nissan during the inspection.

## Summary

### Crash Site

The crash occurred on the eastbound portion of a divided roadway at night in April 2016. According to the National Weather Service, local conditions at the time included overcast skies and light rain with a temperature of 13 °C (55 °F), 94% relative humidity, and 26 km/h (16 mph) easterly winds.

The physical environment of the roadway was documented during the SCI crash site inspection using a Nikon Nivo 5.M+ total station mapping system. In the area of the crash, the eastbound portion consisted of a 3.8 m (12.5 ft) wide left travel lane and a 4.0 m (13.1 ft) wide right travel lane. They were delineated by a single dashed-white line, with a single solid-white fog line and a single solid-yellow median line. The right travel lane was supported by a 1.3 m (4.3 ft) wide south shoulder, while the left travel lane was supported by a 2.7 m (8.9 ft) wide north shoulder.

Both shoulders contained rumble strips adjacent to the shows travel lanes. Surfaces consisted of concrete shoulders and asphalt travel lanes. The roadway curved slightly to the right (Figure 2) with a radius of curvature of 860 m (2,822 ft). Along the curve, a guardrail adjacent to the south shoulder of the roadway provided protection for an upcoming overpass over a waterway. The guardrail began 110 m (360 ft) west of the overpass. It consisted of W-beam guardrail with steel I-beam posts and was installed with an ET-Plus end treatment system (see ET-Plus End Treatment and Guardrail section of this report). Speed was regulated by a posted limit of 105 km/h (65 mph). A crash diagram is included at the end of this technical report.

*Figure 2. East-facing view of the Nissan's eastbound pre-crash travel trajectory on the divided roadway*

### Pre-Crash

The 19-year-old male drove the Nissan eastbound in the right lane of the divided roadway. He used the vehicle's 3-point lap and shoulder seat belt for manual restraint. The driver stated during SCI interview that he had left work shortly before the crash and was traveling to his residence.

According to the driver, he drove the Nissan at 97- to 105 km/h (60- to 65 mph) on a straight travel trajectory and approached the slight right curve. The driver made gradual right steering input around the curve and maintained speed. A deer suddenly entered the roadway into the Nissan's travel path. The driver saw the deer, abruptly steered left, and braked to avoid impact. The Nissan crossed the center line into the eastbound lane.

The driver recognized the problem and steered abruptly back to the right. This overcorrection caused the rear tires to lose traction on the wet road, initiating clockwise rotation. The Nissan yawed from the left travel lane back across the centerline into the right travel lane. The driver was unable to regain control as it crossed over the solid white fog line and rumble strip, then across the south shoulder.

As the Nissan approached the south roadway edge and the ET-Plus guard rail end treatment, it achieved approximately 80 degrees of total clockwise rotation, evidenced by yaw marks from the left side tires on the asphalt. Figure 3 shows the visible yaw marks, which have been highlighted in the image for clarity. The total length of the left rear tire mark measured 46.5 m (152.6 ft), while the left rear measured 21.2 m (69.6 ft) long. Based on these tire marks, the Nissan's angle of approach to the ET-Plus end treatment was 29 degrees.

*Figure 3. East-facing view of the Nissan's CW yawing tire marks on approach to impact with the guardrail*

## Crash

The first impact occurred when the front of the Nissan struck the traffic side of the ET-Plus end terminal. Based on the combination of the damage sustained by both the guardrail system and the vehicle, the distance traveled by the Nissan as it yawed on the approach to the guardrail, and SCI expertise, the estimated speed at impact was 72 km/h (45 mph). Associated crash forces from the 10 o'clock sector resulted in the deployment of the Nissan's frontal air bag system for both the driver and the front-right positions.

The Nissan maintained its forward momentum and clockwise rotation in prolonged engagement with the guardrail and rotated downstream along the traffic side of the guardrail. The Nissan's

left side engaged the traffic side of the guardrail from immediately downstream of the displaced ET-Plus impact head at Post 2 until the area of Posts 4 and 5. The vehicle maintained its clockwise rotation as it deformed the end treatment system, and its back plane rotated into and engaged the guardrail from Post 5 to Post 6. With the vehicle's momentum exhausted after deforming the guardrail end treatment until the area of Post 6, the Nissan came to final rest.

At rest the Nissan had its back plane against the guardrail between Post 5 and Post 6, facing northwest at an angle across the south shoulder (Figure 1). The Nissan's center of mass was located 7.1 m (23.2 ft) east of the initial guardrail impact and 1.2 m (4.0 ft) north of the roadway edge. During the crash, the Nissan engaged and deformed 9.8 m (32.3 ft) of the W-beam guardrail.

## Post-Crash

Local law enforcement, fire department, and emergency medical services personnel responded to the crash scene. The driver exited the Nissan without assistance prior to their arrival. He denied injury at the crash scene and refused medical care. The driver was not medically treated or transported. The Nissan was removed from the crash scene by a local service and towed to a local yard, then later transferred by its insurer to a regional vehicle salvage facility.

## ET-Plus End Treatment and Guardrail

The ET-Plus System end terminal was an energy-absorbing end treatment that terminated the 69 cm (27.2 in) high W-beam guardrail. The 10 cm (4 in) version of the ET-Plus System end terminal was a tangent system manufactured by Trinity Highway Products. The end terminal was designed to be displaced along the W-beam and absorb impact force by crushing and 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 manufacturer's literature and installation manuals can be found at www.highwayguardrail.com/products/etplus.html.

The ET-Plus impact head and guardrail treatment system were inspected post-crash and documented by the SCI investigator by measurements and photographs. A diagram showing the deformed guardrail is included at the end of this report. The completed FHWA guardrail forms are included at the end of this report as Appendix A. For exemplar purposes and comparison in this discussion of damage, a similar ET-Plus installation is shown in Figure 4. Although the struck version of ET-Plus end terminal in this investigation was a 10 cm (4 in) model, the exemplar was a 13 cm (5 in) version of the ET-Plus. It was installed on the same roadway as the involved guardrail system, on the opposite side of the roadway.

*Figure 4. Image depicting an exemplar ET-Plus installation located on the opposite side of the roadway from the struck system*

The involved system's installation was a nine-post configuration over a distance of 15.5 m (50.8 ft). It consisted of a 10 cm (4 in) version of the ET-Plus rail flattening head assembly, sections of standard W-beam guardrail, foundation tubes at Posts 1 and 2 with a ground strut, a tension cable from Post 1 to the W-beam guardrail between Post 1 and Post 2, and nine standard steel I-beam posts at Posts 1 to 9. 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 guardrail itself was supported by a carriage bolt at Post 2, with a composite block-out and carriage bolt providing support at Posts 3 to 9. At Post 9, the guardrail system transitioned from the end treatment into standard guardrail, with steel posts, composite block-outs, and carriage bolts.

During the crash, the Nissan struck the traffic-side edge of the impact face of the end terminal. Only cosmetic damage was sustained by the impact head. Displacement of the impact head flattened the guardrail, which curled toward the field side. Approximately 38 cm (15.0 in) of flattened W-beam extruded from the impact head (Figure 5). Note that the orange paint markings were not related to the SCI inspection of the guardrail system or the impact head. Based on comparison to the exemplar guardrail installation located on the opposite side of the roadway from the focus system, the total displacement of the impact head along the guardrail was approximately 79 cm (31.1 in).

*Figure 5. West-facing view of the ET-Plus end terminal impact head and deformed W-beam guardrail in their displaced position following the crash*

As the Nissan rotated during the crash sequence, its front plane rotated off of the guardrail and its left plane rotated into the guardrail downstream of the impact head. The Nissan continued clockwise and rotated off of the guardrail with its left plane and into the guardrail again with its back plane. This explains why the impact head was not displaced further downstream. Because of these dynamics, contact with the guardrail by the Nissan wrapped from the vehicle's front plane onto its left plane, and then onto its rear plane.

During the crash and as the Nissan rotated along the guardrail, deformation was sustained by multiple posts and the guardrail was deflected into the area of protection. Posts 2 to 5 were all deflected in the direction of the Nissan's trajectory. An inspection of the guardrail system revealed that the carriage bolts had pulled through their holes in the guardrail system as designed at all of the affected post locations. The mass of the impact head caused the guardrail to form bends in the locations of the post holes as the end terminal was deflected toward the field side (south).

The deflection of the guardrail and inertia of the impact head produced an approximate 80-degree bend in the guardrail at the Post 2 and Post 3 locations, with an approximate 20-degree bend at the Post 4 location and an approximate 70-degree bend at the Post 6 location. There were no apparent kinks formed in the guardrail during the crash sequence. Figure 6 shows the deformed ET-Plus end terminal in its displaced position in the area of protection at the time of

the SCI crash site inspection. Note that the orange paint markings on the damaged guardrail were unrelated to the SCI inspection.

*Figure 6. North-facing view of the impact head and deformed end terminal system lying in the area of protection at the time of the SCI crash site inspection*

The height of the W-beam was 69 cm (27.0 in), measured at an undamaged section of the guardrail at Post 7. Dimensions of the end terminal impact head measured 38 cm (15.0 in) in width and 71 cm (28.0 in) high. The extruder head's length was 50 cm (19.7 in) and the guide chute's length was 91 cm (35.8 in), producing a total overall length for the ET-Plus end terminal device of 141 cm (55.5 in). The width of the guide chute (Figure 7) was 10 cm (4.0 in).

The first five posts were constructed of 10 x 15 cm (4 x 6 in) steel I-beam and deflected toward the southeast. Post 2 was deflected approximately 80 degrees from vertical, Post 3 was deflected approximately 55 degrees from vertical, Post 4 was deflected approximately 40 degrees from vertical and twisted approximately 60 degrees clockwise, and Post 5 was deflected approximately 70 degrees from vertical (Figure 8).

*Figure 7. Measurement of the guide chute width of the ET-Plus end terminal at the time of the SCI crash site inspection*

*Figure 8. Southeast-looking view showing the damaged guardrail*

The W-beam guardrail sustained damage from Post 1 to Post 6, with a total damaged length of 9.9 m (32.3 ft). Post 1 had separated from the base but remained attached to the impact head. The top surface of the base measured 8 cm (3.1 in) above ground level. Post 2 was partially sheared on its struck side slightly above ground level. The location of the shear was through the shear holes, located at ground level. A ground angle strut was originally installed between Post 1 and Post 2 on the field side. This strut tensioned the system and was bolted to the side of the Post 1 base sleeve and directly to Post 2. The angle strut was at ground level and remained in place post-crash. It did not appear to have sustained direct contact during the crash sequence.

## 2003 Nissan Maxima

### Description

The 2003 Nissan Maxima (Figure 9) was a five-passenger sedan identified by the VIN JN1DA31A53Txxxxxx. It was manufactured in October 2002 and equipped with the GLE level trim package. The vehicle's odometer reading could not be determined during the SCI vehicle inspection as a result of damage sustained by the electrical system that rendered it inoperable. The body was configured on a 275 cm (108.3 in) wheelbase with front-wheel drive. It was powered by a 3.5-liter, 6-cylinder, gasoline engine linked to a 4-speed automatic transmission.

*Figure 9. Front-left oblique view of the Nissan*

The Nissan's gross vehicle weight rating was placarded at 1,948 kg (4,295 lb). Front and rear gross axle weight ratings were 1,062 kg (2,342 lb) and 902 kg (1,989 lb). The vehicle's curb weight was 1,494 kg (3,294 lb). There was no visible placarding of recommended tire sizes/pressures. Manufacturer literature indicated that the original equipment tire sizes for all four axle positions were P215/55R17. At the time of the SCI vehicle inspection, the Nissan had size P215/55R17 tires at both front positions and at the right-rear position. The left-rear wheel and tire had been removed from the vehicle for unknown reasons and were not with the vehicle. Specific tire data measured at the time of the SCI inspection were as follows:

| | Manufacturer/ Model | Tire Identification Number (TIN) | Measured Tread Depth | Measured Pressure | Restriction | Damage |
|---|---|---|---|---|---|---|
| LF | Nexen 5000 | 8E8V ____ ____ | 2 mm (3/32 in) | 228 kPa (33 PSI) | No | None |
| LR | N/A | N/A | N/A | N/A | N/A | N/A |
| RR | Dunlop SP Sport | PJPJ 571R 0215 | 7 mm (9/32 in) | 221 kPa (32 PSI) | No | None |
| RF | Nexen 5000 | 8E8V BFML 1513 | 2 mm (3/32 in) | 228 kPa (33 PSI) | No | None |

The Nissan had two rows seating up to five occupants (2/3). The front seats were bucket seats with electronic seat track and seat back recline adjustments, and had adjustable head restraints. At the time of the SCI inspection, the driver's seat was adjusted to its full-forward position, with the seatback upright and the adjustable head restraint 3 cm (1.2 in) upward. However, the left-front door was engaged against the left aspect of the seat and seat frame, such that the controls

for the seat's electronic adjustments were in contact with the intruded door. As a result, it was evident that the seat was not in the same position post-crash as it had been pre-crash. According to the driver, he had adjusted the seat to a middle track position with the seatback slightly reclined prior to the crash.

The second row of the Nissan was a three-passenger bench seat with integral head restraints at the outboard positions. Manual restraints in the Nissan were 3-point lap and shoulder seat belts for all five seat positions. Both front seat belts were adjustable at their shows D-ring locations. Supplemental restraints consisted of dual-stage frontal air bags and outboard, seat-mounted, side impact air bags for both the driver and front-right positions.

### Exterior Damage

The Nissan sustained impact damage to its front, left, and back planes consistent with the dynamics of the crash. Associated with the Nissan's rotation, the damage and engagement with the guardrail began on the front plane and wrapped onto the left and back planes.

*Figure 10. Front-plane view of the Nissan and location of the impact head direct contact (highlighted)*

Direct contact damage on the front plane from the initial impact with the ET-Plus end terminal impact head began 10 cm (4.0 in) right of center and extended 24 cm (9.4 in) to the right (Figure 10). This damage was evidenced by vertically oriented impressions and crush that mirrored the side profile of the impact head. A second area of deformation to the front plane was visible on the lower radiator support, beginning 14 cm (5.5 in) right of center and extending 16 cm (6.3 in) to the right. This damage was attributed to Post 1. Engagement of the front of the Nissan with the guardrail, in conjunction with the vehicle's rotation, fractured and sheared the front bumper fascia, front bumper beam, front bumper beam mounts, grille, and both front headlight assemblies from the vehicle. Longitudinal deformation was sustained by both the upper and lower radiator supports, hood, and engine compartment components. The only deformation (crush) sustained by the lower radiator support was in the area of the Post 1 damage, which measured 5 cm (2.0 in).

The Nissan's left plane engaged the guardrail between Post 2 and Post 5, resulting in lateral deformation to the left-front and left-rear doors. Based on the physical evidence at the scene and

the vehicle's damage, Post 3 struck the center aspect of the left-front door at 74 cm (29.1 in) rearward of the left-front axle. Direct damage extended rearward 20 cm (7.9 in), and the maximum crush measured 19 cm (7.5 in). The door-sill differential measured 13 cm (5.1 in). Post 4 struck the rear aspect of the left-rear door in the area of the left C-pillar, 27 cm (10.6 in) forward of the left-rear axle position. Direct contact extended 20 cm (7.9 in) rearward. Along the entire left plane were longitudinal abrasions and minor deformation from contact with the W-beam guardrail. Figure 11 shows the forward aspect of the Nissan's left plane and the Post 3 damage.

The back plane of the Nissan engaged the guardrail between Post 5 and Post 6. Damage from Post 5 was located at the left corner and included disintegration of the left taillight assembly with minor deformation to the left-rear fender and left-rear bumper corner. Direct contact on the back plane extended 119 cm (46.7 in) from the left-rear corner to 40 cm (15.7 in) right of center. In the damage pattern was deflection of the bumper fascia with surface scratches and abrasions. Figure 12 shows the rear-plane damage to the Nissan.

*Figure 11. Left view depicting the damage at the left-front door of the Nissan*


*Figure 12. View of the Nissan's rear-plane damage*

Due to the dynamics of the crash and the rotation of the vehicle, no definitive crush profile could be documented that would be representative of the impact deformation to the Nissan. For the purposes of reconstructing the damage and impacts to the Nissan, three separate collision deformation classifications (CDCs), one each to front, left, and back planes, were assigned. The assigned CDCs were 10FDEW2, 09LDEW2, and 07BDEW1.

The circumstances of the crash were beyond the scope of the WinSMASH program. No representative or comparison delta V could be calculated. The multiple plane damage was rated as moderate.

## Event Data Recorder

The 2003 Nissan Maxima did not have an EDR supported by a commercially available tool. Therefore, no crash data were available to be imaged by the SCI investigator during the inspection.

## Interior Damage

The Nissan's interior sustained damage that consisted of air bag deployment and occupant compartment intrusion. Damage to the left-front door from Post 3 impact resulted in the intrusion of all four door quadrants into the occupant compartment. The door was also jammed shut. The greatest intrusion of the door was located at its center aspect immediately above the sill, such that the intruded door was engaged against the seat cushion and adjustment controls of the driver's seat. Figure 13 shows the intruded left-front door. It is likely that minor intrusion occurred due to the Post 4 impact in the area of the left C-pillar. However, deformation to the left-rear door prevented it from re-latching, and there was no measurable intrusion of the left C-pillar. Measurements of the intrusion of the left-front door were as follows:

*Figure 13. Overhead view of the intruded left front door engaged against the driver's seat of the Nissan*

| Quadrant | Magnitude | Direction |
|---|---|---|
| Forward Lower | 11 cm (4.3 in) | Lateral |
| Rear Lower | 8 cm (3.1 in) | Lateral |
| Forward Upper | 2 cm (0.8 in) | Lateral |
| Rear Upper | 1 cm (0.4 in) | Lateral |

It is likely that the driver contacted the left-front door during the crash sequence. However, there was no discernable evidence of such contact visible at the time of the SCI vehicle inspection. No occupant contact was observed to the instrument panel, and there was no deformation to the steering wheel or separation of the steering column's sheer capsules.

## Manual Restraint Systems

The Nissan had 3-point lap and shoulder seat belts for all five seat positions. Each front seat belt system consisted of continuous-loop webbing, a sliding latch plate, and an adjustable D-ring. At the time of the SCI vehicle inspection, the driver's D-ring was adjusted fully upward and the front-right D-ring was adjusted fully downward. The driver's seat belt webbing retracted onto an emergency locking retractor (ELR), while the front-right system used a switchable automatic locking retractor (ALR)/ELR. The second-row seat belt systems also used continuous-loop webbing and sliding latch plates but were not height adjustable.

Inspection of the driver's seat belt system found the webbing slightly extended from the retractor. However, it spooled freely from the ELR. Historical wear was visible on both the latch plate and the webbing. There were two visible areas of abrasions and loading on the webbing. The first was located from 58 cm (22.8 in) to 64 cm (25.2 in) above the lower anchor and was attributable to latch plate loading. The second area, attributable to D-ring loading, was located from 143 cm (56.3 in) to 154 cm (60.6 in) above the lower anchor. This second area of loading is depicted in Figure 14. Based on its post-crash condition, the SCI investigator determined that the driver was restrained by the seat belt system at the time of the crash.


*Figure 14. Area of D-ring loading to the Nissan driver's lap and shoulder seat belt system*

## Supplemental Restraint Systems

Supplemental frontal protection in the Nissan was provided by dual-stage frontal air bags for the driver and front-right positions. Supplemental side-impact protection included outboard front-seat-mounted air bags. During the guardrail end terminal impact, both frontal air bags deployed from their modules. The driver's air bag module was located in the center hub of the steering wheel rim, while the front-right occupant's was located in the top of the right instrument panel. Neither side impact air bag deployed as a result of the crash.

The driver's frontal air bag deployed from the module through the H-configuration cover flaps without damage or occupant contact to the module cover flaps. In its deflated state, the air bag measured 62 cm (24.4 in) in approximate overall diameter and extruded a maximum of 35 cm (13.8 in) rearward from the module. There were two 4 cm (1.6 in) vent ports located on the upper aspect of the back of the air bag. No visible occupant contact or crash related damage to the driver's frontal air bag was discernable. Figure 15 shows the Nissan driver's frontal air bag.

The passenger's frontal air bag also deployed from its module through the H-configuration cover flaps without damage to the air bag or cover flaps. The large air bag measured 40 cm (15.7 in) wide and 60 cm (23.6 in) tall in its deflated state. Maximum rearward excursion measured 40 cm (15.7 in) at the air bag's upper aspect. The air bag was vented on each side near its upper aspect

by a 4 cm (1.6 in) vent port. Inspection of the front right air bag was unremarkable. Figure 16 shows the large deployed air bag in its deflated state.

*Figure 15. View of the deployed driver's frontal air bag in the Nissan*

*Figure 16. Deployed passenger's frontal air bag in the Nissan*

## 2003 Nissan Maxima Occupant

### Driver Demographics

| | |
|---|---|
| Age/sex: | 19 years/male |
| Height: | 183 cm (72 in) |
| Weight: | 86 kg (190 lb) |
| Eyewear: | None |
| Seat type: | Forward-facing bucket seat with adjustable head restraint |
| Seat track position: | Middle |
| Manual restraint usage: | 3-point lap and shoulder seat belt system |
| Usage source: | Vehicle inspection |
| Air bags: | Frontal air bag deployed; outboard seat-mounted air bag available, but not deployed |
| Alcohol/drug data: | None |
| Egress from vehicle: | Exited vehicle under own power |
| Transport from scene: | None |
| Type of medical treatment: | None |

### Driver Injuries

| Injury No. | Injury | Injury Severity AIS 2015 | Involved Physical Component (IPC) | IPC Confidence Level |
|---|---|---|---|---|
| N/A | None | N/A | N/A | N/A |

*Source: police crash report; driver interview.*

### Driver Kinematics

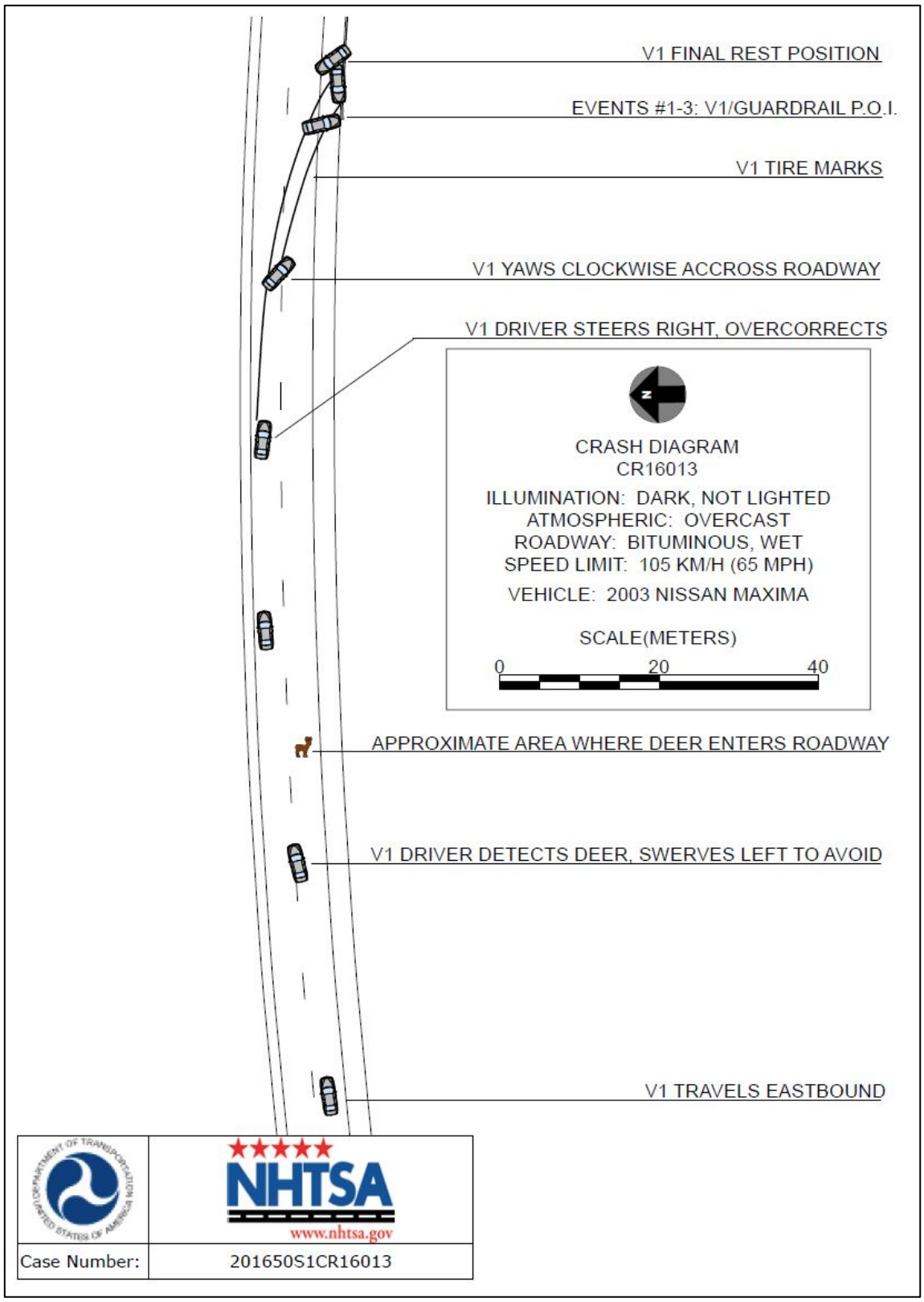
The 19-year-old male reported that he was seated in the driver's seat of the Nissan with the seat adjusted to a middle track position and the seatback slightly reclined. Based on the observations of the SCI inspection, the driver used the available 3-point lap and shoulder seat belts for manual restraint. Driving eastbound on the divided roadway and negotiating the slight right curve, the driver saw a deer entered the roadway ahead. He steered left and braked to avoid impact. The driver then steered back right and overcorrected, resulting in a loss of control as the Nissan yawed clockwise left-side leading. This imparted a slight left lateral trajectory. The Nissan departed the roadway and struck the impact head and guardrail.

At impact with the end terminal impact head and guardrail system, crash forces deployed the Nissan's driver and front-right passenger frontal air bags. The driver initiated a forward/left trajectory in response to the 10 o'clock direction of the impact forces. His use of the seat belt prevented his unrestricted movement in the vehicle's interior. His body loaded the seat belt, resulting in the loading evidence observed by the SCI investigator during the vehicle inspection. Although not supported by discernable contact evidence, it is likely that his left lower leg and left flank contacted and loaded the left-front door as it intruded into the occupant compartment when the Nissan's left plane hit the guardrail. These contacts produced unknown injuries.

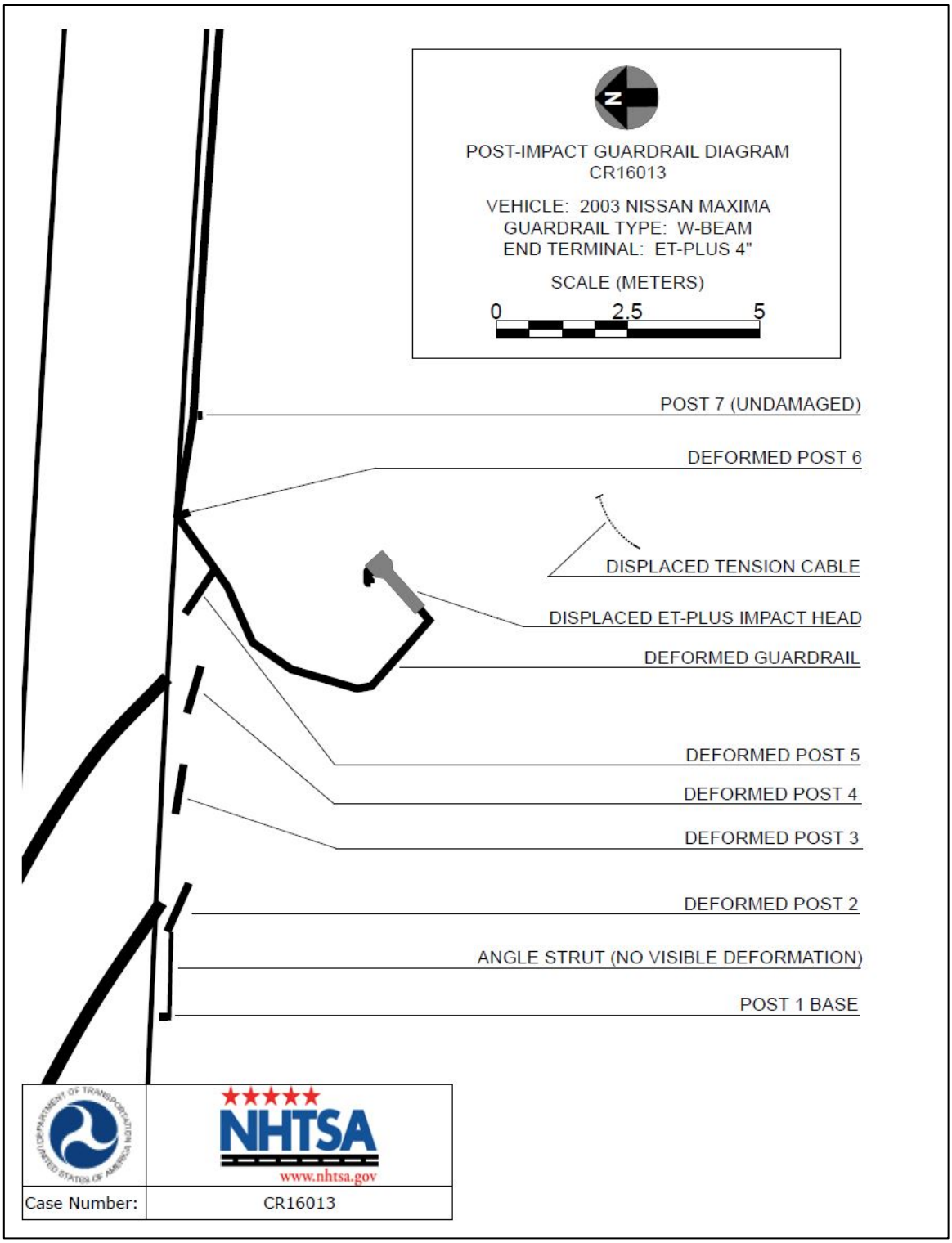
As the Nissan rotated along the guardrail and its back plane engaged the guardrail, the driver was directed rearward toward the driver's seat back. He remained in the driver seat as the Nissan came to final rest. Intrusion of the left-front door resulted in the engagement of the door panel against the electronic controls for the driver's seat adjustments, which caused the seat track to move forward and the seat back to move upright.

The driver unbuckled the seat belt system. He climbed over the center console of the front row and exited the vehicle through the right-front door, without assistance. The driver denied injury at the crash site and did not receive any medical care. He was not medically transported from the crash scene.

# Crash Diagram



# Post-Impact Guardrail Diagram



# Appendix A: Federal Highway Administration Guardrail Forms

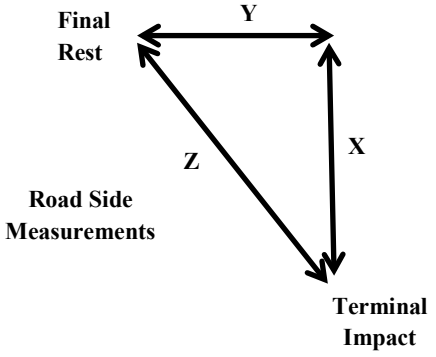
**Case No.: CR16013**

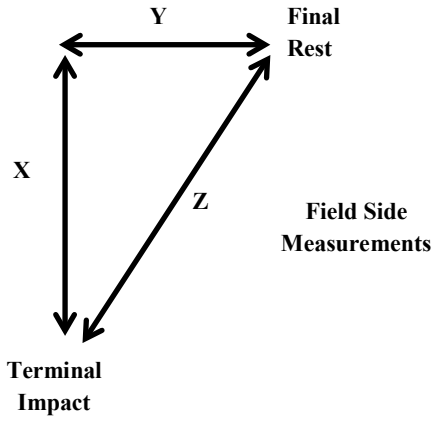
| PREPOPULATED DATA (BY OTHERS) | | | |
|---|---|---|---|
| **Date of Crash** | April 2016 | **Time of Crash** | Late evening |
| **Case Number** | CR16013 | **State** | Missouri |
| **Traffic Route** | Divided highway | **Direction (Southbound = SB)** | EB |
| **Ambient Conditions (at time of crash)** | | | |
| **Temperature (°F)** | 55 °F | **Lighting** | Dark, Not lighted |
| **Atmospheric** | Overcast, light 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) | Estimated impact speed 45 mph |
| Est. distance (straight line) from terminal impact to COM final rest position (ft.) | Z = 23.5 ft<br>☒ Road Side ☐ Field Side |
| Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.) | X = 23.2 ft |
| Est. distance (normal) from either<br>1. the white paint line; or<br>2. roadway/shoulder/pavement edge<br>to COM rest position (ft.) | Y = 4.0 ft |
| Super elevation | ☐ +2% ☒ -2% ☐ NONE or FLAT |
| Curve Radius (ft.) | 2822 ft |

**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 | | 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 | 1 ft 3 in | N/A | 6 ft 6 in |
| 2 | Steel | 6 x 4 | None | N/A | No | N/A | 1 ft 4 in | N/A | 6 ft 5 in |

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| GUARDRAIL INSTALLATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Post No. | Post | | Block-Out | | Pre-Existing Damage | | Offset to Post or Post Hole | | 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 | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 4 in | N/A | 6 ft 6 in |
| 4 | Steel | 6 x 4 | Composite | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 5 in | N/A | 6 ft 6 in |
| 5 | Steel | 6 x 4 | Composite | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 6 in | N/A | 6 ft 4 in |
| 6 | Steel | 6 x 4 | Composite | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 6 in | N/A | 6 ft 2 in |
| 7 | Steel | 6 x 4 | Composite | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 6 in | N/A | 6 ft 4 in |
| 8 | Steel | 6 x 4 | Composite | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 8 in | N/A | 6 ft 1 in |

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| GUARDRAIL INSTALLATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Post No. | Post | | Block-Out | | Pre-Existing Damage | | Offset to Post or Post Hole | | 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 | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 7 in | N/A | 3 ft 3 in |
| 10 | Steel | 6 x 4 | Composite | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 7 in | N/A | 3 ft 1 in |
| 11 | Steel | 6 x 4 | Composite | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 7 in | N/A | 3 ft 1 in |
| 12 | Steel | 6 x 4 | Composite | 7.5 x 4 | Yes | Minor scraping to W-beam | 1 ft 7 in | N/A | 3 ft 1 in |

**Additional Comments:**

All pre-existing damage was minor in severity, with no apparent deformation to the W-beam guardrail. Therefore, there also was presumably no deformation/displacement of any of the system's posts.

**Case No.: CR16013**

| 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.) | 1 ft 3 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.] | Total = 32 ft 4 in | | |

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

| ALL-SYSTEM PERFORMANCE | | | |
|---|---|---|---|
| Railkinks Downstream of Head? | ☒ No | ☐ Yes | No. of Kinks in Rail: N/A |
| Was there intrusion into the Occupant Compartment by foreign object (guardrail)? | ☒ No ☐ Yes | | |
| 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 - % | -25% | -23% | -28% |
| Adjacent Lane Width (ft) | 12.7 ft | | |
| Lane Type (NASS EDS Variable: Sur. Type) | Bituminous (asphalt) | | |
| Shoulder Type | Bituminous (asphalt) | | |
| Shoulder Width (ft) | 8.4 ft | | |
| Guardrail Height (in) | 27.2 in | | |

**Case No.: CR16013**

| VEHICLE INFORMATION | | |
|---|---|---|
| Vehicle Type (NHTSA Input) | 2003 Nissan Maxima | |
| Vehicle Identification Number (VIN) | JN1DA31A53Txxxxxx | |
| Vehicle Mass (NASS var.: veh.wgt) | 3,294 lb | |
| Vehicle orientation upon impact | ☐ Case Type 1 ☐ Case Type 2 ☐ Case Type 3<br>☒ Case Type 4 ☐ Case Type 5 ☐ Case Type 6<br>☐ Case Type 7 ☐ Case Type 8 ☐ Other | |
| If 'Other', describe | N/A | |
| Collision Deformation Classification | 10FDEW2, 09LDEW2, 07BDEW1 | |
| Delta-V | Unknown | |
| 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<br>☐ 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 | |

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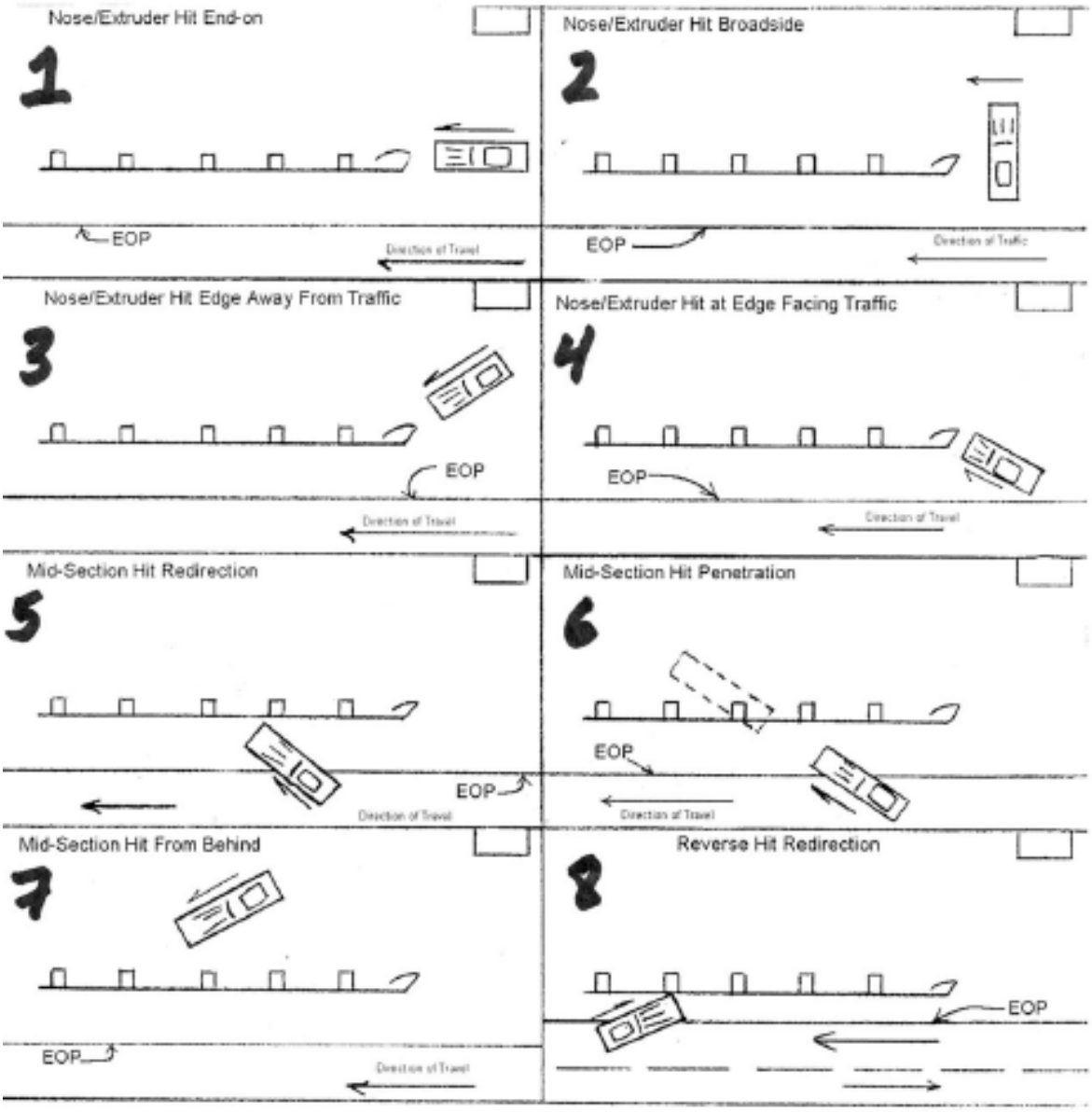

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U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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