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Special Crash Investigations On-Site Guardrail End Terminal Investigation
Vehicle: 2001 Buick LeSabre
Location: Missouri
Crash Date: March 2017

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Each crash represents a unique sequence of events and generalized conclusions cannot be made concerning the crashworthiness performance of the involved 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 a passenger vehicle crash to a Sequential Kinking Terminal (SKT) guardrail end terminal that is of interest to the Federal Highway Administration (FHWA). This crash occurred in a rural area on the north side of a two-lane undivided state highway. The Buick LeSabre was equipped with an event data recorder (EDR); however, the EDR was damaged during the crash and could not be imaged. An unbelted 36-year-old male driver and a belted 33-year-old female front row passenger occupied the vehicle. The Buick was traveling in the eastbound lane in a right curve. As the driver attempted to negotiate the curve, the vehicle drifted left into the westbound travel lane. The driver counter-steered right in an attempt to regain the eastbound lane. As the Buick reentered the eastbound lane, the driver steered left in an attempt to regain directional control of the Buick. The left steering maneuver initiated counterclockwise yaw as the Buick traversed the westbound lane. The vehicle departed the left (north) side of the road and the right plane struck the guardrail end terminal (Event 1). The impact resulted in deployment of the front row passenger's seat-mounted side impact air bag. The vehicle damaged the guardrail and rotated clockwise as it separated from the guardrail and traveled down an embankment. The left plane struck a 28 cm (11.0 in) diameter cedar tree (Event 2), rotated clockwise around the tree, and then came to final rest facing in a northeast direction. The front row right passenger was pronounced deceased at the crash scene. The driver sustained police-reported "B" (non-incapacitating) injuries and was transported by ambulance to a hospital where he was treated for his injuries and released. The vehicle was towed from the crash scene due to damage.

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BACKGROUND

This on-site investigation documents a passenger vehicle impact to a Sequential Kinking Terminal (SKT) guardrail end terminal (**Figure 1)** that is of interest to the Federal Highway Administration (FHWA). This crash was identified by an engineer with the Missouri Department of Transportation (MoDOT), who submitted photographs of the damaged guardrail end terminal to the FHWA. The FHWA determined that the guardrail end terminal and crash type were of interest for further research. This crash investigation was then initiated by the National Highway Traffic Safety Administration in March 2017 and assigned to the Special Crash Investigations team at the Indiana University Transportation Research Center. This single-vehicle crash involved a 2001 Buick LeSabre (**Figure 2**). The crash occurred in Missouri in March 2017 in the evening and the crash scene, guardrail, and vehicle were inspected in the same month.

Figure 1: Overhead view of the damaged end terminal and guardrail

Figure 2: The damaged 2001 Buick LeSabre

This crash occurred in a rural area on the north side of a two-lane undivided State highway. The Buick was equipped with an event data recorder (EDR); however, the EDR was damaged during the crash and could not be imaged. An unbelted 36-year-old male driver and a belted 33-year-old female front row passenger occupied the vehicle. The Buick was traveling in the eastbound lane in a right curve. As the driver attempted to negotiate the curve, the vehicle drifted left into the westbound travel lane. The driver counter steered right in an attempt to regain the eastbound lane. As the Buick reentered the eastbound lane, the driver steered left in an attempt to regain directional control of the Buick. The left steering maneuver initiated counterclockwise yaw as the Buick traversed the westbound lane. The vehicle departed the left (north) side of the road and the right plane struck the guardrail end terminal (Event 1). The impact resulted in deployment of the front row passenger's seat-mounted side impact air bag. The vehicle damaged the guardrail and rotated clockwise as it separated from the guardrail and traveled down an embankment. The left plane struck a 28 cm (11.0 in) diameter

cedar tree (Event 2), rotated clockwise around the tree, and then came to final rest facing in a northeast direction. The front row right passenger was pronounced deceased at the crash scene. The driver sustained police-reported "B" (non-incapacitating) injuries and was transported by ambulance to a hospital where he was treated for his injuries and released. The vehicle was towed from the crash scene due to damage.

CRASH SUMMARY

Crash Site

This crash occurred during the evening on the north side of a two-lane undivided State highway. The weather conditions were light thunderstorms and rain with clear visibility, north-northeast winds at 20 km/h (13 mph), a temperature of 13.9 °C (57 °F), and a dew point of 11.7 °C (53 °F), according to local weather reports. The roadway traversed in an east/west direction and had one bituminous, 3.1 m (10.2 ft) wide lane in each direction. The roadway surface was wet at the time of the crash. The roadway was bordered on each side by a blocked-out, W-beam guardrail equipped with an SKT end terminal. The guardrail protected errant vehicles from a bridge that traversed over a creek. There was no shoulder adjacent to either guardrail; however, on the eastbound approach to the guardrails, the roadway was bordered on the south side by a 0.5 m (1.6 ft) wide bituminous shoulder and a 0.5 m (1.6 ft) wide grass shoulder on the north side. The roadway was curved to the right for eastbound traffic and became straight approximately 80 m (262 ft) prior to the struck guardrail end terminal, which was located on the north side of the roadway. The roadway grade for eastbound traffic at the beginning of the straight section of roadway was -7 percent, which transitioned to level on the approach to the struck guardrail end terminal. The roadway pavement markings consisted of solid white edge lines and a double-yellow center line. A rumble strip was cut into the road surface at each edge line. The speed limit was 89 km/h (55 mph). The crash diagrams are included on pages 13 and 14 of this report.

Figure 3: Eastbound approach of the Buick to the area of lane departure

Figure 4: View northeast to area of onset of yaw marks and approach to end terminal impact

Pre-Crash

The driver of the Buick was traveling eastbound and was negotiating a right curve. The vehicle drifted left and crossed the centerline into the westbound lane (**Figure 3**). The driver initiated a right steering maneuver and crossed back into the eastbound lane. The police reported the onset of tire marks from the left side tires in the westbound lane that were located 132.0 m (433.0 ft) from the impact with the guardrail end terminal. The driver initiated a left steering maneuver as the vehicle reentered the eastbound lane and the Buick began to yaw counterclockwise. The vehicle traveled 32.3 m (105.9 ft) in a northeast direction across the roadway (**Figure 4**) as it continued to yaw counterclockwise and departed the left (north) side of the road. The vehicle continued for an additional 4.8 m (15.7 ft) to impact with the guardrail end terminal with the front portion of the vehicle off-road.

Crash

The right plane of the Buick (**Figure 5**) struck the end terminal (**Figure 6**, event 1). The vehicle was rotated counterclockwise 105 degrees relative to the end terminal at the moment of the impact. The impact speed is not known. The impact was centered on the right front door and the force direction on the vehicle was in the 3 o'clock sector. The crash damaged and kinked a total of 7.6 m (25.0 ft) of guardrail and damaged six posts. The impact resulted in deployment of the front row passenger's seat-mounted side impact air bag. Due to stress overload, the striker post pulled through the B-pillar and the upper hinge tore free of the A-pillar while the lower hinge separated at the pivot. The deformed door intruded an estimated 65 cm (26 in) into the front row right position.

Figure 5: Yellow tape outlines the end terminal contact to the Buick's right front door

Figure 6: Damaged terminal

The outer sheet metal skin of the door remained engaged to the end terminal. The deformed guardrail contacted and crushed the right rear door and quarter panel. WinSMASH could not be used to calculate a delta V for this impact since an impact to a yielding object is out of scope for the program. However; the barrier equivalent speed algorithm of the WinSMASH was used to calculate a barrier equivalent speed of 45 km/h (28 mph) based on the crush to the right plane.

The Buick began to rotate clockwise as it separated from the end terminal. The Buick rotated 110 degrees clockwise and traveled 12.3 m (40.3 ft) down a 12 percent grade of the roadside. The left plane (**Figure 7**) struck a 28 cm (11.5 in) diameter cedar tree (Event 2). The impact fractured and displaced the tree. The force direction on the vehicle was in the 10 o'clock sector and the impact did not result in deployment of the driver's seat-mounted side impact air bag. WinSMASH

calculated a barrier equivalent speed for this yielding object impact of 17 km/h (11 mph). The results should be considered under-estimated since part of the crush profile had to be measured on the sill due to removal of the left front door by emergency responders. The vehicle rotated approximately 70 degrees clockwise from the tree impact as it traveled an estimated 3.5 m (11.5 ft) before coming to final rest northeast of the struck tree heading in a southerly direction.

Figure 7: Damage to the left plane from the impact with 28 cm (11.5 in) diameter cedar tree

Post-Crash

The emergency response system was alerted of the crash; police, fire, and emergency medical personnel responded. Rescue personnel removed the right front door from the vehicle and use hydraulic equipment to remove the left front door of the Buick. The front row right passenger was determined to be deceased and was pronounced by the county coroner. The driver was removed from the vehicle and was transported by ambulance to a local hospital where he was treated for his injuries and released. The Buick was towed from the crash scene to a local tow yard where it was inspected for this investigation.

Guardrail Damage

The right plane of the Buick struck the SKT end terminal and extruded 0.9 m (3.0 ft) of guardrail to the field side (**Figure 8**), damaged six posts (**Figure 9**) and deformed 7.6 m (25.0 ft) of guardrail. The full height and width [51 cm (20.1 in) and 51 cm (20.1 in)] of the face of the end terminal was directly contacted. The guardrail was displaced from posts 1 to 3. Post 1 was separated from its base at the bolt hinge. The base was pulled partially out of the ground and was bent approximately 50 degrees from vertical in the downstream direction. Post 2 was rotated to the ground in the downstream direction about its hinge bolt. Post 3 was bent downstream approximately 50 degrees from vertical and away from the roadway approximately 45 degrees. The composite offset block was slightly damaged but remained attached to the post. Post 4 was bent downstream approximately 10 degrees off vertical and was twisted in the ground toward the field side. The composite offset block remained attached to the post but was slightly damaged and displaced. The bolt was pulled through the guardrail. Posts 5 and 6 remained attached to the guardrail and were slightly displaced in the

Figure 8: Extruded guardrail and field side of the end terminal

Figure 9: View east to the damaged and displaced posts and guardrail

ground. The guardrail was kinked in four locations. One kink was located in the feeder channel. The guardrail was also twisted and kinked at the entrance to the feeder channel (**Figure 10**), which locked the guardrail in the feeder channel probably causing the feeder channel to bend and kink. A third kink was located at post 4 with the fourth kink located between the feeder channel and post 4. The width of the feeder channel was 10.2 cm (4.0 in) and the guide chute exit height was 34.3 cm (13.5 in). The connection of the feeder channel to the end terminal was not damaged and there were no fractured welds. The anchor cable was present and remained connected to the guardrail and was located in the feeder channel. The FHWA In-Service End Terminal Evaluation Data Collection Form is attached to the end of this report as **Appendix A**.

Figure 10: Twisted guardrail at the entrance to the feeder channel

2001 BUICK LESABRE

Description

The Buick was a front-wheel-drive, 4-door sedan with the custom trim level. The vehicle was identified by Vehicle Identification Number 1G4HP54K214xxxxxx. The powertrain consisted of a 3.8-liter, V-6 engine linked to a 4-speed automatic transmission with a column-mounted selector lever. The vehicle's specified wheelbase was 285 cm (112.2 in). The service brakes were power-assisted 4-wheel disc with antilock and electronic brake force distribution. The vehicle manufacturer's recommended tire size was P215/70R15. The vehicle was equipped with Goodyear Viva 2 tires of the recommended size. The manufacturer's recommended cold tire pressure for the front and rear tires was 228 kPa (33 PSI). All the tires appeared in fair condition prior to the crash.

The interior of the Buick was configured for seating of six occupants. The front row was equipped with a cloth-covered split-bench seat with a folding center seat back. The driver's and front right passenger's seats had adjustable head restraints. The second row was equipped with a cloth-covered bench seat without head restraints. The driver's and front right passenger's seat track positions could not be determined since the seats were deformed and displaced during the crash by occupant compartment intrusion. Safety systems consisted of manual seat belts and dual-stage frontal air bags and front-seat-mounted side impact air bags.

Exterior Damage

Exterior Damage Event 1: The Buick sustained direct and induced damage to the right plane during the impact with the end terminal. The right front and rear doors, B- and C-pillars, sill, and quarter panel were directly damaged. The direct damage began 86 cm (33.9 in) rear of the right front axle and extended 223 cm (87.8 in) rearward on the right plane. The Field L was 238 cm (93.7 in). Integrity of the passenger compartment was lost by separation of the striker from the B-pillar and the right front door hinges. The door skin, which separated during the crash, was repositioned on the vehicle in the approximate crushed location and crush measurements were

documented at the mid-door and sill level. The maximum residual crush at the mid-door level was 73 cm (28.7 in) occurring at C_5. The maximum residual crush to the sill was 65 cm (26.6 in) occurring at C_4. The crush at each level was averaged as required by the crush measurement protocol and the crush values were: C_1 = 12 cm (4.7 in), C_2 = 46 cm (18.1 in), C_3 = 51 cm (20.0 in), C_4 = 62 cm (24.4 in), C_5 = 58 cm (22.8 in), C_6 = 30 cm (11.8 in).

Damage Classification Event 1: The collision deformation classification was 03RZAW4 (80 degrees). The severity of the damage was severe.

Exterior Damage Event 2: The left plane of the vehicle struck a 28 cm (11.0 in) diameter cedar tree fracturing and displacing the tree. Branches from the tree knocked down a barbed wire fence during this impact. The vehicle did not impact the fence since no direct damage consistent with a barbed wire fence impact was present on the vehicle. The direct damage from the trunk of the cedar tree began 20 cm (7.9 in) rear of the left front axle and extended 58 cm (22.8 in) rearward on the left plane. The Field L was 230 cm (90.6 in). The crush measurements were taken at the mid door level on the fender and at the sill since the left front door had been removed from the vehicle. The maximum residual crash was 27 cm (10.6 in) occurring at C_3. The crush values were: C_1 = 0 cm, C_2 = 0 cm, C_3 = 27 cm (10.6 in), C_4 = 6 cm (2.4 in), C_5 = 3 cm (1.2 in), C_6 = 0 cm.

Damage Classification Event 2: The collision deformation classification was 10LYAW2 (300 degrees). The severity of the damage was moderate.

Event Data Recorder

The Buick was equipped with an EDR. The air bag control module (ACM), which contains the EDR, had been removed by the police from its original location in the center tunnel and was not available at the SCI vehicle inspection. The police report stated that the ACM was damaged during the crash to the extent that they were unable to image the data. It appears that the ACM was damaged due to the intrusion. The police reported that the crash data retrieval (CDR) tool could not communicate with the EDR. The police photographs confirmed the extent of the damage sustained by the ACM (**Figure 11**).

Figure 11: Police photographs of the Buick's damaged ACM

Interior Damage

The interior of the Buick sustained severe damage from intrusion of the occupant compartment as a result of the impact with the end terminal. The rear upper quadrant of the right front door intruded laterally an estimated 65 cm (25.6 in) into the front row. The right B-pillar and right sill intruded laterally 48 cm (18.9 in) and 43 cm (16.9 in), respectively. The side panel forward of the left A-pillar, lower left A-pillar, and sill each intruded laterally 24 cm (9.4 in) into the driver's seating position as a result of the impact with the tree. Evidence of occupant contact consisted of a scuff mark on the right B-pillar from the front row passenger's head. No other discernable occupant contact evidence was observed. The left front door was jammed shut and

was removed by emergency responders using a hydraulic rescue tool. The right front door was separated from its hinges and the striker pulled through the B-pillar during the impact with the end terminal. The right rear door was jammed shut. The left rear door remained closed and operational. The windshield glazing was cracked from impact forces. The left front, right front, right rear, second right rear, and backlight glazing were disintegrated.

Manual Restraint Systems

The front row left and right seating positions were equipped with integrated three-point lap and shoulder seat belts. The belt system used separate retractors and belt webbings sewn to a common latch plate. The shoulder portion of the integrated belt systems retracted into the seat backs. The center positions of both rows were equipped with lap belts. Inspection of the driver's seat belt assembly revealed that the lap belt retractor was locked by damage with the belt in the retracted position indicating that the driver was not belted at the time of the crash. The front row passenger's seat belt was cut by emergency responders and the latch plate was still in the buckle indicating that the passenger was belted at the time of the crash.

Supplemental Restraint Systems

The Buick was equipped with dual-stage frontal air bags and front seat-mounted side impact air bags. The front row passenger's seat-mounted side impact air bag likely deployed during the impact with the end terminal. The side impact air bag module was located in the outboard aspect of the seat back and deployed through a tear seam. The deflated air bag was 37 cm (14.6 in) wide and 36 cm (14.2 in) high and provided supplemental abdominal and thoracic protection. There was no discernable evidence of occupant contact on the air bag. The air bag sustained no damage during the crash. No other air bags deployed in this crash.

2001 BUICK LESABRE OCCUPANTS

Driver Demographics

Age/sex:	36 years/male
Height:	175 cm (69 in)
Weight:	66 kg (145 lb)
Eyewear:	Unknown
Seat type:	Split-bench with reclining seat back
Seat track position:	Unknown
Manual restraint usage:	None
Usage source:	Vehicle inspection
Air bags:	Frontal and seat-mounted side impact, not deployed
Alcohol/drug involvement:	BAC=0.25 g/dl
Egress from vehicle:	Removed by emergency responders
Transport from scene:	Ambulance
Medical treatment:	Treated and released

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Cervical spinal muscle strain, acute (whiplash injury), No Further Specificity	640278.1	Isolated Left Door Panel - Left rear upper quadrant	Probable
2	Skin/subcutaneous/muscle abrasion, Nose	210202.1	Isolated Noncontact Injury - Flying glass	Probable
3	Skin/subcutaneous/muscle laceration-> minor; superficial, Palm of left hand	710602.1	Isolated Front - Left instrument panel	Possible
4	Skin/subcutaneous/muscle abrasion, left hand, 1.5 cm	710202.1	Isolated Noncontact Injury - Flying glass	Probable
5	Skin/subcutaneous/muscle abrasion, right hand	710202.1	Isolated Front - Center instrument panel	Possible

Source: Emergency room records

Driver Kinematics

The driver was not restrained by the integrated lap and shoulder seat belt. The seat track adjustment could not be determined since the seat had been deformed and displaced during the crash. The driver was displaced to the right in his seat position as the vehicle yawed counterclockwise across the roadway and decelerated prior to the end terminal impact. As the right plane struck the end terminal, the driver was displaced to the right. His right pelvis probably contacted the center fold-down armrest. This did not produce injury but may have caused his upper torso to pitch downward. Although not supported by injury, he probably contacted the front right passenger as she was displaced left by the intruding door panel. The driver did sustain an abrasion to the right hand that was possibly attributed to contact with the center instrument panel.

As the Buick separated from the guardrail system and rotated clockwise down the embankment, the left plane struck the cedar tree. The lateral impact disintegrated the door glazing and intruded the door into the driver's position. Flying glass was the probable source of abrasions to the left nare and the left hand. He also sustained a laceration to the palm of his left hand from possible contact with the left instrument panel. The driver subsequently contacted the upper rear aspect of the intruding left front door panel. As a result of the door panel contact, the driver's head flexed outside the door window opening causing cervical strain. The left front door was jammed shut and emergency responders removed the door using hydraulic rescue equipment and removed the driver from the vehicle. He was transported by ambulance to the emergency room of a local hospital where he was treated for his injuries and released.

Front Row Right Occupant Demographics

Age/sex:	33 years/female
Height:	171 cm (67.5 in)
Weight:	86 kg (190 lb)
Eyewear:	Unknown
Seat type:	Split bench with folding center back
Seat track position:	Unknown
Manual restraint usage:	Lap and shoulder belt
Usage source:	Vehicle inspection
Air bags:	Seat-mounted side impact, deployed; front, not deployed
Alcohol/drug involvement:	BAC=0; positive for THC
Egress from vehicle:	Removed by emergency responders
Transport from scene:	Funeral home vehicle to mortuary
Medical treatment:	None, pronounced deceased at crash scene

Front Row Right Occupant Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Open pelvic ring fracture with fractures to left and right sacroiliac joints, fractures of left and right iliac bones, fractures of left and right pubic bones with extraperitoneal and pelvic hemorrhages	856172.4	Isolated IPC Right Door Panel - Right rear lower quadrant	Certain
2	Distraction of 1st and 2nd cervical vertebrae	650206.3	Isolated IPC Right Side - Right B-pillar	Certain
3	Disruption of vertebral artery	321012.3	Isolated IPC Right Side - Right B-pillar	Certain
4	Cerebrum brain swelling-> mild; compressed ventricles without compressed brain stem cisterns, No Further Specificity	140662.3	Isolated IPC Right Side - Right B-pillar	Certain
5	Subdural basilar cerebral hemorrhage	140650.3	Isolated IPC Right Side - Right B-pillar	Certain
6	Cerebrum subarachnoid hemorrhage NFS; no LOC, No Further Specificity	140693.2	Isolated IPC Right Side - Right B-pillar	Certain
7	Thoracic cavity injury Hemothorax, Right No Further Specificity	442200.3	Tandem IPC Right Air Bag - Right seat back/Intruding right door panel, upper rear quadrant	Probable Certain

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
8	Thoracic cavity injury Hemothorax, Left No Further Specificity	442200.3	Tandem IPC Right Air Bag - Right seat back/Intruding right door panel, upper rear quadrant	Probable Certain
9	Bladder (urinary) rupture, No Further Specificity	540640.3	Isolated IPC Right Door Panel - Right rear lower quadrant	Certain
10	Humerus fracture Distal humerus fracture-> open, Right No Further Specificity	751332.3	Isolated IPC Right Door Panel - Right rear upper quadrant	Certain
11	Liver lacerations, 2.5 cm depth, 9 cm in length	541822.2	Isolated IPC Right Door Panel - Right rear lower quadrant	Certain
12	Laceration of gastric serosa, 2 cm	544422.2	Isolated IPC Right Door Panel - Right rear upper quadrant	Certain
13	Stomach contusion; hematoma [OIS I], No Further Specificity	544410.2	Isolated Right Door Panel - Right rear upper quadrant	Certain
14	Rib Cage fracture(s) without flail, any location unilateral or bilateral-> one rib [OIS I], Right Rib 7	450201.1	Isolated Right Door Panel - Right rear upper quadrant	Certain
15	Abrasion to right chin	210202.1	Isolated Injured, Unknown Source - Injured, unknown source	Unknown
16	Abrasion to right neck	310202.1	Isolated Interior - Shoulder portion of belt restraint	Certain
17	Contusion to right lower chest	410402.1	Isolated Right Door Panel - Right rear lower quadrant	Certain
18	Abrasions to right lower chest	410202.1	Isolated Right Door Panel - Right rear lower quadrant	Certain
19	Abrasion to left mid back	410202.1	Isolated Interior - Other seating position seat back	Probable
20	Abrasion to lateral mid abdomen	510202.1	Isolated Interior - Lap portion of belt restraint	Certain

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
21	Laceration over the dorsum of right 3rd phalanx	710602.1	Isolated Right Door Panel - Right door panel unknown/multiple quadrant	Probable
22	Laceration over the dorsum of right 4th phalanx	710602.1	Isolated Right Door Panel - Right door panel unknown/multiple quadrant	Probable
23	Laceration over the dorsum of right 5th phalanx	710602.1	Isolated Right Door Panel - Right door panel unknown/multiple quadrant	Probable
24	Skin/subcutaneous/muscle laceration-> minor; superficial, Left Forearm	710602.1	Isolated Injured, Unknown Source - Injured, unknown source	Unknown
25	Abrasion to dorsum of left wrist	710202.1	Isolated Injured, Unknown Source - Injured, unknown source	Unknown
26	Abrasion to lateral left hip	810202.1	Isolated Interior - Other seating position seat back	Probable
27	Contusion to lateral right buttock	810402.1	Isolated Interior - This occupants seat cushion	Probable
28	Contusions to anterior, medial, and posterior aspect of upper left leg	810402.1	Isolated Interior - Other seating position seat back	Probable
29	Contusions to posterior and medial aspect of upper right leg	810402.1	Isolated Right Door Panel - Right rear lower quadrant	Certain
30	Abrasions to lateral and medial aspects of upper right leg	810202.1	Isolated Right Door Panel - Right rear lower quadrant	Certain
31	Contusion to lateral right popliteal fossa	810402.1	Isolated Right Door Panel - Right forward lower quadrant	Probable
32	Contusions to posterior right lower leg	810202.1	Isolated Right Door Panel - Right forward lower quadrant	Certain

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
33	Laceration to lateral aspect of lower right leg	810602.1	Isolated Right Door Panel - Right forward lower quadrant	Probable
34	Contusion to posterior aspect of lower left leg	810402.1	Isolated Right Door Panel - Right forward lower quadrant	Probable

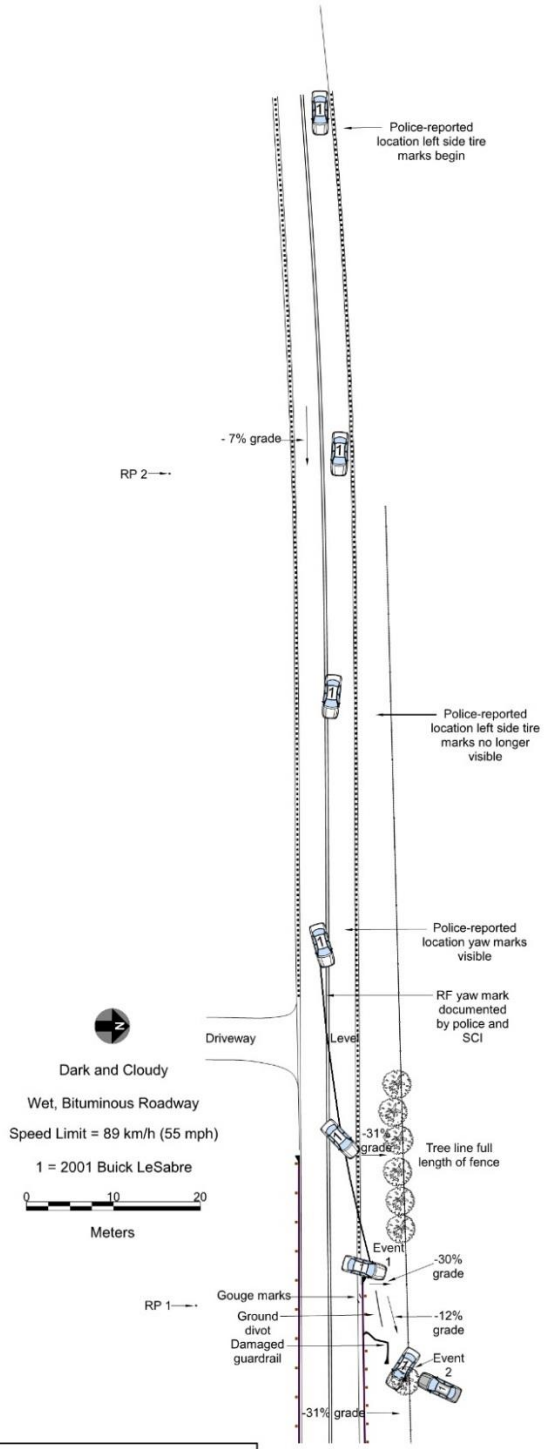
Source: Autopsy report (internal)

Front Row Right Occupant Kinematics

The front row right occupant was seated with the seatback reclined and restrained by the manual integrated lap and shoulder seat belt. The seat track adjustment could not be determined since the seat had been deformed and displaced during the crash. The occupant was minimally displaced to the right in her seat position as the Buick rotated counterclockwise across the roadway. At impact with the end terminal, the right seat-mounted side impact air bag likely deployed as the occupant was displaced laterally right in response to the 3 o'clock direction of force. Simultaneously, the right front door and B-pillar intruded into her occupant space. The combination of occupant motion and intrusion resulted in door contact to the occupant's right torso and abdomen. The effectiveness of the deployed air bag was minimized by the severity of the intrusion. As a result of door contact, the occupant sustained an open pelvic ring fracture, left and right hemothorax, a right rib fracture, an open right humerus fracture, contusions and lacerations of abdominal organs and multiple soft tissue injuries of the torso and extremities. Her head struck the intruding upper right B-pillar resulting in a distraction of the first and second cervical vertebrae with disruption of the vertebral artery, cerebral edema, and subdural basilar and subarachnoid hemorrhage. She sustained an abrasion of the right neck that was associated to the shoulder belt webbing. Deformation of the seat cushion produced a buttock contusion. Although she was contacted by the unrestrained driver, there was no specific injury related to this occupant-to-occupant interaction.

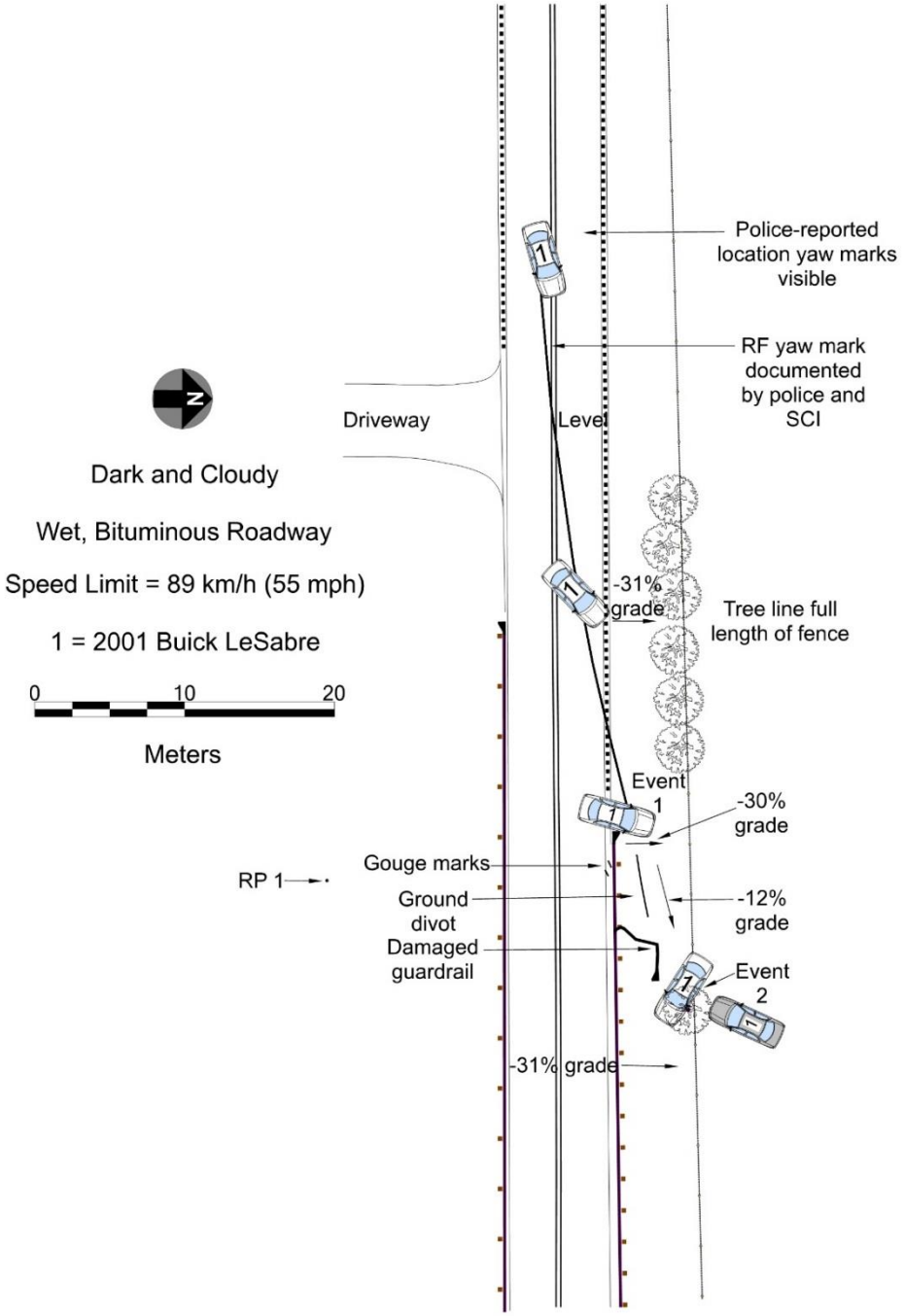
The occupant was also redirected to the left when the left plane struck the cedar tree, and again, probably contacted the driver. This occupant sustained fatal injuries and was pronounced deceased at the crash scene by the county coroner. Emergency responders removed her from the vehicle and she was transported by to a mortuary for autopsy.

CRASH DIAGRAM



DEPARTMENT OF TRANSPORTATION UNITED STATES OF AMERICA	NHTSA
Case Number:	IN17014

CRASH DIAGRAM - DETAILED VIEW



DEPARTMENT OF TRANSPORTATION UNITED STATES OF AMERICA	NHTSA
Case Number:	IN17014

APPENDIX A:
FHWA IN-SERVICE END TERMINAL EVALUATION DATA COLLECTION FORM

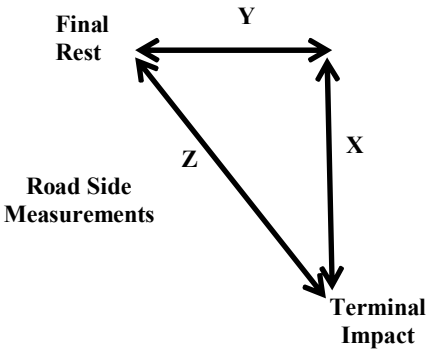
Case No.: IN17014

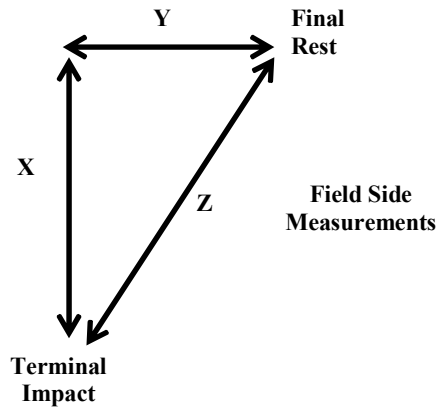
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	March 2017	**TIME OF CRASH (MILITARY)**	Evening
Case Number	IN17014	**State**	Missouri
Traffic Route	State highway	**Direction (Southbound = SB)**	EB
Ambient Conditions (at time of crash)			
Temperature (°F)	57	**Lighting**	Dark
Atmospheric	Rain		

SCENE INFORMATION	
Type of area where crash occurred	❒Urban ☒Rural ❒Suburban
Terminal on a horizontal curve?	☒No ❒Curve/LT ❒Curve/RT
Estimated or Reconstructed Speed at Impact (MPH)	Unknown
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 46 ft
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 52 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 26 ft
Super elevation	❒+2% ❒-2% ☒ NONE or FLAT
Curve Radius (ft.)	N/A

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: IN17014

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

GUARDRAIL INSTALLATION									
Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	Steel	6 x 6	None	N/A	No		1.7	N/A	0
2	Steel	6 x 4	None	N/A	No		1.5	N/A	6’ 3”

Case No.: IN17014

Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
3	Steel	6 x 4	Composite	7 x 4	No		Unk	N/A	6’ 8”
4	Steel	6 x 4	Composite	7 x 4	No		1.5	N/A	5’ 10”
5	Steel	6 x 4	Composite	7 x 4	No		1.7	N/A	6’ 4”
6	Steel	6 x 4	Composite	7 x 4	No		1.7	N/A	6’3”
7	Steel	6 x 4	Composite	7 x 4	No		1.5	N/A	6’ 3”
8	Steel	6 x 4	Composite	7 x 4	No		1.5	N/A	6’ 3”

Case No.: IN17014

Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
9	Steel	6 x 4	Composite	7 x 4	No		1.5	N/A	6’ 3”
10	Steel	6 x 4	Composite	7 x 4	No		1.3	N/A	3’ 2”
11	Steel	6 x 4	Composite	7 x 4	No		1.3	N/A	3’ 2”
12	Steel	6 x 4	Composite	7 x 4	No		1.3	N/A	3’ 2”

Additional Comments

Case No.: IN17014

EXTRUDER			
Feeder Channel Width at impact head	☒4inches ☐5 inches ☐Other _____		
Guide Chute Exit Height (in.)	13.5 in		
Connection of feeder channels to head damaged?	☐No ☒Yes	Are Welds Broken?	☒No ☐Yes
Anchor Cable Present?	☐No ☒Yes	Connected?	☐No ☒Yes
Rail Extrusion?	☐No ☒Yes	Length (ft. in.)	3.0 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.]	25.0 ft		

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

ALL-SYSTEM PERFORMANCE			
Railkinks Downstream of Head?	☐No	☒Yes ;	No. of Kinks in Rail: 4
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	11.5 in cedar tree		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	-31%	-31%	-31%
Adjacent Lane Width (ft)	10 ft		
Lane Type (NAS EDS Variable: Sur. Type)	Bituminous		
Shoulder Type	None		

Shoulder Width (ft)	No shoulder
Guardrail Height (in)	30.5 in

VEHICLE INFORMATION		
Vehicle Type (NHTSA Input)	Four-door sedan	
Vehicle Identification Number (VIN)	1G4HP54K214xxxxxx	
Vehicle Mass (NASS var.: veh.wgt)	3567	
Vehicle orientation upon impact	❒Case Type 1 ☒ Case Type 2 ❒Case Type 3 ❒ Case Type 4 ❒ Case Type 5 ❒ Case Type 6 ❒ Case Type 7 ❒ Case Type 8 ❒ Other	
If 'Other', describe		
Collision Deformation Classification	03RZAW4	
Delta-V	Unknown Delta-V; BES = 30 mph	
Occupant Compartment Penetration of rail	☒No	❒Yes; Describe:
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	

DOT HS 812 903
March 2020

U.S. Department
of Transportation

**National Highway
Traffic Safety
Administration**

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