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ON-SITE AMBULANCE CRASH INVESTIGATION

CASE NUMBER - IN10032
LOCATION - WEST VIRGINIA
VEHICLE - 2003 FORD E350 TYPE II AMBULANCE
CRASH DATE - September 2010

Submitted:

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Contract Number: DTNH22-07-C-00044

Prepared for:

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National Highway Traffic Safety Administration
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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 in order 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 vehicle(s) or their safety systems.

Technical Report Documentation Page

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16. *Abstract*

This on-site investigation focused on the dynamics of the crash and the injury sources for the fatally injured driver of a 2003 Ford E350 Type II Ambulance. The ambulance was traveling north without the emergency lights and siren activated on a winding 2-lane, undivided, state highway during night time hours under dry and clear weather conditions. The vehicle had just exited a right curve and entered a straight section of roadway. The vehicle departed the east side of the roadway and the front plane impacted a guardrail (event 1). The vehicle displaced the guardrail and dropped off a steep embankment rolling over (event 2) right side leading 3 quarter turns. During the rollover, the unrestrained driver was ejected through the partially open left front window glazing. He sustained a crushed skull when his head was entrapped between the left roof side rail and the ground. A 21-year-old male EMT, a 12-year-old female patient and the patient's 32-year old mother were in the patient compartment. The patient was restrained on the patient cot and her mother was restrained on the bench seat located on the right side of the ambulance compartment. The EMT was unrestrained and also seated on the bench seat. The EMT, patient, and the patient's mother sustained minor injuries. The EMT and the patient's mother were transported to medical facilities. The patient was released to the care of a relative. The vehicle was towed due to damage.

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BACKGROUND

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This on-site investigation focused on the dynamics of the crash and the injury sources for the fatally injured driver of a 2003 Ford E350 Type II Ambulance (**Figure 1**). This crash was initiated by the National Highway Traffic Safety Administration (NHTSA) on September 8, 2010 through an on-line news article. This investigation was assigned on September 10, 2010. The crash occurred when the ambulance impacted a guard rail and rolled over. The crash happened in September, 2010, at 0300 hours, in West Virginia and was investigated by the county sheriff department. The ambulance and the crash scene were inspected on September 13-14, 2010. An interview was conducted with the chief of operations for the ambulance service and the Emergency Medical Technician (EMT) on September 20, 2010. A passenger of the ambulance (the mother of the patient) was interviewed on September 16, 2010. This report is based on the police crash report, ambulance inspection, crash scene inspection, exemplar vehicle inspection, interview information, occupant kinematic principles, and evaluation of the evidence.

Figure 1: The damaged 2003 Ford E350 Type II Ambulance

AMBULANCE COMPANY AND PERSONNEL

The ambulance service was operated by the county and had been in operation since 1980. Prior to that date, the ambulance service was staffed by volunteers. The ambulance service operated a fleet of 4 ambulances. Their area of operation covered 935 square kilometers (581 square miles). The ambulance service provided primarily 9-1-1 emergency response and occasionally provided emergency transfers of patients. The company required its ambulance drivers to complete an Emergency Vehicle Operators Course, which consisted of eight hours of classroom instruction and eight hours of driving an ambulance.

The driver of the ambulance was a 34-year-old male. He served only as an ambulance driver and was not an Emergency Medical Technician (EMT). He had been an employee of the ambulance service for approximately 10 months. His work schedule comprised 48 hours on duty and five days off duty. On the day of the crash, he had been on duty for approximately 17 hours. The amount of sleep he had prior to the crash is not known. It was reported that he had been under stress related to personal issues for several weeks and had some trouble sleeping. The driver had no known medical issues and was not on any medication. The driver was unrestrained at the time of the crash.

The EMT was a 21-year-old male. He had been an EMT for 2 months and had worked for the ambulance company for approximately two weeks. Prior to earning his EMT license, he had been a volunteer fireman for approximately two years. On the day of the crash, he began work at 1400 hours and was working a 12-hour shift. He was seated in the patient compartment on the

bench seat in the seat position nearest the front of the vehicle and was attending to the patient. He was not restrained.

PATIENT AND TRANSPORT DETAILS

The patient was a 12-year-old female. Based on the SCI interview with the patient's mother, the patient was suffering from mental issues. She was being transported to a regional medical center. The ambulance was operating without the emergency lights and siren during the transport. The patient's 32-year-old mother was seated in the patient compartment on the bench seat in the middle seat position. She was restrained by a lap belt. The patient was restrained on a Ferno 93ES Squadmate patient cot. The crash occurred approximately 15 minutes into the transport. The patient was not receiving any oxygen, intravenous fluids, or medications during the transport.

CRASH CIRCUMSTANCES

Crash Environment: This crash occurred in a rural, mountainous area on a winding 2-lane, undivided, state highway during night time hours under dry and clear weather conditions. The roadway traversed in a north-south direction and was curved. Each travel lane was approximately 2.9 m (10 ft) in width. The roadway became straight approximately 35 m (115 ft) prior to the crash location. The east side of the roadway was bordered by a gravel shoulder 0.9 m (3 ft) in width and a blocked-out W-beam steel guardrail. The guardrail posts and block-outs were wood. A residential driveway intersected the east side of the roadway immediately prior to the crash location. There was a pavement drop of 34 cm (13.4 in) at the south edge of the driveway in the area where the ambulance departed the roadway. There was no shoulder on the west side of the roadway. The roadway surface was dry bituminous and the grade for the ambulance was negative 3.2%. The Crash Diagram is on page 12 of this report.

Pre-Crash: The ambulance was traveling north without the emergency lights and siren activated. The vehicle had just exited a right curve and entered a straight section of roadway (**Figure 2**). The right front wheel departed the east side of the roadway and dropped off the pavement near a residential driveway. The ambulance traveled 11.5 m (37.7 ft) from the drop-off to impact with a guardrail on the north side of the driveway. It is unknown if the driver took any actions to avoid the crash.

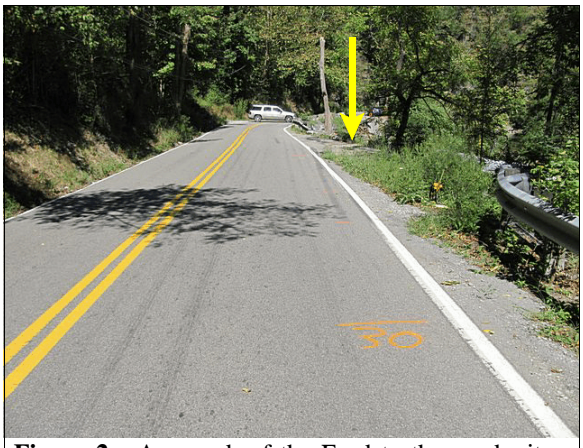


Figure 2: Approach of the Ford to the crash site; arrow shows the area of impact with the guardrail

Crash: The front plane of the ambulance (**Figure 3**) impacted the guardrail (**Figure 4**, event 1). The impact broke three of the guard rail posts and bent the guardrail to an approximate 90 degree angle as the ambulance dropped off the embankment. The vertical drop from the roadway to the bottom of the embankment was approximately 6.1 m (20 ft). The ambulance rolled over (event 2) right side leading 3 quarter

turns and came to final rest on the left side plane in a residential driveway heading north (**Figure 5**). During the rollover, the unrestrained driver was partially ejected through the partially open left front glazing. The driver's head was entrapped between the left roof side rail and the ground, and he sustained a fatal injury. The unrestrained EMT was displaced off the bench seat during the rollover and came to final rest between the patient cot and the left side of the patient compartment. The patient cot remained secured by the antler bracket and rail clamp. The patient remained secured on the cot by the three restraints. The passenger remained restrained on the bench seat.

Figure 3: Damage on the front bumper of the ambulance from the impact with the guardrail

Figure 4: Impact area with the guardrail, arrow shows the initial area of contact with the guardrail

Figure 5: Arrow shows the area of final rest of the ambulance

Post-Crash: The passenger and EMT assisted the patient out of the ambulance through the patient loading doors. The sheriff's department, emergency medical personnel, and rescue personnel responded to the crash scene. Rescue personnel cut the vehicle's A-pillars and bent the roof to extricate the driver. The patient was examined at the crash scene by emergency medical personnel and released to the care of a relative. The passenger was transported by ground ambulance to a nearby school where she was transferred to an air ambulance and transported to a regional trauma center. The EMT was transported by ground ambulance to a regional medical center. The vehicle was towed from the crash scene due to damage.

CASE VEHICLE

The 2003 Ford E350 was a 4-wheel drive, 4-door, van (VIN: 1FDSS34F23H------) equipped with a 7.3-liter, V-8 turbo diesel engine, automatic transmission, and anti-lock brakes. The vehicle was manufactured as an incomplete vehicle in August 2002 and was configured as a Type II ambulance by the McCoy Miller Company in December 2002. The vehicle's drive system was converted to 4-wheel drive by the Quigley Motor Company in March 2003. The front row was equipped with box-mounted seats, integral head restraints, lap-and-shoulder safety belts, and driver and front right passenger frontal air bags. The patient compartment had a typical layout with a box-mounted rear-facing paramedic seat behind

the driver, a three passenger bench seat along the right side with lap safety belts, double right side entry doors, double rear doors for patient loading, and multiple cabinets along the left side and front for storage. The odometer reading at the SCI inspection was 384,333 kilometers (238,813 miles). The specified wheelbase was 351 cm (138 in).

Figure 6: The damage on the roof of the ambulance from the rollover

CASE VEHICLE DAMAGE

Exterior Damage Event 1: The ambulance sustained direct damage on the front bumper during the impact with the guardrail. The direct damage began at the front right bumper corner and extended 170 cm (66.9 in) across the front bumper. There was also overlapping damage on the right portion of the bumper from the rollover. The crush measurements were taken at the bumper level and the maximum residual crush was 22 cm (8.7 in) occurring at C_4. The table below presents the front crush profile.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	170	22	161	0	3	12	22	5	21	0	0
in		66.9	8.7	63.4	0.0	1.2	4.7	8.7	2.0	8.3	0.0	0.0

Damage Classification Event 1: The Collision Deformation Classification (CDC) for the front plane damage was 12FDLW2. WinSMASH could not be used to calculate a Delta V since an impact with a yielding object is out of scope for the program and there was overlapping damage from the rollover on the bumper. The severity of damage on the bumper was moderate.

Exterior Damage Event 2: The ambulance sustained damage on both side planes and the top plane during the rollover. The direct damage on the right side plane began 135 cm (53 in) rear of the right rear axle and extended forward 519 cm (200.4 in) to the end of the damaged right fender. The direct damage was intermittent along the side and resided primarily rear of the patient compartment entry doors. The direct damage on the left side plane began 146 cm (57.5 in) rear of the left rear axle and extended forward 549 cm (216.4 in). The direct damage on the top plane extended from the front of the hood to immediately rear of the B-pillars and involved the full width of the roof. The front portion of the fiberglass roof structure was broken and the metal frame was crushed. The maximum vertical crush on the roof was 72 cm (28.3 in), which included the crush of the fiberglass roof structure and its metal frame (**Figure 6**). The location of the maximum vertical crush was 15 cm (5.9 in) inboard and 12 cm (4.7 in) forward of the right B-pillar. There was no lateral crush of the roof structure.

Damage Classification Event 2: The CDC for the rollover damage was 00TYDO4. The WinSMASH program could not be used on this impact since a rollover is out of scope for the program. The severity of the damage was severe based on the extent of the crush on the roof.

The vehicle manufacturer's recommended tire size was LT245/75R16. The vehicle was equipped with the recommended size tires. The vehicle's tire data are presented in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	386	56	379	55	10	13	None	No	No
LR	524	76	552	80	6	7	None	No	No
RR	538	78	552	80	5	6	None	No	No
RF	Flat	Flat	379	55	10	12	Hole in sidewall	No	Yes

Vehicle Interior, Front Row: The inspection of the front row revealed two scuff marks on the left front door armrest (**Figure 7**) from contact by the driver's left torso. Blood transfer was also located on the driver's sunvisor and windshield header adjacent to the sunvisor. The steering wheel had been cut by rescue. There was no compression of the energy absorbing steering column.

Figure 7: Yellow tape shows location of occupant contact scuff marks on the left front door armrest

The left front door remained closed and operational. The right front door was jammed shut. Prior to the crash, the left front window was partially open and the right front window was closed. The right front and right rear widows were disintegrated from impact forces. The left front window was disintegrated, but it could not be determined if this was due to occupant contact or impact forces. The windshield had been removed during rescue operations and its damaged condition is not known.

The vehicle sustained 10 intrusions. The most severe intrusion into the driver's space was approximately 5 cm (2 in) of vertical roof intrusion. The most severe intrusion in the patient compartment was 30 cm (11.8 in) of vertical intrusion of the upper right side trim panel.

The rollover of the ambulance was initiated after the vehicle impacted the guardrail and traveled off the embankment. The steep grade of the embankment caused the vehicle to rollover. The vehicle rolled over 3 quarter turns with the right side leading as it dropped a vertical distance of approximately 6.1 m (20 ft). It traversed a longitudinal distance of approximately 15 m (49.2 ft). The vehicle came to final rest on its left side plane heading north. The NHTSA website (Safercar.gov) had no rollover rating information for this vehicle.

AUTOMATIC RESTRAINT SYSTEM

The front row was equipped with redesigned driver and front right passenger frontal air bags. The driver's frontal air bag did not deploy in this crash. The front right passenger air bag deployed during the crash.

The front right passenger air bag was located within the middle of the instrument panel and the module cover consisted of a single flap constructed of medium gauge vinyl. The flap measured 38 cm (15 in) in width and 28 cm (11 in) in height. The module cover flap opened at the designated tear points and was undamaged. The deployed air bag was 48 cm (18.9 in) in width and 60 cm (23.6 in) in height and had two 2 cm (0.8 in) diameter vent ports and no tethers. The air bag was not damaged during the deployment.

MANUAL RESTRAINT SYSTEM

The front row was equipped with driver and front right passenger lap-and-shoulder safety belts. The driver's safety belt was equipped with continuous loop belt webbing, an adjustable upper anchor that was in the middle position, a sliding latch plate, an Emergency Locking Retractor (ELR), and a buckle-mounted pretensioner. The front right safety belt was similarly equipped but had an ELR/Automatic Locking Retractor (ALR).

The inspection of the driver's safety belt assembly revealed historic usage scratches on the latch plate. There were no load marks visible on the belt webbing, latch plate belt guide, or the D-ring. The buckle-mounted pretensioner did not actuate. There was no evidence to support safety belt usage during this crash. The EMT also stated during the SCI interview that the driver was not restrained. The front row right seat position was not occupied. The manual restraint systems in the patient compartment are discussed below.

PATIENT COMPARTMENT

The patient compartment (**Figure 8**) was configured with a storage cabinet on the left side. A work shelf with a storage cabinet beneath it was located at the front right of the patient compartment adjacent to the entry doors. The left side storage cabinet was equipped with plexiglass sliding doors and was stocked with medical supplies. The front portion of the cabinet was displaced downward approximately 4 cm (1.6 in). The sliding doors were undamaged. A fold-up patient cot was stored on the back left side and was secured by a nylon strap. The cot remained secured and was not damaged. An M-size oxygen cylinder was located within a cabinet

located at the right rear of the patient compartment. The oxygen cylinder was 109 cm (42.9 in) in height and 18 cm (7.1 in) in diameter. The oxygen cylinder was held in place by three nylon securement straps. The top straps were secured tightly on the cylinder. The bottom strap was loose. The regulator and oxygen lines that were visible were undamaged. The patient loading doors remained closed and operational and were undamaged. The patient compartment entry doors were jammed closed. The forward door had been forced open. Both doors were damaged during the rollover. Scuff marks from probable contact by the EMT were observed on the roof above and inboard side of the bench seat.

Figure 8: View of the patient compartment from the patient loading doors.

The paramedic seat was located on the forward left side of the patient compartment immediately behind the driver's seat. It was a non-adjustable box-mounted rear-facing seat and was equipped with a lap safety belt. The buckle portion of the safety belt was present but no latch plate/belt webbing was available (**Figure 9**).

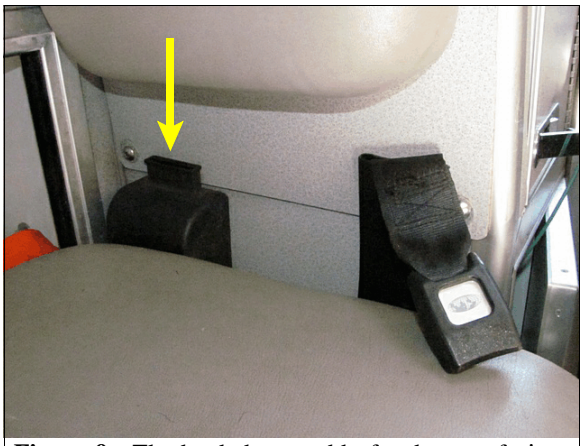


Figure 9: The lap belt assembly for the rear-facing paramedic seat; no latch plate/belt webbing was available

A three passenger bench seat was located on the right side of the patient compartment. It was equipped with three lap belts with sewn latch plates and ALRs. The safety belts were bolted to the wall of the patient compartment. The EMT was seated in the first seat nearest the front of the vehicle. He stated during the SCI interview that he was not restrained. Inspection of his safety belt revealed no discernable evidence of usage. The passenger was seated in the middle seat. She stated during the SCI interview that she was restrained by the lap belt. Inspection of this safety belt assembly revealed a scuff mark on the belt webbing.

Patient Cot: The cot that was used to transport the patient was a Ferno 93ES Squadmate (**Figure 10**). There was no date of manufacturer located on the cot. The cot was constructed of steel tubing and the load capacity was indicated as 227 kg (500 lb). The cot was 204 cm (80 in) in length and 54 cm (21.3 in) in width. The mattress was 180 cm (70.9 in) in length, 47 cm (18.5 in) in width, and 11 cm (4.3 in) thick. The cot was undamaged. It was configured with three restraints. The restraints consisted of a non-adjustable buckle portion and an adjustable length locking latch plate portion. The restraints were tied to the cushion support frame with the exception of the buckle portion of the leg restraint, which was not secured to the cot at the time of the inspection. The latch plate portion of the leg restraint was equipped with a securement clip, which was broken. Inspection of the belts revealed historical usage evidence. On the upper torso

restraint, the latch plate portion of the belt webbing was heavily abraded from historic usage. Based on the SCI interview with the EMT, the patient was secured by the three restraints, which were positioned snugly across the patient's chest, hips, and legs.

The EMT stated that the patient cot was secured by the ambulance's antler bracket and rail clamp. The antler bracket secures the head of the cot by restraining the undercarriage using the wheel frames as anchor points. The rail clamp secured the frame of the cot. The cot remained secured throughout the crash and the patient remained secured on the cot.

Figure 10: The Ferno 93ES Squadmate patient cot

CASE VEHICLE DRIVER KINEMATICS

The unrestrained driver [34-year-old male, 173 cm (68 in) and 116 kg (255 lbs)] of the ambulance was seated in an unknown posture. The driver's seat track was located in the rear position at the time of the SCI vehicle inspection. The seat back was in a slightly reclined position. The tilt steering column was in the full down position.

The impact with the guardrail displaced the driver forward. During the rollover, he was redirected to the left and contacted the left front door. His upper body above the mid-chest area was ejected through the partially open left front window and the driver's head was entrapped between the ground and the left roof side rail. He sustained a crushed skull and was pronounced deceased at the scene. The extrication of the driver took approximately 1.5 hours.

CASE VEHICLE DRIVER INJURIES

The table below outlines the driver's injury and injury source.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 2005	Injury Source	Source Confidence	Source of Injury Data
1	Crushed skull, not further specified	maximal 113000.6,0	Ground[1]	Certain	Interviewee (other occupant)

[1] Head was entrapped between the ground and the exterior left roof side rail of the ambulance.

The patient [12-year-old female, 157 cm (62 in) and 52 kg (115 lbs)] was restrained supine on the patient cot by the three restraints. Her head was positioned toward the front of the ambulance and the cot's backrest was elevated to an unknown degree. The restraints were positioned snugly on the patient.

The patient remained secured on the cot throughout the crash and the cot remained secured by the antler bracket and rail clamp. The EMT reported that the patient was not displaced forward on the cot and remained in the supine position. She sustained contusions on both arms, probably from contact with the left side storage cabinet. The passenger removed the restraints from the patient and the EMT and passenger assisted the patient out of the vehicle through the patient loading doors.

CASE VEHICLE OTHER ROW PASSENGER, PATIENT INJURIES

The patient was examined at the crash scene by emergency medical personnel and released to the care of a relative. The table below outlines the patient's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 2005	Injury Source	Source Confidence	Source of Injury Data
1	Contusions, bilateral (on both) arms, not further specified	minor 710402.1,3	Interior object: storage cabinet on left side of ambulance compartment	Probable	Interview (relative)

CASE VEHICLE OTHER ROW PASSENGER, EMT KINEMATICS

The unrestrained EMT [21-year-old male, 183 cm (72 in) and 104 kg (230 lbs)] was seated on the bench seat located on the right side of the patient compartment in the seat nearest the front of the vehicle. He was turned partially toward the rear of the vehicle and was leaning forward talking with the patient.

The impact with the guardrail displaced the EMT forward off the bench seat. During the rollover, he was redirected to the left and contacted the roof of the patient compartment. Based on the SCI interview with the EMT, his face, right shoulder, and chest contacted the work area adjacent to the rear-facing seat located at the front left of the patient compartment. This contact fractured his nose and caused an abrasion, contusion, and sprain to his right shoulder. He also sustained strained ribs. He came to final rest on the floor between the patient cot and the left side of the patient compartment. He exited the vehicle through the patient loading doors.

The EMT was transported by ground ambulance to a regional medical center where he was treated in the emergency room and released. The table below outlines the EMT's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 2005	Injury Source	Source Confidence	Source of Injury Data
1	Fractured nose, bilateral nasal bones, septum midline	minor 251000.1,4	Interior object: work shelf of storage cabinet on left side of ambulance compartment	Probable	Emergency room records
2	Strain ribs, pain and tenderness bilateral rib areas; no rib fractures	minor 410099.1,3	Interior object: work shelf of storage cabinet on left side of ambulance compartment	Probable	Emergency room records
3	Sprain, right shoulder, with pain, tenderness, and decreased range of motion; no fracture found	minor 771010.1,1	Interior object: work shelf of storage cabinet on left side of ambulance compartment	Probable	Emergency room records
4	Contusion right shoulder, not further specified	minor 710402.1,1	Interior object: work shelf of storage cabinet on left side of ambulance compartment	Probable	Interviewee (same person)
5	Abrasion right shoulder, superior posterior area (near top toward back)	minor 710202.1,1	Interior object: work shelf of storage cabinet on left side of ambulance compartment	Probable	Emergency room records
6	Abrasion left lower leg, at calf area	minor 810202.1,2	Unknown injury source	Unknown	Emergency room records

CASE VEHICLE OTHER ROW PASSENGER KINEMATICS

The restrained passenger [32-year-old female, 165 cm (65 in) and 82 kg (180 lbs)] was seated on the bench seat located on the right side of the patient compartment in the middle seat. She was leaning forward talking to the patient.

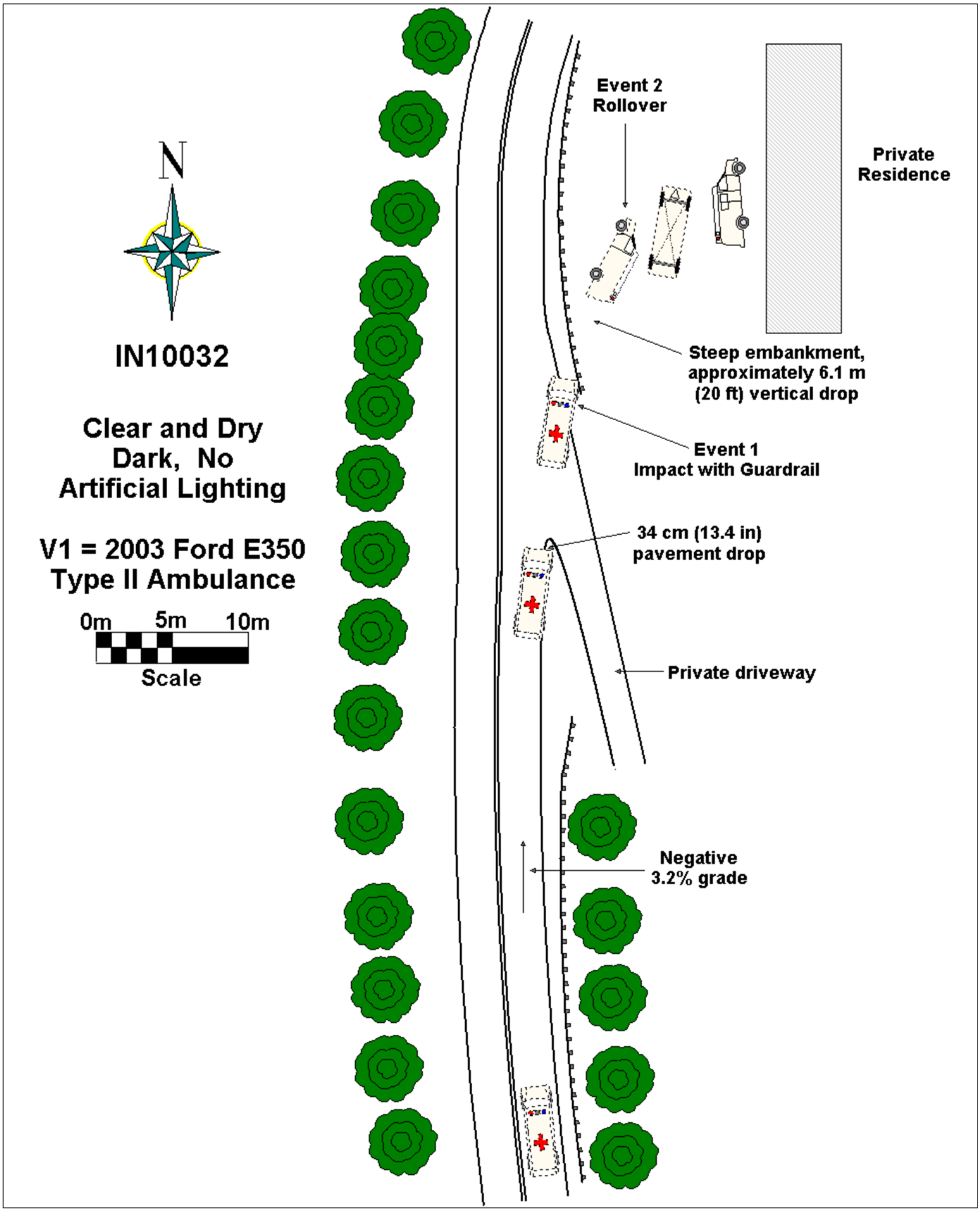
The initial impact with the guardrail displaced the passenger's upper torso toward the front of the vehicle, but she remained restrained on the seat and remained restrained throughout the crash. The passenger sustained a contusion and abrasion across her lower abdomen from loading

the safety belt. She also sustained sprained ankle, possibly from contacting the floor of the patient compartment, an abrasion to her left ring finger, and a contusion to her upper left thigh.

CASE VEHICLE OTHER ROW PASSENGER INJURIES

The passenger was transported by ground ambulance to a nearby school where she was transferred to an air ambulance and transported to a regional trauma center. She was treated in the emergency room and released. The table below outlines the passenger's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 2005	Injury Source	Source Confidence	Source of Injury Data
1 2	Contusion and abrasion across lower abdomen and hematoma at left hip area	minor 510202.1,8 510402.1,8	Lap portion of safety belt system	Certain	Emergency room records
3	Abrasion, small, left palmer surface of ring (#4) finger	minor 710202.1,2	Unknown contact source	Unknown	EMS treatment record
4	Contusion (bruising, ecchymosis), 15.2 cm (6 in), medial (inner) left upper thigh, with discoloration	minor 810402.1,2	Unknown contact source	Unknown	Emergency room records
5	Sprained left ankle; pain, tenderness, and mild swelling was reported in medical records	minor 877110.1,2	Interior object: floor of ambulance compartment	Possible	Interviewee (same person)


N
IN10032
Clear and Dry
Dark, No
Artificial Lighting
V1 = 2003 Ford E350
Type II Ambulance
0m 5m 10m
Scale
Event 2
Rollover
Private
Residence
Steep embankment,
approximately 6.1 m
(20 ft) vertical drop
Event 1
Impact with Guardrail
34 cm (13.4 in)
pavement drop
Private driveway
Negative
3.2% grade