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Special Crash Investigations On-Site Ambulance Crash Investigation Vehicle: 2004 Ford E-350 Type III Ambulance Location: Colorado Crash Date: April 2016

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15. Supplementary Notes

This report documents the on-site investigation of the rollover crash of a 2004 Ford E-350 Type III van-based ambulance and the injury sources to the patient and two crew members occupying the vehicle.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicles or their safety systems. This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was published.

16. Abstract

The crash occurred in April 2016 on a two-lane divided east/west interstate highway in Colorado. The Ford ambulance was being driven westbound in the second lane from the right by a belted 23-year-old female emergency medical technician (EMT). The patient compartment was occupied by an unbelted 53-year-old female EMT and a 57-year-old female patient who was restrained on an ambulance cot. Conditions were dark with no streetlights present and it was snowing at the time of the crash. The asphalt roadway was straight, level, and slush-covered. The driver lost control of the Ford due to the roadway conditions, the vehicle departed the roadway on the left edge, and entered the grassy center median. The vehicle began a counterclockwise rotation that was followed by a right side leading trip rollover. The Ford rolled five quarter turns before coming to rest on its right side. During the crash, the ambulance cot separated from its fastening system and the cot and patient were displaced inside the rear compartment. The patient was fatally injured. The driver sustained police-reported "B" (evident non-incapacitating) injuries and was transported by ambulance to an area hospital. The rear compartment EMT sustained "A" (evident - incapacitating) injuries and was transported by ambulance to an area hospital. The Ford was towed from the scene and placed on a police hold.

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On-Site Ambulance Crash Investigation
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BACKGROUND

This report documents the on-site investigation of the rollover crash of a 2004 Ford E-350 Type III van-based ambulance and the injury sources to the patient and two crew members occupying the vehicle (**Figure 1**). The National Highway Traffic Safety Administration's Office of Emergency Medical Services (EMS) and Dynamic Science, Inc., concurrently notified NHTSA's Special Crash Investigations (SCI) group of the crash in April 2016. Permission to inspect the vehicle was obtained in April 2016 and the case was assigned on the same day. The Ford was inspected in May 2016. The vehicle was under a police evidentiary hold and two State patrol officers were present during the inspection.

Figure 1. 2004 Ford E-350 Type III Ambulance.

The crash occurred in April 2016 on a two-lane, divided, east/west interstate highway in Colorado. The Ford ambulance was being driven westbound in the second lane from the right by a belted 23-year-old female emergency medical technician (EMT). The patient compartment was occupied by an unbelted 53-year-old female EMT and a 57-year-old female patient who was restrained on an ambulance cot. Conditions were dark with no streetlights present and it was snowing at the time of the crash. The asphalt roadway was straight, level and slush-covered.

The driver lost control of the Ford due to the roadway conditions. The vehicle departed the roadway on the left edge and entered the grassy center median. The vehicle began a counterclockwise rotation that was followed by a right-side-leading trip rollover. The Ford rolled five quarter turns before coming to rest on its right side. During the crash, the ambulance cot separated from its fastening system, and the cot and patient were displaced in the rear compartment. The patient was fatally injured. The driver sustained police-reported "B" (evident non-incapacitating) injuries and was transported by ambulance to an area hospital. The rear compartment EMT sustained "A" (evident-incapacitating) injuries and was transported by ambulance to an area hospital. The Ford was towed from the scene and placed on a police hold.

SUMMARY

Crash Site

The crash site was in the westbound lanes of a two-lane, divided, east/west interstate highway (**Figure 2**). The asphalt roadway was straight with a positive slope of 1 percent. The roadway was bordered on the right by a solid white painted fog line, a rumble strip, and an asphalt shoulder. It was bordered on the left by a solid yellow painted stripe, a rumble strip, an asphalt shoulder, and a 28.8 m (93.5 ft) wide grass-covered, depressed median. The median had a descending slope of 10 percent from north to south that leveled out at approximately 10.7 m (35.1 ft) south of the roadway. The posted speed limit was 121 km/h (75 mph). It was dark with no streetlights present and the police reported that it was snowing at the time of the crash with near white-out conditions. The roadway was slush-covered. The weather at the nearest reporting station was -6 °C (21 °F), 98 percent humidity, 2.4 km (1.5 miles) visibility, and the winds were out of the north northwest at 18.5 km/h (11.5 mph). A crash diagram is included at the end of this report.

Figure 2. Crash site looking west.

Pre-Crash

The Ford was traveling westbound in the second lane from the right with emergency lights flashing at a calculated speed of 90.6 km/h (56.3 mph).[1] It was transporting a patient from one hospital to another. Prior to transport, the patient had been admitted for possible cardiac issues. Diagnosis at that time revealed hypoxia and lower extremity edema. The patient was manually restrained on the cot using the lap type seat belts with her head and feet elevated. According to the coroner's report, following the crash the manual lap belts on the patient cot were still buckled.

The belted 23-year-old female driver of the Ford was actively steering the vehicle in winter weather conditions. The driver was trained and certified in cardiopulmonary resuscitation (CPR) but had received no specialized driver training. She held an on-call/part-time/volunteer position with the ambulance company and at the time of the crash was working a shift lasting from 6 p.m. to 6 a.m.

The unbelted 53-year-old female occupant was seated on the inboard-facing squad bench seat located along the right wall of the patient compartment. She was seated on the forward-most aspect of the seat cushion while attending to the patient and manually entering data into a laptop computer. This occupant was certified by the National Registry of Emergency Medical Technicians to have completed basic EMT training. She had intravenous certification and had been licensed in Colorado for 3 years. This occupant had received no specialized driver training. She held an on-call/part-time/volunteer position with the ambulance company for 3 years and at

[1] Calculated using coefficient of 1.0 for lateral travel across sod, 0.6 for rollover portion.

the time of the crash was working a shift lasting from midnight to 6 a.m. The 57-year-old female patient was lying supine in the patient cot and restrained by the three belt restraints of the patient cot. Just prior to the crash, the EMT had raised the upper and lower aspects of the cot to elevate the patient's head and feet. She had loosened the upper and lower belt restraints for the purpose of inserting a blanket between the restraints and patient. The restraints were somewhat loose but the belts remained buckled.

Figure 3. Left roadside departure looking west.

The Ford had traveled approximately 43 km (27 miles) west of the departure hospital prior to the crash. The driver indicated to police that strong winds had forced the Ford into the first lane from the right. When the driver steered left to return the vehicle to its original travel lane, she lost traction and control on the wet roads. The Ford departed the roadway to the left edge and entered the grassy center median (**Figure 3**).

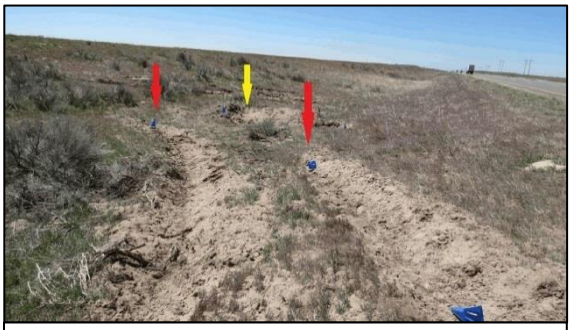


Figure 4. Trip point (red arrows) and right side impact (yellow arrow), looking west.

Crash

The Ford began a counterclockwise rotation while traveling down the descending median. The right side tires engaged the ground with sufficient opposing lateral force to cause a right side leading trip rollover. The trip point was documented in the median at approximately 25.0 m (82.0 ft) southwest of the area of departure. Initially, the Ford rolled one quarter turn and the right side roof rail of the ambulance body struck the ground (**Figure 4**). The distance from trip point to the roof rail impact was 3.0 m (9.8 ft). The vehicle continued to roll four more quarter-turns along its longitudinal axis while traveling approximately 9.1 m (30.0 ft). The total rollover distance measured 12.1 m (39.8 ft). It came to rest on its right side in the center of the median facing generally south (**Figure 5**).

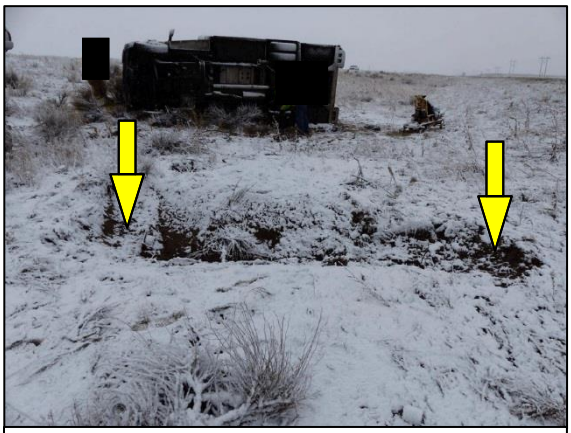


Figure 5. Right roof rail impact (yellow arrow) and final rest (police photo), looking west.

During the crash, the lower left attachment arm of the patient cot fractured at both ends and the cot separated from the floor fastener. The cot and patient were displaced from their anchored position and, during the rollover, moved freely in the patient compartment. This topic is discussed further in the Patient Cot and Occupant Kinematics sections of this report.

Post-Crash

Two passersby who witnessed the crash stopped to render aid to the occupants of the Ford. One witness kicked the vehicle's windshield until it fractured and then peeled the glass back with his hands. The ambulance driver removed her seat belt and moved through the access door from the cab to the patient compartment. She self-extricated and moved alternately in and out of the ambulance during post-crash activities. The same witness then went to the back of the vehicle and opened the back door using the handle, which remained operational. After opening the back door, he heard the EMT occupant in the rear compartment complaining of pain but could not immediately see either of the rear occupants. The witness observed the empty patient cot and removed it from the compartment through the back door. The EMT and patient were then visible in the rear compartment. The patient had been displaced from the cot either during the crash and was lying on the side panel of the compartment. The EMT stated during the interview that an automated external defibrillator (AED heart monitor) and a small oxygen bottle were displaced from their mounts during the crash. A third passerby stopped at approximately 4 minutes after the crash. At the request of the ambulance driver, this man climbed into the rear compartment and turned off the flow of oxygen from the oxygen tank. The driver smelled gasoline fumes and in response turned off the vehicle's engine. At that point, they all waited for the arrival of emergency responders.

The driver of the Ford sustained police-reported "B" (evident non-incapacitating) injuries. After emergency responders arrived, she was transported by ambulance to an area hospital where she arrived with a Glasgow Coma Scale (GCS) score of 15. The EMT located in the rear compartment remained inside until emergency responders arrived. She sustained "A" (evident-incapacitating) injuries and was removed from the rear compartment through the back door by responders and transported by ambulance to a hospital where she was admitted and hospitalized for 18 days before being transported to a rehabilitation facility. The patient sustained serious injuries and was declared deceased on-scene. Her body was taken to the county coroner's office. The Ford was towed from the scene and placed on a police hold.

2004 FORD E350 TYPE III AMBULANCE

Description

The 2004 Ford E-350 Econoline was manufactured in June 2004 and identified by the Vehicle Identification Number 1FDWE35P34Hxxxxxx. The vehicle mileage is unknown. The Ford was manufactured as a cutaway type chassis. The Ford chassis was a rear-wheel drive platform powered by a 6.0-liter, 8-cylinder, diesel engine linked to an automatic transmission.

Secondary manufacturing as a Type III certified ambulance was completed in December 2004 by American Emergency Vehicles. It consisted of installation of the patient compartment module and installation of emergency services operational equipment including warning lights, sirens, and radio communications. It was configured with a forward cab and rear patient compartment equipped for the treatment of medical emergencies in a mobile environment. The ambulance was certified as a "Star of Life" ambulance and conformed to Federal specification KKK-A-1822.

The Ford's cab was configured for the seating of two occupants, with forward-facing box-mounted seats that featured manual seat track and seat back recline adjustments integrated into

the seat backs and integral head restraints. Three-point, continuous loop lap and shoulder seat belts were available for manual restraint. The cab's seats were divided by a center console that integrated communications equipment and an array of switches related to the ambulance's emergency response and operational activities.

In the patient compartment module was seating for up to three crew members as well as the patient (**Figure 6**). This included a rearward-facing high-back attendant seat at the forward plane, a two-passenger squad bench seat on the right plane, and a centrally located single-occupant cot. The attendant seat was equipped with adjustable arm rests and a lap belt. It was configured with a lap belt. The squad bench was configured with lap belts.

Figure 6. Patient compartment, 2004 Ford E-350 ambulance.

The patient compartment was 375.9 cm (148.0 in) long and 241 cm (95.0 in) wide. It was configured with double-wide rear doors for the loading and unloading of the cot, as well as entry for the crew, and a single door at the forward aspect of the right side.

Vehicle Weight, Payload, and Tire Data

The Ford chassis was placarded with a gross vehicle weight rating (GVWR) of 5,216 kg (11,500 lbs). This was distributed as gross axle weight ratings (GAWR) of 2,086 kg (4,600 lbs) front and 3,538 kg (7,800 lbs) rear. The vehicle curb weight was 4615 kg (10,175 lbs) and the maximum payload was 601 kg (1,325 lbs). The vehicle manufacturer's recommended tire size was LT225/75R16 with recommended cold tire pressures of 448 kPa (65 psi) for the front and rear tires. The vehicle was equipped with Firestone Transforce tires of the recommended size. Specific tire data was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	448 kPa (65 psi)	10 mm (11/32 in)	No	None
LR outer	414 kPa (60 psi)	4 mm (5/32 in)	No	None
LR inner	Unknown	4 mm (5/32 in)	No	None
RR outer	Tire Flat	5 mm (6/32 in)	No	De-beaded
RR inner	Unknown	4 mm (5/32 in)	No	None
RF	434 kPa (63 psi)	8 mm (10/32 in)	No	None

Exterior Damage

The Ford sustained minor damage to the right plane during the five quarter-turn rollover (Event 1). The direct damage began at the rear aspect of the patient compartment and extended535.0 cm (210.6 in) forward (**Figure 7**). The vertical damage extended from the sill to the roof side rail. The right mirror, windshield, right light bar, and antenna were damaged. There was no measurable crush. The Truck Deformation Classification (TDC) was 00RDAO2.

Figure 7. Right plane damage, 2004 Ford E-350 ambulance.

Interior Damage

The inspection of the interior cab did not reveal any damage or occupant contacts. There was no deformation of the steering wheel rim or compression of the column. There were no deformations to any of the seats. Both front doors, the right side door, and the dual rear doors all remained closed and operational. The right windshield was fractured and holed during extrication and the right rear side glass was disintegrated. The interior of patient compartment had been partially stripped prior to the SCI inspection (i.e., oxygen tanks, drugs, supplies removed). The interior sustained minor damage from occupant contacts and damage caused by the displaced EMT, ambulance cot, and patient.

Figure 8. Patient compartment damage, 2004 Ford E-350 ambulance.

There was contact damage to the right roof area at one of the interior lights (**Figures 8** and **9**). The fiberboard was fractured and there was blood along the fracture. There was fracture damage along the left roof area and blood located along the right wall. There was tearing damage to the right padded surface near the roof hand rail.

Figure 9. Patient compartment damage, 2004 Ford E-350 ambulance.

Manual Restraint Systems

The cab of the Ford was equipped with manual restraint systems for both seating positions. Both seat belts exhibited historical usage. The driver of the Ford was buckled but her seat belt did not reveal any apparent evidence of occupant loading. In the rear compartment, the rear-facing attendant seat and squad bench seats were equipped with lap seat belts. The EMT attending the patient was not belted during the crash. The patient cot was configured with lap type seat belts which were used to restrain the patient.

Supplemental Restraint Systems

The Ford was equipped with frontal air bags for supplemental restraint. The history of these air bags was unknown. Neither air bag deployed during the crash.

Rollover Mitigation

There are no specific rollover ratings for this vehicle. The Ford was equipped with 4-wheel disc brakes with ABS and power steering. The driver lost control of the vehicle due to the roadway conditions and excessive speed for those conditions. The Ford began a counterclockwise rotation, departed the roadway on the left edge, and traveled into the median. The vehicle traveled down the -10 percent slope of the grass and snow-covered median. As the right side tires furrowed into the ground the vehicle tripped and began a right-side-leading trip rollover. During the first quarter-turn, the Ford traveled 3.0 m (9.8 ft) and its right roof rail struck the ground. The vehicle continued to roll four more quarter-turns along its longitudinal axis while traveling approximately 9.1 m (30.0 ft). The total rollover distance measured 12.0 m (39.3 ft). It came to rest on its right side in the center of the median facing generally south.

Figure 10. Rugged POWER-PRO XT Ambulance Cot.

Patient Cot

The patient cot was a Rugged POWER-PRO XT ambulance cot that was manufactured by Stryker (**Figure 10**). The X-frame supporting the mattress platform featured power height adjustment capabilities and the mattress platform featured 0-73 degrees of backrest articulation. Its length was 203 cm (80 in) and the width was 58 cm (23 in). The cot (minus mattress and restraints with one battery on board) weighed 57 kg (125 lbs) and had a maximum weight capacity of 318 kg (700 lbs). The cot was equipped with three lateral cot restraints manufactured by Ferno. The cot was secured in place in the passenger compartment using a Stryker antler design floor-mount cot fastener system. The system consisted of a forward antler bracket and rearward locking-clamp mechanism. The antler bracket cradled the forward portion (location of the patient's head area) of the cot's frame, while the vertically-oriented locking

Figure 11. Lower frame rail damage at rear.

Figure 12. Lower frame rail damage at rail.

mechanism clamped around a pin protruding from the cot's lower frame rail. During this crash, the lower frame rail fractured at both ends (**Figures 11–13**) and the cot and patient were displaced to the right and toward the roof (probably during the first one- quarter roll). The lower frame rail/pin remained clamped to the cot fastener system (**Figure 14**).

Figure 13. Lower frame rail/pin.

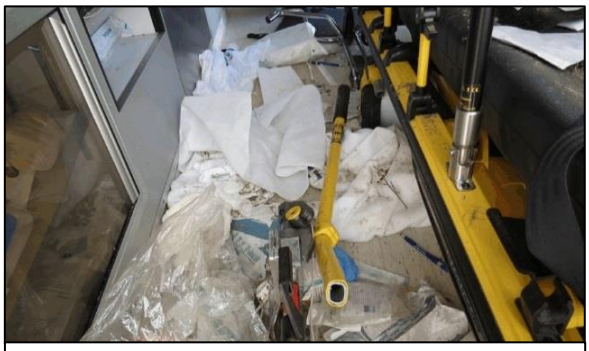


Figure 14. Lower frame rail damage.

2004 FORD E350 AMBULANCE OCCUPANTS

Driver Demographics

Age/Sex:	23 years/female
Height:	173 cm (68 in)
Weight:	68 km (150 lb)
Eyewear:	Unknown
Seat type:	Box-mounted seat
Seat track position:	Unknown track position
Manual restraint usage:	Lap and shoulder belt
Usage source:	Vehicle inspection
Air bags:	Frontal air bag available, did not deploy
Alcohol/drug data:	Tested negative for alcohol/drugs
Egress from vehicle:	Under own power
Transport from scene:	Ambulance to a local hospital
Type of medical treatment:	Treated and released. Returned to emergency room

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Contusion, left anterior thigh	810402.1	Steering wheel rim	Probable
2	Cervical strain	640278.1	Seat belt	Probable

Source: Physician documentation, radiology report.

Driver Kinematics

The 23-year-old female driver of the ambulance was seated in an unknown posture and was using the manual lap and shoulder belt. As the vehicle began a counterclockwise rotation, the driver was displaced to the right as the vehicle decelerated. During the right-side-leading rollover, she was displaced alternately to the right, top, and left. Her left thigh likely contacted the steering wheel rim, causing a contusion. Her torso remained held in place in the seat position by the seat belt but hyper-extensive movement of her head and neck caused a strain to the muscles of her cervical spine. She self-extricated and was transported by ambulance to a local hospital for treatment.

Rear Compartment EMT Demographics

Age/Sex:	53 years/female
Height:	168 cm (66 in)
Weight:	109 kg (240 lb)
Eyewear:	None
Seat type:	Bench-type inboard-facing squad seat
Manual restraint usage:	None
Usage source:	Vehicle inspection, medical records, interview
Air bags:	None available
Alcohol/drug data:	None
Egress from vehicle:	Removed from vehicle due to serious injuries
Transport from scene:	Ambulance to hospital
Type of medical treatment:	Hospitalized and later transferred to rehabilitation facility

Rear Compartment EMT Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1 2	Fractures, bilateral ribs, with hemopneumothorax Right ribs: 3-8, 12 Left ribs: 8-10, 12	450203.3 442205.3	Side panel	Possible
3	Contusions, lungs, bilateral	441410.3	Side panel	Possible
4	Fracture, thoracic spine, right T3 pedicle	650426.2	Side panel	Possible
5	Compression fracture, thoracic spine, T12	650416.2	Side panel	Possible
6 7	Fractures, lumbar spine, L1 and L2	650616.2 650616.2	Side panel	Possible
8	Rotator cuff tear, right	740600.1	Side panel	Possible
9	Laceration, right scalp	110600.1	Side panel	Possible

Source: Medical records.

Rear Compartment EMT Kinematics

The unbelted rear compartment EMT was in a seated upright posture on the forward aspect of the inboard-facing, bench-type squad seat. She had just finished adjusting the patient cot recline angles and was preparing to enter data into a laptop computer when the crash sequence began.

During the rollover, the occupant was displaced from her seated position and moved freely in the rear compartment. Her complexity of movement in the compartment caused by the rollover included contacts multiple objects and surfaces. She indicated an antiepileptic drug-monitoring device was displaced from its mount and possibly contacted her back and torso. An oxygen bottle was displaced from its mount but did not directly contact the occupant. At some point she held tight to a metal grab bar with her right hand, possibly causing a rotator cuff injury. This occupant likely contacted the side, floor, and roof panels of the compartment, as well as the patient cot, patient and other stationary and loose objects. The likely primary cause of her injuries were the side panels of the compartment. She sustained serious injuries including fractures to the bilateral ribs, hemopneumothoraces, and contusions to the bilateral lungs, multiple fractures to the thoracic and lumbar spine, laceration to the scalp and tear to the right rotator cuff.

Following the crash, this occupant came to rest in the rear compartment. She complained of pain and waited for emergency responders to arrive, who then removed her through the back doors and transported her to an area hospital. The occupant was discharged after eighteen days of treatment from the hospital to a rehabilitation center where she underwent two weeks of additional treatment.

Cot Occupant Demographics

Age/Sex:	57 years/female
Height:	170 cm (67 in)
Weight:	139 kg (306 lbs)
Eyewear:	Unknown
Seat type:	Immobilized longitudinally on cot
Seat track position:	N/A
Manual restraint usage:	Three lap-type belts
Usage source:	Police report
Air bags:	None available
Alcohol/drug data:	None
Egress from vehicle:	Removed by responders
Transport from scene:	Fatal at scene
Type of medical treatment:	None

Cot Occupant Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Component (IPC)	IPC Confidence Level
1	Subgaleal hematoma, left frontal parietal and temporal scalp	110402.1	Roof	Certain
2	Moderate perinephric soft tissue hemorrhage, right kidney	541699.2	Side panel	Possible
3	Laceration, left frontal parietal and temporal scalp, 13.0 cm (5.1 in). Laceration, right occipital scalp, 6.0 cm (2.4 in).	110602.1	Roof	Certain
4 5	Contusion, right forehead and right eyebrow	210402.1 210402.1	Roof	Certain
6 7 8	Multiple abrasions, right upper lip and cheek, chin	210202.1 210202.1 210202.1	Roof	Certain
9	Contusion, right ear	210402.1	Roof	Certain
10	Laceration, right aspect of nose	210600.1	Roof	Certain
11	Abrasion, horizontal, patterned, lateral aspect of right breast, 6.0 x 3.0 cm (2.4 x 1.2 in). Abrasion linear, patterned, right torso, 9.0 x 7.0 cm (3.5 x 2.8 in).	410202.1	Cot restraints	Probable
12	Contusion, right biceps, upper arm and shoulder, 15.0 x 2.0 cm (5.9 x 0.8 in)	710401.1	Side panel	Possible
13	Laceration, left hand	710600.1	Side panel	Possible
14	Contusion, left shoulder, upper arm, forearm, hand	710402.1	Side panel	Possible

Source: Autopsy report.

Cot Occupant Kinematics

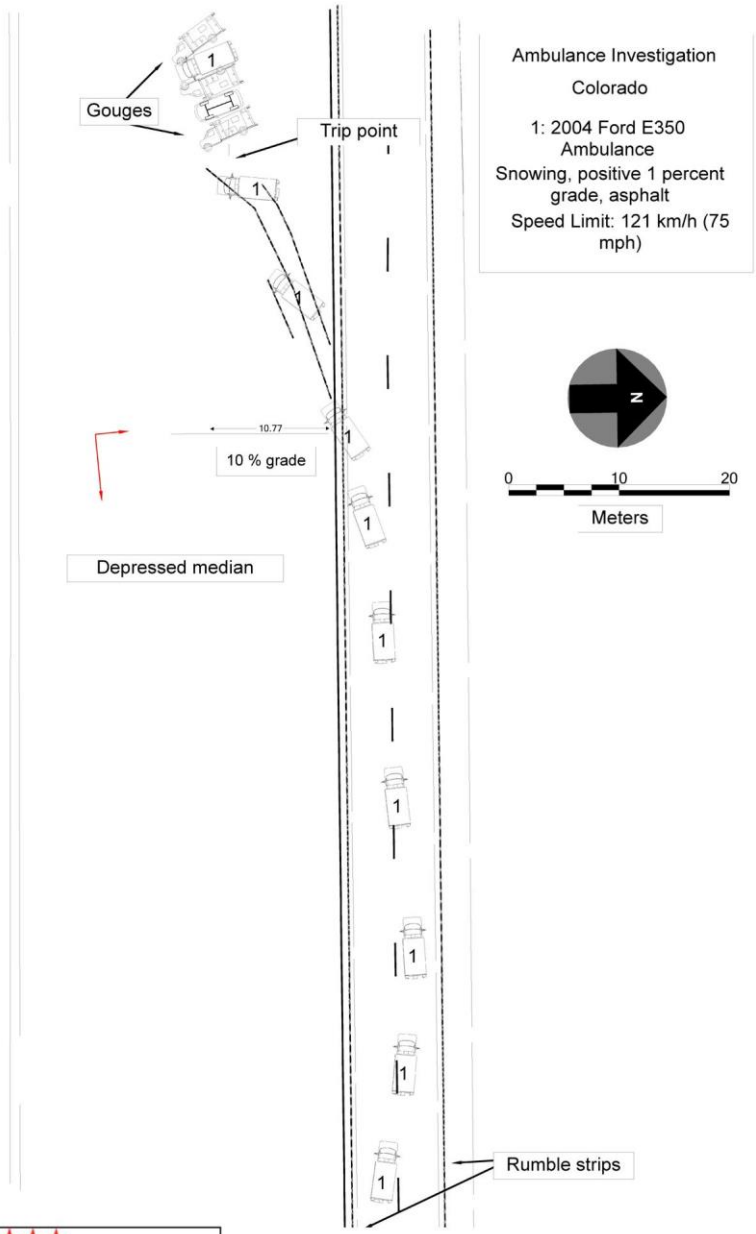
Figure 15. Contact evidence, probable injury source for patient, 2004 Ford E-350.

The 57-year-old female patient was immobilized on the cot and restrained by the available lap belts. Her head and feet were elevated and the upper and lower belt restraints were loosened. Following the crash, the cot had been placed back into the rear compartment of the ambulance and it was in the partially reclined position. As the vehicle began a counterclockwise rotation, the patient was directed to the right as the vehicle decelerated. She was held in place by the lap belts. As the vehicle tripped and then struck the ground with its right side, the ambulance cot lower frame rail fractured, and the cot and its occupant were displaced to the right and top. The cot and patient likely struck the right roof (**Figure 15**). Injuries to her head and face included subgaleal hematomas, laceration to the scalp and nose, and contusions and abrasions to the face and right ear. The patient sustained abrasions to her right breast and torso caused by loading of the belt restraints. She sustained a hemorrhage of the right kidney and contusions to her upper extremities caused by contact with the side panels of the rear compartment.

When a passerby opened the back door to the rear compartment, he did not see the patient. The police log indicated one non-responsive occupant was buried under debris. It is likely the log referred to the patient, because the EMT located in the rear compartment was alert and speaking. The passerby pulled the patient cot from the rear compartment through the back door and observed the occupant afterward. She came to rest against the side panel of the compartment and fully displaced from the cot.

The autopsy report stated the cot's belt restraints remained in the buckled position following the crash. The autopsy stated the likely cause of death for this occupant was blunt force trauma to the head. It further stated that the blunt force trauma to the head may not have been fatal by itself in an otherwise healthy individual. It considered the decedent's comorbidities to be contributing factors.

CRASH DIAGRAM



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