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Special Crash Investigations: On-Site Ambulance Crash Investigation; Vehicle: 2020 Freightliner M2 Type I Ambulance; Location: Oklahoma; Crash Date: March 2021

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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 submitted.

16. Abstract

This report documents the on-site investigation of the rollover crash involving a 2020 Freightliner M2 Type I ambulance that resulted in minor injuries to the driver and serious injuries to the emergency medical technician (EMT) and the patient being transported. The crash occurred on the south roadside of a 3-lane, divided U.S. highway that traversed in a general east-west direction. The south roadside was undergoing major construction at the time of the crash. The Freightliner was occupied by an unbelted 32-year-old male driver, an unbelted 28-year-old male EMT who was seated facing rearward, and the 68-year-old female patient who was restrained on a Stryker Model 6500 Power Pro XT patient cot. The patient was being transported to a hospital for renal failure, and the ambulance was being operated without emergency lights or siren activated. During heavy rain, the vehicle began to rotate clockwise and departed the right side of the roadway into a construction site. The vehicle rolled over, left side leading, one quarter turn and came to final rest in the construction area facing west. The driver sustained minor injuries and was transported by ambulance to a level 2 trauma center where he was treated and released. The EMT and patient were both transported by ambulance to a level 2 trauma center and were hospitalized for 6 and 11 days, respectively.

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Special Crash Investigations
On-Site Ambulance Crash Investigation
Case No.: CR21010
Vehicle: 2020 Freightliner M2 Type I Ambulance
Location: Oklahoma
Crash Date: March 2021

Background

This report documents the on-site investigation of the rollover crash involving a 2020 Freightliner M2 Type I ambulance (Figure 1) that resulted in minor injuries to the driver and serious injuries to the emergency medical technician (EMT) and the female patient being transported. The EMT was attending to the patient at the time of the crash. The investigation was initiated by the National Highway Traffic Safety Administration's Office of Emergency Medical Services who identified the March 2021 crash. The on-site investigation was assigned to the Special Crash Investigation (SCI) team at Crash Research and Analysis, Inc. in March. This single-vehicle crash was investigated by the local State police agency.

Figure 1. 2020 M2 ambulance

On-site activities included inspection of the Freightliner to examine and document exterior and interior damage, identify occupant contacts and determine kinematics, and evaluate the manual, supplemental, and patient restraint systems. The inspection of the Freightliner and crash scene, as well as the driver interview, were all completed in April 2021.

The crash occurred on the south roadside of a 3-lane, divided U.S. highway that traversed in a general east-west direction. The south roadside was undergoing major construction at the time of the crash. The Freightliner was occupied by an unbelted 32-year-old male driver, an unbelted 28-year-old male EMT who was seated facing rearward, and the 68-year-old female patient who was secured to a Stryker Model 6500 Power Pro XT patient cot. The patient was being transported to a hospital for renal failure and the ambulance was being operated in non-emergency mode (without emergency lights or siren). During heavy rain, the vehicle began to rotate clockwise and departed the right side of the roadway into the construction site. The vehicle rolled over, left side leading, one quarter turn and came to final rest in the construction area facing west. The driver sustained minor injuries and was transported by ambulance to a level 2 trauma center where he was treated and released. The EMT and patient were both transported by ambulance to a level 2 trauma center and were hospitalized for 6 and 11 days, respectively. The Freightliner was towed from the crash scene.

Ambulance Service Data

According to the assistant fire chief, the ambulance service was part of a municipal fire department that provided emergency medical services (EMS) as well as non-emergency transfers. The ambulance service covered an area of 1,100 square km (425 square miles) with a fleet of five ambulances.

The assistant fire chief also stated the ambulance service employed career professionals, some of whom also did fire/rescue work. The ambulance service required its employees who operated vehicles to complete emergency vehicle operations training. This consisted of an in-house emergency vehicle operations course which was to be recertified every 2 years. The involved driver had been a certified driver since 2016 and renewed his training multiple times, with his last certification in 2020 from in-house training.

The EMS personnel primarily were scheduled on a 24 hours on/48 hours off shift rotation but could fill in on an as-needed basis. The driver did not work prior to the day of the crash and started work at 0800 hours on the day of the crash. The EMT was a full-time employee and had come on duty at 0800 hours on the day of the crash. The crash occurred 9 hours into their shifts.

Crash Summary

Crash Site

The crash occurred during the daytime on the roadside of a 3-lane, divided U.S. highway. The weather conditions were heavy rain, a temperature of 16 °C (61 °F), and wind from the southeast at 26 km/h (16 mph), according to local weather reports.

The eastbound roadway had three lanes and was separated from the westbound lanes by a grassy median with concrete and cable barriers. The lanes were 3.9 m (12.8 ft) wide, and the roadway curved to the right with a radius of 562.0 m (1,843.8 ft). The concrete roadway was level and was bordered by bituminous shoulders that measured 1.0 m (3.3 ft) and 2.5 m (8.2 ft) on the left and right, respectively. Roadway markings consisted of a solid yellow median line, a solid white edge line, and dashed white and black lane lines. The roadway surface was wet with standing water at the time of the crash. A crash diagram is included at the end of this report.

Pre-Crash

The Freightliner was traveling east (Figure 2) at a driver and witness-reported speed of approximately 80 km/h (50 mph). The vehicle was enroute to a hospital, operating in non-emergency mode with no lights or siren. The driver was unbelted, as was the EMT who occupied the rear-facing captain's chair in the patient compartment. The patient was secured to the cot system with lateral straps across her feet, thighs, and chest with her upper body elevated approximately 20 degrees from horizontal. According to the driver and police crash report, the Freightliner traveled into standing water on the roadway, and began to hydroplane and rotate clockwise. The vehicle veered to the right and traveled off the roadway (Figure 3).

Figure 2. East view of the Freightliner's travel path prior to roadway departure

Figure 3. Tire marks leading off roadway

Crash

The Freightliner traveled off the roadway into a sand/dirt construction area and continued to rotate clockwise. Due to the ongoing construction, it is unlikely that the crash area was the same at the time of the crash as it was during the inspection. The Freightliner's left wheels tripped in the dirt and the ambulance rolled over, left side leading, one quarter turn and came to final rest on its left side facing west (Figure 4). No air bags deployed during the crash sequence.

Figure 4. Police image, west view of the Freightliner at final rest

Post-Crash

The police and EMS were notified of the crash and responded to the site. The Freightliner driver stated during the SCI interview that he crawled through the space between the cab and patient compartment to render aid to the EMT and patient. The EMT and patient were both subsequently removed on backboards, having sustained serious injuries, and were transported by ambulance to a level-2 trauma center where they were hospitalized. The driver exited the vehicle under his own power. He sustained minor injuries and was transported to the same level 2 trauma center, where he was treated and released.

2020 Freightliner M2 Type I Ambulance

Description

The Freightliner was a rear-wheel drive incomplete vehicle with dual rear wheels, manufactured in April 2019 with Vehicle Identification Number 1FVACWFC8LHxxxxxx. It was equipped with a six cylinder, 6.7-liter diesel engine. The patient compartment was installed in September 2020 with a Type I ambulance body by REV Ambulance Group. A placard confirmed that the ambulance compartment conformed to Federal standard KKK-A-1822F in effect on the date of manufacture. This designation refers to the United States General Services Administration standard for minimum specifications, test parameters, and criteria for design, performance, equipment, and appearance.

The Freightliner's cab was configured for the seating of two occupants, with forward-facing box-mounted seats, three-point lap and shoulder seat belts, integrated head restraints, and dual frontal air bags.

The patient compartment was equipped with a right-side door and double rear doors for patient entrance/exit. Medical supplies and roadside safety equipment were kept in exterior and interior cabinets. A rear-facing, high back pedestal-mounted seat equipped with an integrated lap and shoulder seat belt was mounted at the forward aspect. There was also a two-passenger bench seat parallel to the right wall, and a centrally located single occupant patient cot mount. The bench seat was equipped with two 4-point seat belts, as well as wall-mounted straps to secure an additional patient.

According to the information placard, the Freightliner had a gross vehicle weight rating of 9,072 (20,000 lbs.) and gross axle weight ratings of 3,629 kg (8,000 lbs) front and 5,443 kg (12,000 lbs.) rear. The total usable payload of the vehicle (weight capacity of occupants and cargo) was 9,952 kg (4,526 lbs.).

The vehicle manufacturer's recommended tire size was LT245/70R19.5 with a recommended cold tire pressure of 827 kPa (120 PSI) for the front and rear tires. The vehicle was equipped with Falken RI 1919 tires on the front wheels and Michelin XZE tires on the rear outside wheels, all the recommended size. The front tires were in good condition with a minimum of 15 mm (19/32 in) of tread depth. All rear tires showed excessive wear, with 4 mm (5/32 in) or less tread depth (Figure 5). Manufacturer and size of the rear inside tires could not be determined.

Figure 5. 4 mm (5/32 in) tread on left rear tires

Exterior Damage

The direct damage from the rollover consisted of body panel deformation and abrasions extending the entire length of the left side of the Freightliner (Figures 6 and 7). There was no lateral or vertical crush to the vehicle. The WinSMASH program could not be used to determine crash severity (delta V) because rollovers are out of the scope for the program. The truck deformation classification assigned to this impact was 00LDAO1.

Figure 6. Ambulance cab rollover damage

Figure 7. Left side of ambulance

Interior Damage

The interior of the Freightliner cab sustained minor damage during the crash. There was no measurable intrusion. Occupant contacts were identified on the roof and left roof side rail above the driver's seating position. The windshield had a spider-web breakage pattern at the left central aspect. This damage did not appear to be a result of contact by the driver, but more likely from a loose object in the cab.

The interior of the patient compartment sustained minimal damage from the crash. Due to the lateral forces associated with the rollover, the forward right side cabinet was slightly displaced.

The primary contacts in the patient compartment were attributed to the unbelted EMT and involved the longitudinal roof rail (Figures 8 and 9), which was contacted by his head as he was displaced upward and toward the left cabinetry from the rear-facing captain's chair. Blood splatters were noted on the ceiling near the point of contact with the railing. No contacts were attributed to the patient, who remained belted throughout the crash sequence. However, the patient did sustain a significant head injury, possibly from contact with the left side cabinetry. It is also possible that the patient's head injury was caused by contact with the EMT.

Figure 8. Patient compartment looking forward and left at the ceiling rail contact

Figure 9. Closeup of contact to ceiling rail and blood mist/splatter on ceiling

Manual Restraint Systems

The cab of the Freightliner was equipped with a 3-point lap and shoulder seat belt system for both seating positions that consisted of continuous loop webbing, sliding latch plates, and fixed upper anchors. The driver's seat belt retracted onto an emergency locking retractor (ELR), while the front right passenger's seat belt retracted onto an ELR/automatic locking retractor. The driver was not restrained by his lap and shoulder seat belt.

The patient compartment was equipped with manual seat belt systems at the three seating positions. The rear-facing captain's chair was equipped with a 3-point, integrated seat belt. The bench seat was equipped with two 4-point seat belts which were housed on the right side of the patient compartment. The seat positions had two separate shoulder belts, with attachments to the bench at hip level and on the wall at shoulder level. There were also three straps mounted to the right wall that were used for restraint of a patient lying on the bench. None of the patient compartment seat belts were in use at the time of the crash.

Patient Cot System

The 6500 Power Pro-XT patient cot (Figure 10) was manufactured by Stryker, serial number: 101041xxx. It was constructed with a tubular aluminum frame with an X-frame supporting the mattress and featured power lift capabilities. The cot had a height range of 36 cm (14.2 in) to 105 cm (41.5 in) and a maximum load capacity of 318 kg (700 lbs.). The weight of the cot with one battery pack, no mattress or restraints was 55 kg (122 lbs.). The backrest could be adjusted from

Figure 10. Stryker 6500 Power Pro-XT patient cot and defibrillator unit

0–73 degrees. Similarly, the leg rest could be raised from 0–15 degrees above horizontal. Overall dimensions of the cot were 58 cm (22.8 in) wide and 206 cm (81.1 in) long.

The Stryker cot was equipped with a multi-point harness system for manual restraint of the patient. This multi-point harness system included lateral leg, lap, and chest straps. A shoulder harness was available but not in use at the time of the crash. The safety belt webbing was mounted to the cot frame and all straps included locking latch plates for length adjustment. A discussion with a fire department representative revealed that shoulder belts were recommended for use on patients but were also at the discretion of the medical technician. It was further stated that the patient remained secured to the cot system during the crash sequence.

Cot Fastening System

The Stryker cot was secured to the floor of the patient compartment via a Stryker Power-Load system (Figure 11). The fastening system consisted of two components, including the bracket/assembly that attached to the cot and a continuous bracket that mounted to the floor of the patient compartment. The floor bracket measured 241 cm (94.9 in) long and was 62 cm (24.4 in) wide. Manufacture specifications indicated that the complete system weighed a total of 95.9 kg (211.5 lbs.). The cot was secured to the fastening system with two latches at the head and one at the foot. The floor-mounted bracket (Figure 12) guided the cot into and out of the patient compartment of the ambulance. This latching system secured the cot longitudinally and laterally to the floor during vehicle operation.

There was no damage to the patient cot or loading system due to the crash. The cot was inspected by a manufacturer representative and approved for return to service.

Figure 11. Image of an exemplar patient cot secured to the Stryker Power-LOAD cot fastening system

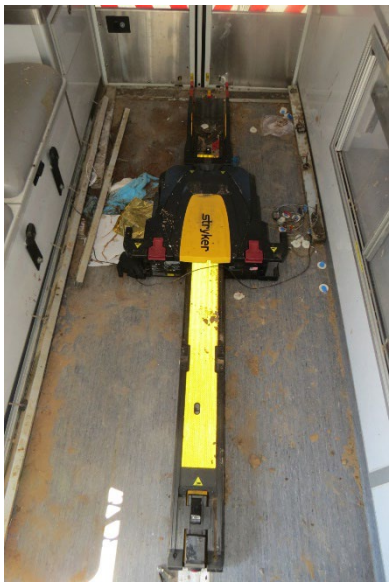


Figure 12. Stryker Power Load cot securing system

2020 Freightliner M2 Occupant Data

Driver Demographics

Age/Sex:	32 years/male
Height:	185 cm (73 in)
Weight:	101 kg/222 lb
Eyewear:	None
Seat type:	Box mount with integral head restraint
Seat track position:	Seat at rear most track position
Manual restraint usage:	None
Usage source:	Vehicle inspection
Air bags:	Driver's frontal available, not deployed
Alcohol/Drug involvement:	No test performed
Egress from vehicle:	Exited under own power
Transport from scene:	Ambulance to level 2 trauma center
Type of medical treatment:	Treated and released

Driver Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Lumbar strain	640678.1	Isolated Interior – Door panel, unknown quadrant	Probable
2	Small abrasion to left forehead	210202.1	Isolated Roof – Roof left side rail	Probable

Source: Emergency room report

Driver Kinematics

The driver was seated in the box-mounted driver's seat with the seat track adjusted to the full-rear track position and was not restrained by the available 3-point lap and shoulder seat belt. The driver was displaced in multiple directions as the vehicle rotated clockwise, then directed toward the left side as the vehicle rolled over, left side leading. The driver likely contacted the left roof side rail with the left side of his forehead and sustained a 1 cm (0.4 inch) abrasion. He also sustained a lumbar strain during the crash sequence. The driver crawled through the passageway between the cab and patient compartment to render aid to the EMT and patient. He stated he rode in the ambulance with the other two victims to a level 2 trauma center where he was treated and released.

EMT Demographics

Age/Sex:	28 years/male
Height:	180 cm (71 in)
Weight:	101 kg (222 lb)
Eyewear:	None

Seat type:	Rear-facing captain's chair
Seat track position:	Not adjustable
Manual restraint usage:	None
Usage source:	Vehicle inspection
Air bags:	None available
Alcohol/Drug involvement:	Alcohol = 0, drug screen negative
Egress from vehicle:	Removed by EMS
Transport from scene:	Ambulance to level 2 trauma center
Type of medical treatment:	Hospitalized 6 days

EMT Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	T11 fracture of superior end plate with minimal anterior vertebral body loss, mild compression	650432.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
2	T11 fractures of the lamina, extending to inferior articular facets and spinous process	650417.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
3	T1 vertebral body fracture, minor compression	650432.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
4	T2 vertebral body fracture, minor compression	650432.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
5	T3 vertebral body fracture, minor compression	650432.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
6	T4 vertebral body fracture, minor compression	650432.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
7	T12 vertebral body fracture, minor compression	650432.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
8	L1 vertebral body fracture, minor compression	650632.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
9	C7 fracture of the superior end plate, minimal compression	650232.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
10	Large posterior scalp laceration with degloving, 23 cm	110804.2	Isolated IPC Interior – Grab handle	Certain
11	Posterior scalp contusion	110402.1	Isolated IPC Interior – Grab handle	Certain
12	Right 6th posterior rib fracture	450201.1	Isolated Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
13	Interspinous ligament partial tears at C7-T1	640284.1	Isolated Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
14	Interspinous ligament partial tears at T1-T2	640484.1	Isolated Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
15	Interspinous ligament partial tears at T2-T3	640484.1	Isolated Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Probable
16	Left lower leg laceration, 3 cm	810602.1	Isolated Interior – Other interior object(s) (specify): Cot	Probable

Source: Hospital records

EMT Kinematics

According to ambulance service personnel, the EMT was seated on the rear-facing captain's chair, attending to the patient. He was not belted. The EMT's movement during the ambulance's clockwise rotation is unknown. As the vehicle rolled over, left side leading, the EMT was displaced toward the left side of the patient compartment as well as the roof. His head struck the center longitudinal grab bar mounted to the ceiling and sustained a 23 cm (9.1 in) laceration with degloving across the posterior scalp. As he continued toward the left side of the ambulance, he struck the cabinetry on the wall and sustained spinal fractures at T1, T2, T3, T4, T11, T12, and C7 as well as interspinous ligament tears at C7-T1, T1-T2, and T2-T3. During the contact with the cabinetry, he also sustained a fracture of the right 6th posterior rib. His lower left leg probably struck the patient cot, and he sustained a 3 cm (1.2 in) laceration of the left lower leg.

Patient Demographics

Age/Sex:	68 years/female
Height:	157 cm/62 in
Weight:	54 kg/(118 lb)
Eyewear:	Corrective lenses
Seat type:	Patient cot
Seat track position:	Not adjustable
Manual restraint usage:	Foot, thigh, and chest lateral straps
Usage source:	Ambulance service
Air bags:	None available
Egress from vehicle:	Removed by EMS
Transport from scene:	Ambulance to level 2 trauma center
Type of medical treatment:	Hospitalized 11 days

Patient Injuries

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
1	Bilateral subdural hemorrhage along posterior falx and tentorial leaflets; 6 mm on left and 3 mm on right	140654.4	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment (low) Alternate: Interior – Other occupants (specify): EMT	Possible Possible
2	Traumatic subarachnoid hemorrhage, NFS	140693.2	Isolated IPC Primary: Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment (low) Alternate: Interior – Other occupants (specify): EMT	Possible Possible
3	Right posterior lateral scalp hematoma	110402.1	Isolated Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment (low)	Possible
4	Hematoma over left mastoid area	110402.1	Unknown	Unknown

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
5	Right parietal scalp abrasions	110202.1	Isolated Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment (low)	Possible
6	Left forehead abrasions	210202.1	Unknown	Unknown
7	Bilateral abdominal contusions	510402.1	Isolated Interior – Lap portion of belt restraint	Certain
8	Bilateral abdominal abrasions	510202.1	Isolated Interior – Other restraint system component (specify): Cot lateral belts torso, hip, lower legs	Certain
9	Open right 2nd metacarpal neck fracture, NFS	752522.2	Isolated Interior – Other interior object(s) (specify): Left side cabinetry of patient compartment	Possible
10	Right hip contusions	810402.1	Isolated Interior – Other restraint system component (specify): Cot lateral belts torso, hip, lower legs	Certain
11	Left hip contusions	810402.1	Isolated Interior – Other restraint system component (specify): Cot lateral belts torso, hip, lower legs	Certain
12	Right hip abrasions	810202.1	Isolated Interior – Other restraint system component (specify): Cot lateral belts torso, hip, lower legs	Certain

Injury No.	Injury	Injury Severity AIS 2015	Involved Physical Components (IPC)	IPC Confidence Level
13	Left hip abrasions	810202.1	Isolated Interior – Other restraint system component (specify): Cot lateral belts torso, hip, lower legs	Certain

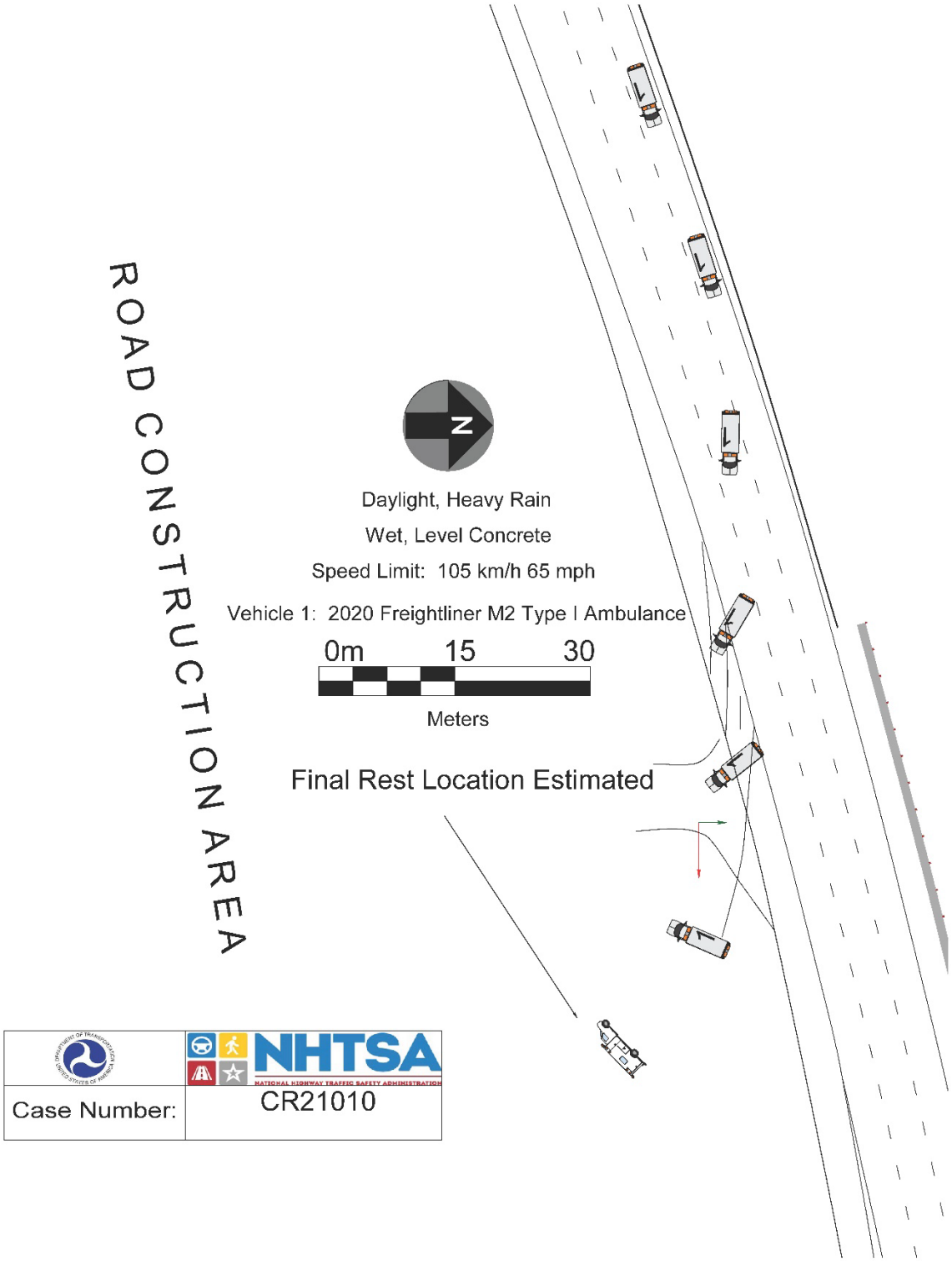
Source: Hospital records

Patient Kinematics

The patient was being transported to a medical facility for treatment of a renal failure issue. According to the ambulance driver, she was secured to the patient cot with lateral straps across the feet, thighs, and chest. The cot's shoulder straps were not in use. It was likely that the location of the chest strap allowed some freedom of movement of her upper torso and head. Transport of the patient was not made in emergency mode.

The patient began to load the webbing of the cot's lateral restraints as the ambulance rotated clockwise. As the vehicle rolled over one quarter turn to the left, the patient sustained contusions on her abdomen and both hips from contact with the lateral restraint straps. During the rollover, the patient possibly contacted the left side cabinetry of the patient compartment and sustained a bilateral subdural hemorrhage and traumatic subarachnoid hemorrhage and additional soft tissue injuries to her head. Based on the position of the EMT and patient, as well as the occupant kinematics, it was possible that the patient was also involved in occupant-to-occupant contact with the EMT. She also sustained a hematoma over the left mastoid area and left forehead abrasions. A source for these injuries could not be determined. She was transported to a level 2 trauma center and was hospitalized for 11 days.

Crash Diagram



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**National Highway
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