CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE AMBULANCE CRASH INVESTIGATION

CALSPAN CASE NO: CA04-048

VEHICLE: 2001 FORD E-350

LOCATION: MARYLAND

CRASH DATE: NOVEMBER 2004

Contract No. DTNH22-01-C-17002

Prepared for:

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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 are 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.

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16. Abstract This on-site investigation focused on the severity of the crash, the integrity of the patient compartment and the injury sources for the occupants of the patient compartment. The subject vehicle was a 2001 Ford E-350 chassis with a McCoy Miller Type III ambulance body. The unit was occupied by a restrained 27-year-old female driver, a restrained 34-year-old male paramedic seated in the rear-facing technician seat at the forward wall of the patient compartment, a 31-year-old female nurse restrained on the right side bench seat of the patient compartment, and a 22-year-old pregnant female in active labor restrained to the cot in an elevated position. The ambulance was traveling in an easterly direction on the inboard lane of a divided interstate roadway with the overhead lights activated at an estimated speed of 113 km/h (70 mph). The patient was being transported to the neonatal unit of a major hospital complex due to her high-risk pregnancy associated with diabetes. While negotiating a straight segment of roadway, the driver of the ambulance relinquished control of the vehicle and departed the left road edge. The ambulance traversed the wide grass median and struck the left side and axles of a tractor, semi-trailer unit that was traveling on the inboard westbound lane. The impact resulted in severe damage to the cab of the ambulance and the contents of the flatbed trailer sheared the front left corner of the patient compartment. The deformation to the patient compartment fractured the roof welds and the roof panel was completely separated from the patient compartment. The driver of the ambulance sustained massive injuries due to the severe intrusion of the cab and expired immediately. The paramedic sustained multiple fractures of the face and extremities, a scalp laceration, and abrasions to his extremities. The nurse sustained serious injuries that included a vertebrae fracture. The patient remained restrained to the cot; however, the cot separated from the locking mechanism and was displaced forward. All occupants of the patient compartment were transported by helicopter to a regional trauma center. An emergency C-section was performed on the patient following her arrival; however, the fetus was stillborn.			
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TABLE OF CONTENTS

CALSPAN ON-SITE AMBULANCE CRASH INVESTIGATION
CASE NO.: CA04-048
VEHICLE CHASSIS: 2001 FORD E-350
AMBULANCE BODY: McCOY MILLER TYPE III
LOCATION: MARYLAND
CRASH DATE: NOVEMBER 2004

BACKGROUND

This on-site investigation focused on the severity of the crash, the integrity of the patient compartment and the injury sources for the occupants of the patient compartment. The subject vehicle was a 2001 Ford E-350 chassis with a McCoy Miller Type III ambulance body. The unit was occupied by a restrained 27-year-old female driver, a restrained 34-year-old male paramedic seated in the rear-facing technician seat at the forward wall of the patient compartment, a 31-year-old female nurse restrained on the right side bench seat of the patient compartment, and a 22-year-old pregnant female in active labor restrained to the cot in an elevated position. The ambulance was traveling in an easterly direction on the inboard lane of a divided interstate roadway with the overhead lights activated at an estimated speed of 113 km/h (70 mph). The patient was being transported to the neonatal unit of a major hospital complex due to her high-risk pregnancy associated with diabetes. While negotiating a straight segment of roadway, the driver of the ambulance relinquished control of the vehicle and departed the left road edge. The ambulance traversed the wide grass median and struck the left side and axles of a tractor, semi-trailer unit that was traveling on the inboard westbound lane. **Figure 1** is an on-scene view of the crash site. The impact resulted in severe damage to the cab of the ambulance and the contents of the flatbed trailer sheared the front left corner of the patient compartment. The deformation to the patient compartment fractured the roof welds and the roof panel was completely separated from the patient compartment. The driver of the ambulance sustained massive injuries due to the severe intrusion of the cab and expired immediately. The paramedic sustained multiple fractures of the face and extremities, a scalp laceration, and abrasions to his extremities. The nurse sustained serious injuries that included a vertebrae fracture. The patient remained restrained to the cot; however, the cot separated from the locking mechanism and was displaced forward. All occupants of the patient compartment were transported by helicopter to a regional trauma center. An emergency C-section was performed on the patient following her arrival; however, the fetus was stillborn.

Figure 1. On-scene view of the crash site.

The crash was identified by NHTSA through local media and Internet news coverage. Due to the severity of the crash and the separation of the roof of the patient compartment,

NHTSA assigned the crash as on-site investigation to the Calspan Special Crash Investigations team on November 24, 2004. Cooperation was established with the investigating police officer and the on-site inspections of the involved vehicles and crash site were initiated on December 1, 2004.

SUMMARY

Crash Site

The crash occurred on a divided interstate roadway during daylight hours. The roadway consisted of two asphalt travel lanes in each direction with paved shoulders bordering the lanes. The east and westbound lanes were 3.7 m (12.0') in width and were divided by a 21.4 m (70.2') wide depressed grass median. The inboard shoulders were paved with asphalt and were 1.2 m (3.9') in width. Tactile warning devices (rumble strips) were cut into the outboard edge of the inboard shoulders. The outboard shoulders were 3.9 m (12.8') in width and paved with asphalt with the tactile strips located at the inboard edge. The inboard lanes were delineated from the shoulders by solid yellow centerlines while a solid white edge line delineated the outboard lane from the shoulder. Broken white lane lines delineated the travel lanes. In the vicinity of the crash site, the roadway was straight with a slight positive grade for eastbound travel. An overpass bridge structure was located 57.4-70.5 m (188.3-231.3') east of the point of impact. **Figure 2** is a view of the crash site from the referenced overpass. At the time of the crash, the environmental surfaces were dry. The posted speed limit was 105 km/h (65 mph). The scene schematic is included as **(Figure 24)** of this report

Figure 2. View of the crash from the overpass.

Vehicle Data

Ambulance - Chassis

The ambulance unit consisted of a 2001 Ford E-350 chassis and a McCoy Miller Type III ambulance body. The chassis of the unit was manufactured on 12/00 and was identified by Vehicle Identification Number (VIN) 1FDWE35FX1H (production number deleted). The chassis was manufactured as an incomplete vehicle and was equipped with the Ford Ambulance Prep Package. The E-350 was powered by a conventionally mounted 7.3-liter turbo diesel engine that was linked to a 4-speed automatic transmission with a column-mounted shifter. The braking system consisted of 4-wheel disc brakes (unknown if ABS equipped). The Dana rear axle consisted of dual tires with a rear axle Gross Vehicle Weight Rating (CVWR) of (7,500 lb). The total GVWR for this chassis was (10,700 lb). The chassis was equipped with LT225/75R16D tires mounted on 40.6 x 15.2 cm (16x6") wheels with manufacturer recommended tire pressures of 448 kpa (65 PSI) for the front axle and 379 kpa (55 PSI) for the dual rear tires. The specific tire data at the time of the SCI inspection for this vehicle is identified in the following table:

Position	Tire Make/Model	Measure Pressure	Measured Tread Depth	Damage
LF	Unknown	Unknown	Unknown	Unknown, separated and positioned under front of vehicle
RF	Firestone Steeltex R45II	0 kpa	7 mm (9/32”)	Tread cut
LR Outer	Firestone Steeltex R45II	Unknown, unable to access valve	4 mm (5/32”)	No damage
LR Inner	Firestone Steeltex R4	359 kpa (52.0 psi)	6 mm (7/32”)	No damage
RR Outer	Firestone Steeltex R45II	Unknown, unable to access valve	6 mm (7/32”)	No damage
RR Inner	Firestone Steeltex R45II	359 kpa (52.0 psi)	6 mm (7/32”)	No damage

Ambulance – Patient Compartment

The patient compartment of the ambulance was manufactured by McCoy Miller and was classified as a Type III body. The overall dimensions of the unit were 361.3 cm (142.2”) in length, 229.4 cm (90.3”) in width, and approximately 228.6 cm (90.0”) in height (roof separated). The patient compartment was constructed of exterior aluminum body panels with compartments concealed by hinged doors, a right side door for occupant access, and rear double doors for patient loading. The roof was constructed of an aluminum panel that capped the four walls of the unit. A strobe light bar was mounted to the forward wall of the patient compartment, above the cab roof of the chassis.

The interior of the patient compartment was partitioned with 1.9 cm (0.8”) luan plywood walls with smooth laminate interior surfaces. **Figure 3** is an overall view of the interior of the patient compartment. The forward aspect of the left wall of the patient compartment contained the HVAC controls and a work counter with several overhead bins for storage of medical supplies. This area was torn open from the impact with the wood cargo of the trailer. At the mid point of the left wall was the CPR technician seat. This seat consisted of a fabricated cushion and backrest, equipped with a manual lap belt system. Aft of this seat, was a stack of compartments that were closed with sliding Plexiglas doors.

Figure 3. View of the patient compartment.

The forward wall of the patient compartment provided access to the cab of the ambulance with a center pass-through. Located above this pass-through was a heating/air conditioning unit that was

mounted in a fabricated plywood box. Located left of the pass-through was a rear-facing technician seat. This seat consisted of a separate cushion and backrest. The backrest was attached to the 1.9 cm (0.8") plywood partition. A lap belt was equipped for this seated position. Located to the right of the pass-though on the forward wall was a stack of three shelves with protruding edges that were banded by 3.8 cm (1.5") wide aluminum. The monitor and the defibrillator were stored on the middle shelf and restrained by a two-point belt system. A paramedic duffle bag was positioned on the lower shelf. The upper shelf was deformed by the crash and all contents were displaced.

The right wall of the interior patient compartment contained the access door with a V-formed stainless steel handle and a tempered glass window in the upper third of the door. This door remained closed during the crash. Located aft of this door was a three position bench seat with storage under the seat cushion and a fixed backrest on the right wall. All three positions were equipped with a separate backrest. Storage cabinets were located above this seat. The rear wall of the patient compartment contained the patient loading doors. These doors were hinged at the outboard aspect and closed to the center. Both doors remained closed during the crash and were forced open by rescue personnel post-crash. Tempered glazing panels were located in the upper third of each rear door. The right glass panel was shattered by door deformation while the left door glazing remained intact.

The roof of the patient compartment separated as a result of the crash. The roof and its associated damage are addressed under the ***Vehicle Damage – Exterior Ambulance*** section of this report.

Tractor Semi-Trailer

The struck vehicle in this crash was a tractor semi-trailer combination that was traveling in the westbound direction. The tractor was a conventional cab PeterBilt that was manufactured in August 1977. The tractor was identified by Serial No. 98111N, placarded on the left B-pillar of the cab. A sleeper berth was located behind the cab and extended the full width of the tractor and measured 157.5 cm (62.0") in depth. Access to the sleeper was provided by a pass-through from the cab and a left side door. The cab and sleeper berth were constructed of aluminum. An aluminum cargo retention plate was mounted to the frame of the tractor to prevent displaced cargo from impacting the back of the sleeper berth.

The tractor was rated at a maximum Gross Vehicle Weight Rating of 22,480 kg (49,560 lb). The chassis was equipped with a large displacement diesel engine linked to a manual transmission. The dual rear drive axles and the front steer axle were was equipped with air brakes. All tractor tires were in new condition and were mounted on alloy wheels.

The trailer of the unit was a flatbed that measured 13.7 m (45.0') in length and 2.3 m (7.6') in width. The bed of the trailer was wood with a channel steel frame. The trailer was manufactured by Transcraft with a Model No. of TL2000 W2 45x96. The VIN for the trailer was 111-F4520-1-W1056562. The trailer's GRWR was listed at 10,233 kg (22,560 lb) with 21.1x62.2 cm (8.3x24.5") wheels and 655 kpa (95 psi) cold tire pressure.

The trailer was loaded with dimensional 5.1x10.2 cm (2x4") lumber of various lengths and Oriented Strand Board (OSB) plywood of multiple thicknesses. It was reported that the trailer was fully loaded with this cargo at the time of the crash. The OSB plywood was positioned at the forward aspect of the trailer with the dimensional lumber positioned at the rear aspect of the trailer. All of the cargo was secured with ratcheting nylon tie-down straps that were secured to the bed of the trailer. The weight of the cargo was unknown.

Crash Sequence

Pre-Crash

The ambulance was providing medical transport for the patient who was reportedly 33 weeks pregnant and in active labor. The patient was also diabetic and was considered a high-risk pregnancy. She was initially evaluated and treated at a local hospital for early labor and prepared for ambulance transport to a neonatal unit of a major hospital that was located approximately 129-145 kilometers (80-90 miles) east of her location. A drug was administered at the initial hospital to slow the labor process. Due to the administering of this drug, a nurse was required to ride in the ambulance to monitor the patient's status.

The ambulance staff consisted of the 27-year-old female driver who was hired as an Emergency Medical Technician Basic in August of 2004 and a 34-year-old male paramedic. The driver was restrained by the manual 3-point lap and shoulder belt system. The paramedic was seated in the rear facing technician seat that was configured at the front wall of the patient compartment. He was restrained by the manual lap belt system. The nurse was seated on the right bench seat and was restrained by the manual lap belt at the direction of the paramedic. She unbuckled the belt system prior to the crash to check on the status of the patient. Based on the injuries sustained by the nurse she apparently re-buckled the safety belt. The patient was restrained in a upright position on the cot. Two restraint belts were positioned at the level of the upper abdomen and at the level of her thighs. The cot was restrained by the mechanical locking mechanism that was mounted to the floor of the ambulance on the left side of the cot.

En route to the neonatal facility, the ambulance driver was traveling in an easterly direction on the divided interstate roadway at an estimated speed of 105-113 km/h (65-70 mph). She was traveling on the inboard travel lane with the strobe light bar activated. The emergency siren was not activated. The investigating officer estimated the total length of this trip at approximately 90 minutes with the ambulance located approximately 20 minutes from its destination at the time of the crash. While en route, the driver of the ambulance relinquished control of the vehicle. It was possible that she may have experienced a medical episode based on prescription medication found in the cab of the ambulance.

The ambulance departed the left edge of the inboard travel lane and traversed the tactile rumble strips without alerting the driver to a roadside departure. The vehicle continued to drift left as it entered the depressed grass median and traversed the median at a shallow angle with respect to its eastbound trajectory. Dual wheel tire marks evidenced the

vehicles trajectory **(Figure 4)**. Based on these tire marks, the ambulance traveled approximately 91.4 m (300.0') while traversing the 21.4 m (70.2') wide median.

Figure 4. Ambulance travel through the median.

Figure 5. Area of impact between the Ambulance and tractor.

The ambulance crossed the inboard shoulder of the westbound travel lane and again overrode the rumble strip warning feature. The tractor, semi-trailer was traveling in a westerly direction on the inboard travel lane of the interstate roadway at a speed of approximately 105 km/h (65 mph).

There was no visible evidence at the crash site to support avoidance action by the driver of the ambulance or the driver of the tractor, semi-trailer.

Crash

As the ambulance entered the westbound lane, it impacted the left side of the tractor-trailer unit **(Figure 5).** The initial impact involved the front left corner area of the ambulance against the left side area of the tractor unit. The ambulance engaged the leading edge of the sleeper berth and the aluminum sidesaddle diesel fuel tank of the tractor. As the vehicles crushed and continued on their forward trajectories, the front left area of the ambulance engaged the drive axles of the tractor. At this point of the crash phase, the plywood cargo on the trailer translated forward and engaged the cargo retention plate of the tractor and the front left corner area of the ambulance cab and patient compartment. Blue paint transfers from the edges of the plywood were present on the ambulance and the back aspect of the cargo retention plate and sleeper berth. The plywood cargo crushed the roof of the ambulance cab and engaged the left door and upper left B-pillar area of the ambulance. Due to the ambulance deformation, the plywood engaged the left upper B-pillar area of the ambulance and cut (shredded) the driver safety belt webbing at the location of the D-ring.

The cargo of the trailer engaged the left upper corner of the patient compartment and the roof of the ambulance. The wood cargo peeled open the left forward side area of the patient compartment at the location of the oxygen cylinder. There was no damage to the oxygen cylinder or valve. The aluminum side panel of the patient compartment was torn rearward approximately 185.0 cm (73.0").

The front left corner of the roof of the patient compartment was crushed to a measured depth of 69.3 cm (27.3”). This longitudinal impact to the one-piece roof panel displaced the entire roof structure rearward. The energy associated with this contact fractured the welds and resulted in a complete separation of the roof panel from the walls of the patient compartment.

As the ambulance engaged the axles of the tractor, the impact deformed the alloy wheels of the tractor and fractured the spring hanger bolts which rotated the left side of the axles rearward (counterclockwise). This engagement snagged the frontal structure of the ambulance and rotated the vehicle in a counterclockwise (CCW) direction. Additionally, the impact arrested the forward velocity of the ambulance, however, the tractor-trailer unit continued on a westerly trajectory. The left side of the trailer engaged the front and right front areas of the ambulance as the vehicle rotated CCW while remaining engaged against the trailer. The left side tires and wheels of the trailer impacted the right front fender and right front tire and wheel of the ambulance. The lateral displacement of the leading edge of the fender of the ambulance was measured post-crash at 139.7 cm (55.0”). It should be noted that the frontal air bag system in the ambulance deployed during the crash event.

The ambulance was displaced approximately 7.5 m (25.0’) in a westerly direction and rotated approximately 210 degrees in a CCW direction prior to coming to rest on the median with the right rear axle positioned on the inboard shoulder of the westbound travel lanes. At rest, the ambulance was facing in a southerly direction.

The tractor-trailer unit was deflected to its right as it continued forward. The unit initiated a counterclockwise jackknife as it traversed the westbound travel lanes and departed the north shoulder. The trailer impacted a W-beam guardrail system that bordered the north shoulder. Prior to coming to rest, the lumber cargo of the trailer was displaced onto the roadway.

As the tractor-trailer unit came to rest, a straight truck that was traveling behind the tractor-trailer impacted the left side of the trailer. Evidence on the roadway indicated that the driver of the straight truck locked the brakes of his vehicle as he attempted to avoid the crash. This impact was minor in severity. The unit continued in a westerly direction coming to rest jackknifed beyond 90 degrees in the westbound lanes approximately 83.0 m (272.0’) west of the initial point of impact. The straight truck was subsequently driven from the scene.

Post-Crash

Emergency responders arrived at the crash site within minutes of the crash. The injured occupants of the patient compartment were removed from the vehicle and transported by helicopter to a regional trauma center where they were admitted for treatment of their injuries. An emergency C-section was performed on the patient; however, the fetus was stillborn. The driver of the ambulance was partially ejected from the cab of the vehicle. The shoulder belt webbing was cut by vehicle deformation and she was found slumped outside the cab with her lower extremities entrapped by the intruding frontal structure of

the cab. She was pronounced deceased at the scene. The driver of the tractor-trailer was not injured.

Vehicle Damage

Ambulance – Exterior

The ambulance sustained severe damage **(Figure 6)** from the impact with the tractor-trailer and its cargo. The initial contact involved the front left area of the chassis of the ambulance against the left side of the tractor's sleeper berth and the side saddle fuel (diesel) tank. The continued engagement against the drive axles of the tractor and subsequent CCW rotation of the ambulance resulted in separation of the front bumper, left front suspension, grille, radiator support, and the hood of the E-350 chassis. The only measurable frontal components that remained to document the extent of crush were the leading aspects of the frame rails. The left rail was displaced 82.0 cm (32.3") rearward and the right rail was displaced 25.4 cm (10.0") rearward. The subsequent engagement by the left rear trailer axles against the right front fender and tire/wheel of the ambulance resulted in lateral displacement of the fender and the entire frontal structure. The leading edge of the fender was displaced approximately 140.0 cm (55.0") laterally to the left. Black tire transfers were prominent on the entire length of the right front fender with deformation of the steel wheel and exposed lug nuts **(Figure 8)**.

Figure 6. Overall view of the damage to the ambulance.

The plywood cargo of the trailer was displaced forward and impacted the left greenhouse area of the cab of the ambulance and the front left corner area of the patient compartment **(Figure 7)**. The plywood engagement displaced the upper left A-pillar rearward and to a near horizontal attitude. The roof of the E-350 cab was displaced to a vertical position, intruding into the occupant space. The left B-pillar was impacted by the plywood which shredded the driver's safety belt webbing in the area of the D-ring.

Figure 7. Damage to patient compartment area.

The left front door of the ambulance was separated by damage while the right door opened due to stress overload of the latch related to the lateral displacement of the frontal structure. The windshield of the ambulance was fractured and mostly separated by the severity of the damage.

The plywood cargo impacted the left front corner area of the patient compartment of the ambulance. The impact separated the corner structure of the compartment and tore the left side aluminum body rearward approximately 185.0 cm (73.0”). The oxygen compartment was torn open as the inner walls of the compartment wrapped around the cylinder which protected the cylinder from potential damage. All remaining doors of the patient remained closed during the crash events. The rear doors were jammed by deformation of the patient compartment and were opened with hydraulic equipment post-crash. The lower edge of the right rear door exhibited extensive damage from the rescue procedure.

Figure 8. Front right view of the ambulance.

Ambulance Roof

The plywood cargo impacted the left leading edge of the ambulance roof. The leading edge of the roof sustained an area of deformation **(Figure 9)** that was documented using the standard measurement protocol. Although the roof separated from the vehicle, the roof was found intact at the tow yard lying upside down filled with crash debris **(Figure 10)**. A reference scale was established around the perimeter of the roof which yielded a maximum crush depth of 69.3 cm (27.3”) at the left leading edge. The overall width of the deformed roof panel was 203.2 cm (80.0”) and yielded a crush profile that was as follows: C1 = 35.6 cm (14.0”), C2 = 55.3 cm (21.8”), C3 = 60.9 cm (24.0”), C4 = 39.3 cm (15.5”), C5 = 25.4 cm (10.0”), C6 = 11.1 cm (4.4”).

Figure 9. Damage area to the roof.

Figure 10. Overall view of the separated roof.

The roof consisted on a single panel that was formed to fit over the four walls of the patient compartment. The aluminum roof panel was welded to the aluminum sidewalls, the pillars, and vertical supports. All roof panel welds were located on the interior surface. At the forward (front) wall of the roof, ten welds were randomly spaced on 18-25 cm (7-10”) centers with each weld approximately 1.3 cm (0.5”) in length. All of these welds were fractured at the location of the joint **(Figure 11)**.

Figure 11. Separated roof welds at the front wall.

Figure 12. Separated right side roof welds.

The right side of the roof panel was welded to the sidewall with randomly spaced welds on 15-36 cm (6-14") centers. Each weld was approximately 4-5 cm (1.5-2.0") in length. All eight pillars, supports, and gussets for the roof were fabricated from 2.5x5.0 cm (1.0x2.0") rectangular aluminum stock. All welds were fractured at the joint overlap **(Figure 12)**.

The left side was welded similarly to the right with randomly spaced 1.3-5.0 cm (0.5-2.0") welds on 11.4-20.3 cm (4.5-8.0") centers. All welds fractured at the joint overlap.

Figure 13. Fractured welds at the rear wall/roof juncture.

The rear wall and roof was welded with a series of five welds that ranged in length from 5.0-8.4 cm (2.0 to 3.3"). All welds fractured at the joint overlap **(Figure 13)**.

The Collision Deformation Classifications (CDC) for the impacts were as follows:

Event No.	CDC	Object Struck
1	12-FYAW-6	Tractor
2	12-FLGW-9	Tractor-trailer's cargo
3	02-RFEW-9 (9=Unknown)	Trailer

Ford E-350 Interior

The interior of the driver's compartment was severely damaged as a result of the impact with the tractor-trailer and displaced wood cargo. The lateral distance between the left instrument panel structure and the left B-pillar measured 33.7 cm (13.3"). The steering column was displaced rearward against the integral head restraint of the driver's seat back. There was complete compression/separation of the steering column shear brackets. The steering wheel rim was also deformed as a result of driver loading and intrusion.

The interior of the patient compartment sustained severe damage that was associated with the above referenced impact. The wood cargo sheared the left corner of the patient compartment and separated the roof from the walls. As a result, the left front corner of the patient compartment sustained gross integrity loss with a sidewall opening that measured approximately 185.0 cm (73.0").

The paramedic was seated on the rear-facing technician seat at the forward wall of the patient compartment. His back loaded the luan plywood partition that separated the patient compartment from the driver's compartment as he responded to the initial crash forces. His loading force fractured the luan plywood at his mid back location and displaced the partition forward as the top of the partition separated from the roof. Located at the top midpoint of the forward wall of the patient compartment, was a heat and air conditioning unit. This unit fell as the roof separated from the patient compartment.

The interior was configured with a series of storage bins with sliding Plexiglas doors. All bins on the aft left side and the right side remained intact. Located at the right side of the forward wall, were three shelves designed to hold large items for use by the crew. These shelves were 65.5 cm (25.8") wide and 40.1 cm (15.8") in depth with rounded interior corners. The edges of the shelves were banded by a 3.8 cm (1.5") wide aluminum strip. The vital monitor and defibrillator units were located on the top shelf and were restrained by a narrow two-point belt system. The belt system was secured to the luan plywood with Grade 5; 8 mm (5/16") diameter bolts.

The patient was positioned on a Striker Ambulance Cot that was identified as Model No. 6080 MX-Pro. The Serial No. was 000239203. The patient was positioned with her torso in an upright attitude at the time of the crash. She was restrained with two safety belts; one positioned above her abdomen, and the other positioned across her thighs. The cot was secured to the floor of the patient compartment with a conventional locking mechanism. The forward aspect of the cot engaged against an antler bracket tubular frame that was secured to the floor with two pin mounts. The left side of the cot was secured with a spring-loaded clamp that engaged a pin on the lower tubular frame of the cot. At the initial impact, the cot was displaced forward. The aft pin of the forward antler bracket fractured as the patient and the cot moved forward. The left side tubular frame of the cot fractured at the pin location **(Figures 14 and 15)** which resulted in the cot's forward displacement. The antler bracket rotated counterclockwise and directed the cot toward the center forward aspect of the patient compartment. **Figures 16 and 17** are the cot locking mechanism and the displaced antler bracket.

The right side and rear doors of the patient compartment remained close during the crash. Both rear doors were jammed in the closed position due to the overall distortion of the patient compartment.

Figure 14. Left side view of the Striker ambulance cot.

Figure 15. Fractured pin/tubing at the locking mechanism location.

Figure 16. Spring loaded locking arm.

Figure 17. Displaced antler bracket.

Vehicle Damage

Tractor - Exterior

Figure 18. Left side view of the damage to the tractor.

The Peterbilt tractor sustained severe damage as a result of the impact with the ambulance **(Figure 18)**. The initial contact damage began at the forward left corner of the sleeper berth and extended onto the left side saddle fuel tank. The frontal structure of the ambulance penetrated the diesel fuel tank at two locations and crushed the aft aspect of the tank. Additionally, the rear tank strap was fractured. As the tractor continued forward, the ambulance engaged the left side of the sleeper berth and the drive axles of the tractor. The contact with the drive axles deformed the outboard alloy wheels to the center hubs and separated the tires from the wheels. The energy from this interaction fractured the six mounting bolts at the forward spring hanger for each axle. This resulted in rearward displacement of the left side axles. The outboard

aspect of the channel steel frame fractured between the spring hangers. Due to the elongation of the wheelbases, the driveshaft separated from the transmission.

Trailer

The ambulance engaged the left leading edge of the trailer as the tractor-trailer unit jackknifed in a counterclockwise direction. The left side of the trailer remained engaged against the ambulance as the ambulance rotated rapidly in a CCW direction. The ratcheting tie-down straps were deformed and several of the nylon straps were severed. The left side tires and wheels of the trailer impacted the right front fender and axle of the ambulance as the vehicles remained engaged. This interaction rotated the axles of the trailer in a CCW direction which contributed to the CCW jackknife of the unit. **Figure 19** is a left side view of the trailer damage. All of the plywood and lumber cargo on the trailer separated from the unit and was scattered onto the road surface.

Figure 19. Left side view of the trailer damage.

The Truck Deformation Classifications (TDC) for the impacts were as follows:

Event No.	CDC	Object Struck
1	12-LKAW-9 (9=Unknown)	Front of ambulance
2	11-LTEW-9 (9=Unknown)	Right side of ambulance

Manual Safety Belt Systems – Ambulance

The 2001 Ford E-350 chassis was equipped with OEM safety belt systems for the driver and front right passenger positions. The driver's belt system consisted of a continuous loop webbing with a sliding latch plate and an Emergency Locking Retractor (ELR). The B-pillar mounted D-ring was equipped with a height adjustment. At the time of the SCI inspection, the latch plate was buckled into the seat frame mounted buckle assembly. The belt webbing at the location of the D-ring was shredded from contact by the cargo of the tractor-trailer. Rescue personnel cut the lap belt aspect during the removal of the driver's body. This evidence confirmed the belted status of the driver at the time of the crash.

The front right belt system was the same as the driver's; however, the retractor was dual mode, ELR and Automatic Locking Retractor (ELR).

The patient compartment of the ambulance was equipped with five aftermarket lap belts for use by the medical personnel and transported parties. All belts were equipped with locking retractors and sewn-on buckles. The retractors and fixed length buckle tethers were bolted to the plywood partitions/walls with Grade 5 anchor bolts that were 10 mm (3/8") diameter.

The CPR seat that was located on the left side of the patient compartment consisted of separate fabricated cushion and backrest. The lap belt system was bolted to the left sidewall of the ambulance. This seat was not occupied during the crash.

The paramedic was seated on the rear-facing seat at the forward wall of the patient compartment. This seat was fabricated of a separate cushion and backrest. The backrest and belt system were mounted to the 2.0 cm (3/4") luan plywood front wall/partition of the patient compartment. The paramedic was restrained by the belt system. He loaded the wall/partition with his back and fractured the plywood, which separated from its top mount as the roof separated from the unit. There was no loading evidence on the belt webbing; however, the belt webbing was cut by first responders as they removed the injured paramedic from the patient compartment.

The right side bench seat was equipped with three lap belt systems. The belt systems were bolted to the right wall of the patient compartment **(Figure 20)**. The nurse was seated at this location and was restrained at the time of the crash. Additional buckles were bolted to the base wall of the bench seat cushion. These could be utilized if an additional patient was placed on this bench seat (lying on seat) and restrained by the belt systems across the chest, waist, and leg areas. There was no damage or separation of these belt components.

Figure 20. Lap belts were locking retractors at the right side bench seat.

Frontal Air Bag System – Ambulance

The 2001 Ford E-350 chassis was equipped with redesigned frontal air bags for the driver and front right passenger positions that deployed as a result of the frontal impact with the tractor-trailer. The driver's air bag was conventionally mounted within the steering wheel. Due to the severity of the crash and the gross intrusion of the driver's compartment, the deployed air bag was barely visible as the wheel rim was compressed against the driver's seat back. The front right passenger air bag was mounted within the mid instrument panel and was concealed by a single top-hinged cover flap **(Figure 21)**. The flap separated from the instrument panel. Although there was no front right passenger and no driver involvement with the front right air bag, body fluid was present on the top surface of the bag.

Figure 21. Deployed front right passenger air bag.

In addition to the frontal air bags, the E-350 was equipped with safety belt buckle pretensioners. Due to the severe intrusion of the passenger compartment, the barrels of the pretensioners were concealed by seat cushion and floor deformation. It was assumed that the safety belt pretensioners fired during the frontal engagement.

Occupant Demographics/Data – Ambulance

Driver

Age/Sex:	27-year old/Female
Height:	163.0 cm (64.0”)
Weight:	45-50 kgs (100-110 lb)
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection
Seat Track Position:	Unknown
Eyewear:	None reported
Experience Driving This Vehicle:	3 months
Type of Medical Treatment:	None, expired at scene

Driver Injuries

Injury	Injury Severity	Injury Source
Massive injuries, whole body	Unknown	Multiple

Source – Police observations

Driver Kinematics

The driver was seated in a presumed mid track position based on her reported demographics. She was restrained by the manual 3-point lap and shoulder safety belt system. Due to the pre-crash travel of the ambulance, it was unknown if the driver was conscious or in an upright attitude at impact with the tractor-trailer. At impact, the redesigned frontal air bag system deployed. As the ambulance crushed and was engaged by the plywood cargo of the trailer, the left front door opened/separated from the E-350 chassis. The plywood cargo impacted the left B-pillar area at the location of the D-ring. The contact shredded the driver’s safety belt webbing. During this event, the steering column and the instrument panel intruded into the driver’s compartment **(Figure 22)**. The driver loaded through the deployed air bag and was engaged by the intruding steering wheel rim which was deformed forward by driver loading. Additionally, the steering column shear

Figure 22. Crush/intrusion of the driver’s compartment.

brackets were completely separated, indicative of occupant loading. The knee bolster panel was separated from the structural instrument panel.

The driver was deflected left by the intrusion of the steering column. This exposed her to probable contact with the cargo of the trailer. The driver sustained massive injuries and slumped outside the vehicle with her legs and pelvic region remaining in the occupant compartment. The investigating officer noted that she experienced a significant loss of blood at the scene and expired. Her body was removed from the vehicle and transferred to the medical examiner's office where an autopsy was performed.

Paramedic

Age/Sex:	34-year old/Male
Height:	191.0 cm (75.0")
Weight:	111.1 kgs (245.0 lb)
Position in Vehicle:	Seated rear-facing in the technician seat fabricated against the forward wall of the patient compartment
Manual Restraint Usage:	Lap belt
Usage Source:	Vehicle inspection
Seat Track:	Fixed
Eyewear:	None
Mode of Transport From Scene:	Helicopter to a regional trauma center
Type of Medical Treatment:	Admitted for treatment and transferred at a later date to a local hospital for additional treatment and physical therapy

Paramedic Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Right femur fracture near hip	Serious (851800.3,1)	Left interior wall
Right shoulder dislocation	Minor (751030.2,1)	Left interior wall
Vertically oriented laceration of the posterior scalp, (left parietal occipital)	Minor (190600.1,6)	Displaced AC/heat unit
Left ear lacerated (wore earring)	Minor (290600.1,2)	Displaced AC/heat unit
Left leg abrasion (NFS)	Minor (890202.1,2)	Patient cot
Right forearm abrasion	Minor (790202.1,1)	Left interior wall
Left orbital floor fracture	Moderate (251200.2,2)	Displaced AC/heat unit
Right humerous fracture	Moderate (752600.2,1)	Left interior wall

Source – Medical records

Paramedic Kinematics

The paramedic was seated in the rear-facing technician seat that was located behind the driver against the forward wall/partition of the patient compartment. He was restrained by the manual lap belt that was equipped with a locking retractor. The belt system was bolted to the plywood partition with 2.0 cm (3/8") diameter bolts. The paramedic was dressed in black "Dickie" work pants, short-sleeved polo shirt (no jacket), white socks and black boots. It was reported by the owner of the ambulance company that he did not wear corrective lenses and wore an earring in his left ear.

Figure 23. Position and damage surrounding the paramedics belted rear-facing position.

At the initial impact with the tractor-trailer, the paramedic moved forward in response to the 12 o'clock direction of force. His back loaded the forward wall/partition of the patient compartment. Due to the penetration of the patient compartment by the plywood cargo of the trailer, the forward wall disengaged from the separated roof panel. The paramedic's loading of the seat back/wall displaced the wall/partition forward and fractured the plywood component laterally at the level of his mid back. The left sidewall of the patient compartment intruded due to the exterior damage. The interior cabinet and work counter loaded his right side, which resulted in the right femur fracture near the hip, a right humerus fracture, right shoulder dislocation and right forearm abrasion.

The patient cot that was displaced forward due to the impact force. The forward displacement of the cot allowed the cot to contact the paramedics left leg resulting the left leg abrasion.

The heat/AC condenser that was mounted at the center of the forward wall at the roof dropped as a result of the roof separation. This component probably fell onto the paramedic, which resulted in the vertically oriented laceration of the posterior scalp, left ear laceration, and the left orbital floor fracture scalp. **Figure 23** is an overall view of the paramedic's position and contact points.

Following the crash, the paramedic's lap belt was cut and he was removed from the vehicle on a backboard. He was transported by helicopter to a regional trauma center where he was admitted in serious condition. The paramedic underwent several surgeries to repair his fractures. He was transferred to a hospital near his residence where he continued to recover and begin an extensive physical therapy program.

Nurse

Age/Sex:	31-year old/Female
Height:	162.3 cm (64.0”)
Weight:	54.4 kgs (120.0 lb)
Seated Position:	Bench seat, right side of patient compartment
Manual Restraint Use:	Lap belt
Usage Source:	Vehicle inspection, occupant ejection
Mode of Transport Scene:	Helicopter to a regional trauma center
Type of Medical Treatment:	Admitted for treatment of her injures

Nurse Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Mid-line forehead laceration	Minor (290600.1,7)	Loose object in patient compartment
Right parietal scalp laceration	Minor (190600.1,1)	Loose object in patient compartment
Linear contusion across abdomen	Minor (590402.1,0)	Lap belt
Right abdominal puncture wound	Minor (590600.1,1)	Scissors
Second lumbar vertebrae compression fracture with 30 percent loss of height	Serious (650634.3,8)	Lap belt (indirect)
Right colon rupture	Severe (540826.4,8)	Lap belt
Bilateral carotid artery aneurisms no surgery required	Not Coded Under AIS	Impact force

Source – Medical records

Nurse Kinematics

The nurse was seated on the right side of the patient compartment on the bench seat facing inward. She was initially restrained by the manual lap belt; however, she unbuckled the manual lap belt to attend to the patient. As the ambulance departed the travel lane, the nurse apparently re-buckled the lap prior to the impact. At initial impact, she initiated a lateral trajectory to her right in response to the frontal impact forces. She loaded the lap belt, which resulted in a linear contusion across the abdomen and a rupture of the right colon. The belt loading, in combination with her lateral motion resulted in a lumbar compression fracture. The severe impact force resulted in the bilateral carotid artery aneurism.

The nurse was carrying a pair of scissors, which contacted her during the crash resulting in the right abdominal puncture wound. The mid-line forehead laceration and the right

parietal scalp laceration probably resulted from loose objects in the patient compartment. The nurse was transported by helicopter to a regional trauma center where she was admitted for treatment of her injuries.

Patient

Age/Sex:	22-year old/Female
Pregnancy:	Reported 33-weeks, in active labor at time of crash
Height:	Not reported
Weight:	Not reported
Position:	Lying on patient cot, restrained by harness straps at upper abdomen and legs; cot secured with mechanical locking mechanism
Mode of Transport From Hospital:	Transported by helicopter to a regional trauma center
Type of Medical Treatment:	Admitted for two days for treatment and recovery from an emergency C-section

Patient Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Source
No injuries reported from the crash.		

Source – Medical records

Patient Kinematics

The 22-year-old female patient was reportedly 33-weeks pregnant and had experienced labor. She was initially transported to a local hospital in the western portion of the state. The patient was diabetic and was classified as a high-risk pregnancy. She was prepared for ground ambulance transferal to a major medical center with an advanced neonatal unit that was located approximately 145 kilometers (90 miles) east. In preparation for the transport, reportedly she was administered a drug to slow the contractions. Due to this procedure, a nurse was required to accompany the patient in the ambulance and monitor her condition and progress. The patient was dressed in a hospital gown and was placed on the Striker ambulance cot. She was restrained to the cot with two harness straps that were positioned at the level of her upper abdomen and legs. Additionally, the patient was allowed to ride in an upright position on the cot to provide comfort. Two intravenous (IV) lines were placed in the patient and two IV pumps were attached upright on the cot.

The cot was placed in the ambulance in a headfirst position. The front wheels of the cot engaged the antler bracket, which positioned and aided in the restraint of the cot. The mechanical floor lock was engaged with the pin that was located on the left side tubing of the cot.

At impact, the patient loaded the upright backrest of the cot. Her loading force and the force of the cot fractured the aft mounting pin of the antler bracket. In addition, the pin

on the cot and the tubular frame of the cot fractured, allowing the cot to translate forward. The investigating officer noted that the patient and the cot were wedged against the forward wall/partition of the patient compartment.

The patient was removed from the ambulance and transported by helicopter to a regional trauma center where an emergency cesarean section was performed. The fetus was stillborn.

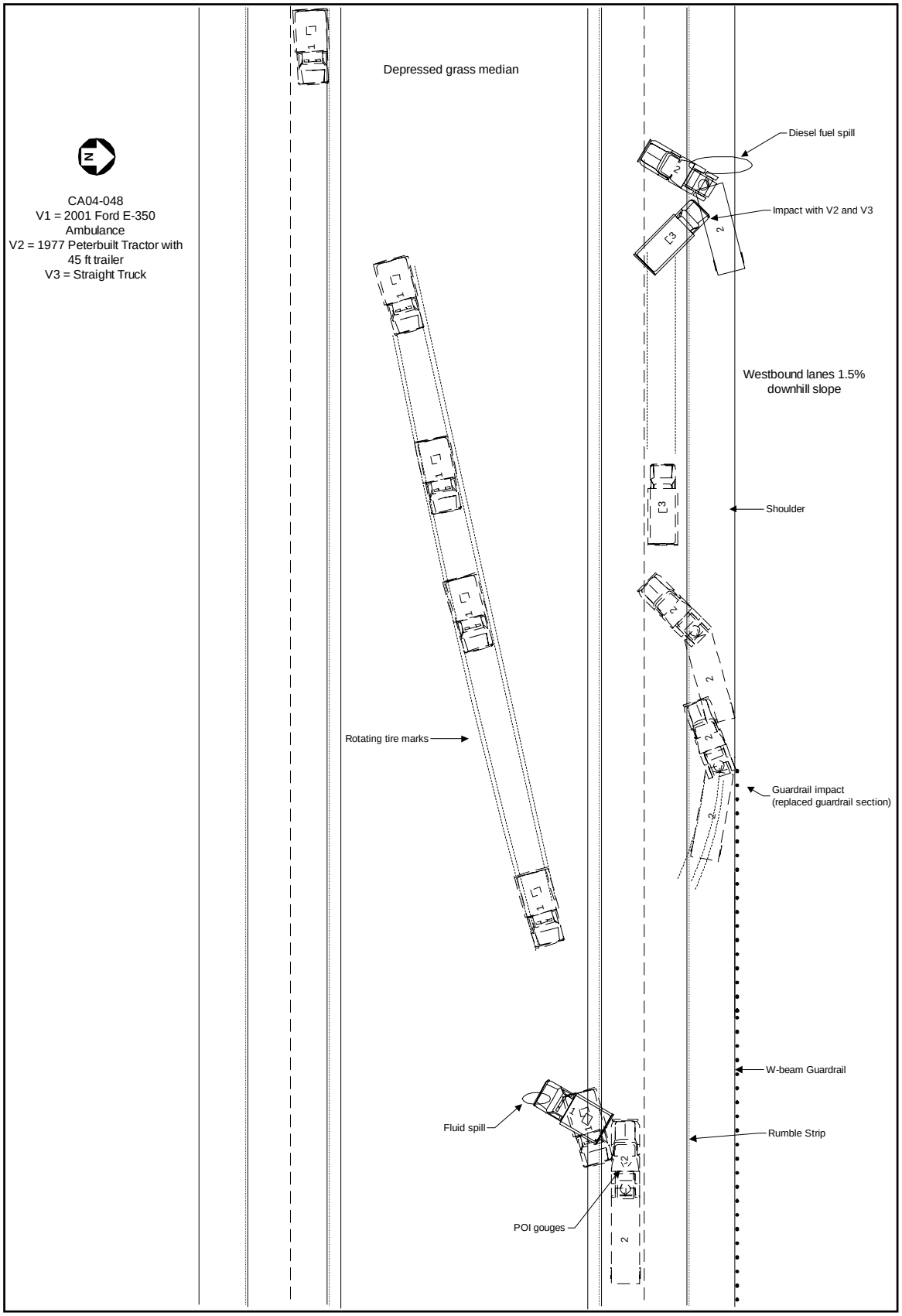

Figure 24: Scene Schematic