On-Site Ambulance Investigation
Dynamic Science, Inc. (DSI), Case Number DS09001
2005 Ford E350 Econoline Type II Ambulance
California
December 2008

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. Abstract

This on-site investigation focused on the crash dynamics and injuries sustained in a crash involving a 2005 Ford E350 Econoline van that was configured as Type II ambulance. This single vehicle crash occurred in December 2008 at 1059 hours in California. The subject vehicle was being driven by a restrained 19-year-old male. There were two unrestrained Emergency Medical Technicians and a 56-year-old female patient positioned in the rear of the ambulance. The Ford was traveling westbound at an unknown speed. There were other vehicles in front of the Ford. The Ford was transporting the patient from a nursing facility to a local hospital for a medical appointment. The Ford was not traveling with lights and siren. While negotiating a left curve, the Ford departed the right side of the roadway. The Ford traveled a short distance off-road before striking a tree with its front end. The frontal air bags in the Ford deployed at that time. The Ford rotated sharply in a clockwise direction, tripped, and overturned with its left side leading. The female patient was fatally injured.

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Dynamic Science, Inc.
Crash Investigation
Case Number: DS09001

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BACKGROUND

This on-site investigation focused on the crash dynamics and injuries sustained in a crash involving a 2005 Ford E350 Econoline van that was configured as Type II[1] ambulance (**Figure 1**). This single vehicle crash occurred in December 2008 at 1059 hours in California. The subject vehicle was being driven by a restrained 19-year-old male. Two unrestrained Emergency Medical Technicians (EMTs) and a 56-year-old female patient were positioned in the rear of the ambulance. The Ford was traveling westbound at an unknown speed. There were other vehicles in front of the Ford. The Ford was transporting the patient from a nursing facility to a local hospital for a medical appointment. The Ford was not traveling with the lights and siren. While negotiating a left curve, the Ford departed the right side of the roadway. According to the investigating officer, there were no indications of steering inputs or braking. The Ford traveled a short distance off-road before striking a tree with its front end. The frontal air bags in the Ford deployed at that time. The Ford rotated sharply in a clockwise direction, tripped, and overturned with its left side leading. The patient was fatally injured; the driver and EMTs sustained minor injuries.

Figure 1. Subject vehicle, 2005 Ford E350 Econoline Ambulance

This on-site ambulance crash investigation was identified by the National Highway Traffic Safety Administration (NHTSA) Office of Emergency Medical Services (EMS) in an internet news article. The article reported that a woman had been fatally injured while being transported by ambulance to a local hospital. The article was forwarded to the Special Crash Investigations (SCI) office with a request to conduct an investigation. DSI was instructed to pursue this as an on-scene investigation. DSI was assigned the case January 6, 2009. Field work was completed on January 13, 2009. The investigating officer, an insurance representative, and several police mechanics were present during the vehicle inspection.

SUMMARY

Crash Site

The crash occurred on the roadside of an east/west two-lane, residential roadway. The initial approach to the crash area was straight (**Figure 2**), but the road began curving to the left (**Figure 3**).

Figure 2. Approach westbound along straight roadway

[1]Type II ambulances are based on passenger/cargo vans.

The distance between the start of the curve and the impacted tree measured 49.6 m (163 ft). At the area of impact, the roadway was level. The east/west travel lanes were separated by double yellow center lines. The westbound travel lane was bordered on the north by a bike lane, a parking lane, and an 8 cm (3.1 in) concrete curb. A 45 cm (17.8 in) diameter tree was located adjacent to the concrete curb. The eastbound travel lane was bordered on the south by a parking lane. The weather was partly cloudy and the travel lanes were dry. Portions of the bike lanes were covered with wet leaves. The posted speed limit for this roadway was 40 km/h (25 mph).

Figure 3. Approach westbound after entering curved roadway

Pre-Crash

The Ford was transporting the patient from a nursing facility to a local hospital for a medical appointment. The Ford was traveling westbound and was not using its lights and siren. The ambulance crew had picked up the patient at approximately 0930 hours. The distance from the nursing facility to the crash area was approximately 89 km (56 miles). The distance from the crash site to the local hospital was 4.5 km (2.8 miles). The driver had never driven this route before and was unfamiliar with the roadway. According to witnesses, the Ford was traveling with the flow of traffic.

One of the EMTs , a 23-year-old male, was seated in the cargo area behind the driver in a rear-facing seat on the left side of the ambulance. A second EMT, an 18-year-old male, was a trainee and was sitting on a bench seat on the right side cargo area of the ambulance. The EMTs were obtaining a blood pressure reading on the patient just prior to the crash. The female patient was lying on her left side on a Stryker Model 6080 MX Pro ambulance cot with her head toward the front of the vehicle. She was lying on her left side because she had undergone a surgical procedure on her right side. She was restrained by the forward and aft cot restraints. The cot was equipped with a shoulder harness that could be used in conjunction with the forward restraint, but there was no evidence that the harness was being used on this patient. The cot was attached to the left side of the ambulance using a Stryker Model 6370 floor mount cot fastener. The system was designed so that the forward antler brackets secured the cot's front wheels and the rail clap fastened directly to the cot frame.

Crash

As the Ford entered the curved aspect of the roadway, it continued in a straight line. There were no indications that the driver attempted to brake or steer the vehicle. The Ford traveled over the north curb edge and continued forward until striking the tree with its front right bumper corner (**Figure 4**). The damage to the tree extended vertically from the ground upward 193 cm (76 in). The impact severity was moderate and resulted in the deployment of the frontal air bag system in the Ford. The Barrier algorithm of the WinSMASH program computed a Total Delta-V of 14 km/h (8.7 mph), based on the front bumper damage profile. The results were low because most of the damage was outboard of the right frame rail and was not included in the crush profile per the measurement

protocols. As the right A-pillar area engaged the tree, the Ford began a sharp clockwise rotation, tripped due to the rotation, and overturned with its left side leading. The Ford came to rest in the westbound travel lane on its left side and facing north.

Figure 4. Area of impact with tree

Post-Crash

The driver indicated that he exited the vehicle through a side door in the rear of the ambulance. He sustained a lower lip laceration. He was transported to a local trauma center where he was treated and released. The 23-year-old passenger sustained a laceration to his left ear. He was transported to a local trauma center where he was treated and released. The 18-year-old passenger sustained a forehead laceration, a left clavicle fracture, and reported a loss of consciousness of unknown duration. He regained consciousness and exited the vehicle through the rear door under his own power. He was transported to a local trauma center where he was treated and released approximately 6 hours after his arrival. The 56-year-old patient sustained multiple brain injuries including subdural hematoma and cerebral edema with flattening of the coritcal convulsions and obliteration of the sulci. She also sustained contusions to the arms, legs, and abdomen. She was transported to a local trauma center for treatment, and was hospitalized for two days before passing away.

VEHICLE DATA - 2005 Ford E350 Econoline

The 2005 Ford Econoline E350 Econoline van was identified by the Vehicle Identification Number (VIN): 1FDSS34P35Hxxxxxx. The vehicle was configured as a Type II ambulance. The vehicle chassis was manufactured in September 2004. The ambulance was manufactured by Osage Industries in February 2005. The van was configured with an 8-cylinder, 6.0-liter diesel engine, rear-wheel drive, 4-wheel disc brakes, automatic transmission, and a tilt steering wheel.

The ambulance conversion included a fiberglass roof cap, a patient compartment sliding door in the walk-thru, and a lights and siren warning system. The vehicle mileage was 209,577 km (130,225 miles). The vehicle maintenance records were obtained, and the vehicle had repair work completed in March 2008 to the left frame, suspension, and steering drag link. The steering gear assembly had been replaced at that same time. Mechanics present during the vehicle inspection did not report any mechanical problems with the vehicle.

The Ford was configured with Big O Big Foot LT245/75R16 tires for the left front, right front, and right rear positions. The left rear position was configured with a Hankook Dyna Pro AS LT245/75R16 tire. The tire manufacturer's maximum pressure was 552 kPa (80 psi). The vehicle manufacturer recommended cold pressure was 414 kPa (60 psi) for the front and 552 kPa (80 psi) for the rear. All the tires remaining on the vehicle were underinflated. Two front tires had been replaced in April 2008. The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	207 kPa (30 psi)	9 mm (11/32 in)	No	None
LR	414 kPa (60 psi)	10 mm (12/32 in)	No	None
RR	379 kPa (55 psi)	4 mm (5/32 in)	No	None
RF	Tire flat	8 mm (10/32 in)	Yes	Sidewall cut

The seating in the Ford was configured with front pedestal style seats, a rear facing high back seat behind the driver's seat, and a squad bench on the right side of the vehicle.

Vehicle Damage

Exterior Damage

The Ford sustained moderate front end damage as a result of the impact with the tree (**Figure 5**). The direct damage began at the front right bumper corner and extended laterally 35 cm (13.7 in) along the plastic fascia on frontal plane. The damage extended longitudinally down the right side and terminated at the right A-pillar. The A-pillar was deformed and the right front door was jammed and bowed outward. The windshield was cracked and holed. The bumper fascia and hood fascia were separated from the vehicle. The front right wheel was fractured from the front axle. The rim sustained a 16 cm (6.3 in) wide by 9 cm (3.5 in) deep deformation. There was a 9 cm (3.5 in) by 10 cm (3.9 in) tear in the outboard sidewall. The right side wheel base was shortened by 94 cm (37 in), based on the location of the front axle. Six crush measurements were documented at the bumper level as follows: C1 = 41 cm (16.1 in), C2 = 0 cm, C3 = 0 cm, C4 = 0 cm, C5 = 0 cm, C6 = 0 cm. The Collision Deformation Classification (CDC) for the impact with the tree was 12FREE6.

Figure 5. Right front/side damage

The Ford sustained minor left side damage as a result of the left side leading one-quarter turn rollover (**Figure 6**). The damage began 12 cm (4.7 in) forward of the left A-pillar and extended 412 cm (162.2 in) rearward along the left side plane. The direct damage measured 112 cm (44 in) vertically and there was a maximum crush of 4 cm (1.6 in) that was located on the left door 12 cm (4.7 in) forward of the B-pillar. The CDC for the rollover was 00LDAO2.

Interior Damage

The Ford sustained moderate interior damage as a result of passenger compartment intrusion, occupant contacts, and first responder activity in the vehicle. The right and middle instrument panel, lower A-pillar, and toe pan sustained longitudinal intrusion (**Figure 7**). The center console sustained lateral intrusion. The driver's knee bolster was deformed and the plastic fascia was displaced. A storage table on the right side of the ambulance was deformed, possibly by the EMT seated on the squad bench. There was blood located on the left side cabinetry that probably came from the right ear injury to the second EMT. The base of the rear-facing seat was deformed, probably by the patient.

The sliding door and glass partition of the walk-thru was cracked and dislodged by the investigating officers as they attempted to get paperwork from the cab area.

The right front door was bowed outward which formed a 30 cm (11.8 in) area of integrity loss along the upper window frame. The side glass for both front windows was disintegrated.

Figure 6. Left side rollover damage

Figure 7. Right interior intrusion

Manual Restraints

The 2005 Ford Econoline was configured with 3-point manual lap and shoulder belts for the two front row seating positions. The belts were configured with sliding latch plates, Emergency Locking Retractors (ELRs), and shoulder belt anchorages which were in the full-down position. The front belts were equipped with buckle pretensioners. The driver's pretensioner actuated during the impact with the tree. The buckle position was compared to an exemplar vehicle and the stalk was shortened by 2 cm (0.8 in). An area of the driver's belt webbing was scuffed and worn; the area was located 59 cm (23.2 in) from the anchor and measured 36 cm (14.2 in) in length (**Figure 8**).

Figure 8. Marks located on driver's belt webbing

The rear-facing seat behind the driver's seat was equipped with a manual lap belt. The left facing squad seat on the right side of the ambulance was equipped with two manual lap belts.

The Stryker Model 6080 MX Pro ambulance cot was configured with two lap belts and one 4-point shoulder restraint. The shoulder restrained was designed to be used in conjunction with the forward lap belt (**Figures 9-10**). There was no evidence that the shoulder restraint was used during this crash. There was a 12 cm (4.7 in) section of loading located on the right belt webbing (forward lap belt) that was located 13 cm (5.1 in) from the latch.

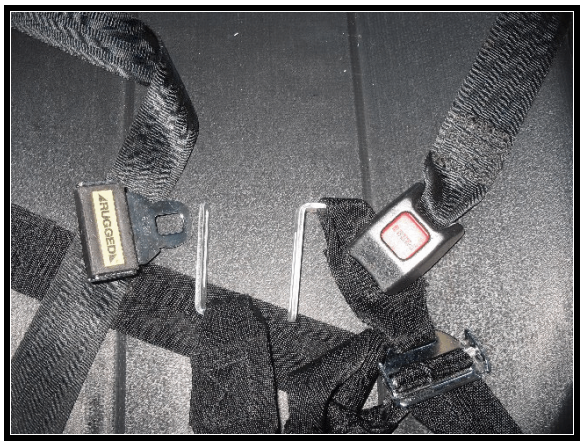

Figure 9. Forward lap belt and shoulder restraint, unassembled

Figure 10. Forward lap belt and shoulder harness, assembled

Supplemental Restraint System

The 2005 Ford Econoline was equipped with frontal air bags that deployed as a result of the impact with the tree.

The driver's air bag deployed from the center of the steering wheel hub through symmetrical T-configuration module cover flaps (**Figure 11**). The top flap measured 8 cm (3.1 in) high by 15 cm (5.9 in) wide. The bottom flaps measured 6 cm (2.4 in) high by 7 cm (2.8 in) wide. The air bag measured 48 cm (18.9 in) in diameter in its deflated state. The air bag was configured with two circular vent ports at the 11 and 1 o'clock positions. There was no evidence of damage or contact to the air bag.

Figure 11. Driver's air bag

The front right passenger's air bag deployed from the asymmetrical H-configuration module cover flaps located within the mid-instrument panel. The top flap measured 25 cm (9.8 in) wide by 6 cm (2.4 in); the bottom flap measured 25 cm (9.8 in) wide by 4.5 cm (1.8 in) high. The air bag measured 38 cm (14.9 in) seam to seam, 69 cm (26.2 in) high, and with an excursion of 51 cm (20 in). The air bag was configured with circular vent ports at the 3 and 9 o'clock positions.

Rollover Dynamics

The Ford was configured as a Type II ambulance and was equipped with rear-wheel drive, 4-wheel disc brakes, and an automatic transmission. The Rollover Resistance Rating (RRR) and Static Stability Factor (SSF) for this particular vehicle is not known. The SSF is a number that relates the height of the center of gravity of a vehicle to its width. For a somewhat similar vehicle, a 2006 Ford E350 15-passenger van, the RRR yielded a 30% chance of rollover with a SSF of 1.07[2]. The subject vehicle impacted the tree with its right front bumper. The crush damage was outside the right frame rail and extended down the right side. As the right A-pillar area engaged the tree, the Ford began a sharp clockwise rotation. When the rotation reached 90 degrees, the vehicle tripped due to forces against the tires, and overturned with its left side leading. The Ford rolled one-quarter turn and came to rest in the westbound travel lane on its left side facing north. The estimated distance from the trip point to final rest was 3 m (10 ft).

OCCUPANT DEMOGRAPHICS

	Driver	**Second Row Left Occupant**
Age/Sex:	19/Male	23/Male
Seated Position:	Front left	Second row, left
Seat Type:	Box mounted pedestal	Bench
Seat Track Position:	2 adjustment stops rear of forward most track position	N/A
Height:	170 cm (67 in)	Unknown
Weight:	56 kg (124 lbs)	Unknown
Alcohol/Drug Involvement:	None	N/A
Body Posture:	Unknown	Facing rear of vehicle
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt	None

[2]www.safercar.gov

	Third Row Right Occupant	Other Row Occupant
Age/Sex:	18/Male	56/Female
Seated Position:	Third row right	On cot
Seat Type:	Bench, facing left	N/A
Seat Track Position:	N/A	N/A
Height:	175 cm (69 in)	165 cm (65 in)
Weight:	60 kg (132 lbs)	104 kg (230 lbs)
Alcohol/Drug Involvement:	N/A	N/A
Body Posture:	Seated facing left side of vehicle, head forward	Lying on left side
Hand Position:	Elbows on knees	Unknown
Foot Position:	Both feet on floor	Unknown
Restraint Usage:	None	Forward and aft lap belts on cot

Occupant Injuries

Driver: Injuries obtained from police report.

Injury	AIS Code	Injury Mechanism	Confidence Level
Lower lip laceration	290600.1,8	Driver air bag	Probable

Second Row Left Occupant: Injuries obtained from police report.

Injury	AIS Code	Injury Mechanism	Confidence Level
Right ear laceration	290600.1,1	Side interior surface	Probable

Third Row Right Occupant: Injuries obtained from interviewee.

Injury	AIS Code	Injury Mechanism	Confidence Level
Left clavicle fracture	752200.2,2	Occupant 2	Probable
Forehead laceration, 5.0 cm (2.0 in)	290602.1,7	Unknown	Unknown
Reported loss of consciousness, unknown length of time	Not codeable[3]		

Other Row Occupant: Injuries obtained from autopsy report.

Injury	AIS Code	Injury Mechanism	Confidence Level
Subdural hematomas, overlying right frontoparietal convexity and base of right temporal lobe, overlying frontal and parietal lobes on left side of the brain	140654.5,3	Seat base	Probable
Cerebral edema with flattening of the coritcal convulsions and obliteration of the sulci. Bilateral tonsillar herniation[4], and left side uncal herniation.	140664.4,9	Seat base	Probable
Subgaleal hemorrhage, mid front area, 4 x 2 cm (1.6 x 0.8 in)	190402.1,5	Seat base	Probable
Scalp and subgaleal hemorrhage, occipital area of skull, right of midline, 9 x 7 cm (3.5 x 2.8 in)	190402.1,6	Seat base	Probable
Multiple contusions, upper mid abdomen	590402.1,0	Cot webbing	Possible
Abrasion, right hip, 8 x 8 cm (3.1 x 3.1 in)	890202.1,1	Cot webbing	Certain

[3]The level of consciousness and its duration must be observed by emergency or medical personnel.

[4]A brain herniation is when brain tissue, cerebrospinal fluid, and blood vessels are moved or pressed away from there usual positions in the head. www.nlm.nih.gov/medlineplus/ency/article/001421.htm

Injury	AIS Code	Injury Mechanism	Confidence Level
Contusions, right anterior and medial thigh 10 x 5 in, right anterolateral leg, 3 x 2 cm (1.2 x 0.8 in) and back of leg, right hip and lateral right abdomen, 20 x 38 cm (7.9 x 14.9 in)	890402.1,1	Cot webbing	Probable
Contusion, left medial thigh, anterior leg	890402.1,2	Unknown	Unknown
Hematoma, right vulva	545610.1,8	Unknown	Unknown
Contusion, back of distal right forearm, 1.5 x 1 cm (0.6 x 0.4 in), elbow, lateral arm 8.5 x 9 cm (3.3 x 3.5 in)	790402.1,1	Side interior surface	Possible
Multiple contusions, back of right shoulder	751010.1,1	Side interior surface	Possible
Contusions, middle and ring fingers of left hand	790402.1,1	Unknown	Unknown
Hemorrhage tongue	243400.1,8	Seat base	Probable

OCCUPANT KINEMATICS

Driver Kinematics

The driver of the Ford was seated in an unknown posture and was restrained by the lap and shoulder belt. The driver stated to the police that he was traveling at or near the speed limit and was following other vehicles on the roadway. It is presumed that his right foot was on the accelerator and his left on the floor board. There were no avoidance maneuvers prior to the impact. At impact, the driver's air bag deployed and the seat belt pretensioner actuated. The driver was displaced in a forward direction and he loaded the shoulder belt and his knees impacted and deformed the knee bolster (**Figure 12**). His face contacted the deployed air bag, causing a small lip laceration. After the initial impact, the Ford rotated sharply in a clockwise direction. The driver was displaced to the left during this movement and likely engaged the left door. As the vehicle tripped and rolled onto its left side, the driver came to rest against the left door. The driver indicated that he exited the vehicle through a side door in the rear of the ambulance. He was

Figure 12. Deformed knee bolster

transported to a local hospital where he was treated and released

Second Row Left Occupant (02) Kinematics

The 23-year-old male second row left occupant was seated in a rear-facing seat. He was not wearing the manual lap belt. He had no warning that a crash was imminent. Prior to impact, he was assisting the second EMT in obtaining a blood pressure reading. At impact, he was displaced rearward into the seat back (**Figure 13**). There were no indications of damage to the seat back. As the vehicle rotated clockwise, this occupant was displaced to his right and he contacted the left interior surface of the ambulance with the right side of his head, likely causing the ear laceration. As the vehicle tripped and rolled on to its left side, this occupant came to rest against the left interior surface. Occupant 03 reported that he contacted this occupant during the rollover. This occupant was able to exit the vehicle through the back door under his own power. He was transported to a local hospital where he was treated and released.

Figure 13. Rear-facing seat behind driver

Third Row Right Occupant Kinematics (03)

The 18-year-old male third row right occupant was seated in a left side-facing seat (**Figure 14**). He was not wearing the manual lap belt. He had no warning that a crash was imminent. Prior to impact, he was assisting the first EMT in obtaining a blood pressure reading. At impact, he was displaced toward the front of the vehicle with his right side leading into a metal/wood table attached to the right bulkhead. The table was slightly deformed. As the vehicle tripped and rolled on to its left side, this occupant was displaced to the left and contacted Occupant 02 with his left shoulder, causing a left clavicle fracture. This occupant also sustained a forehead laceration from an unknown source. He came to rest on the left side of the ambulance and reported that he lost consciousness for a short period of time. He was able to exit the vehicle through the back door under his own power and was transported to a local hospital where he was treated and released.

Figure 14. Overview of occupant 03 seated position and possible contact to table

Other Row Occupant Kinematics (04)

The 56-year-old female was a patient and was being transported from a care facility to a hospital for a doctor's appointment. She had an unknown surgery on her right side, so she was placed on the ambulance cot on her left side for comfort (**Figures 15**). Her head was oriented towards the front of the vehicle. The forward and aft lap belts on the cot were being used to secure the patient's torso and lower extremities at the time of the crash. The shoulder restraint was not being used. The cot itself was anchored to the side of the ambulance using the rail clamp. Prior to impact, the EMTs were trying to obtain a blood pressure reading from her. At impact, this occupant slid forward on the cot. There were indications of loading to the forward lap belt. She sustained contusions and abrasions due to contacts with the restraints. She probably contacted the base of the rear-facing seat and possibly Occupant 2's knees/lower legs with her head **(Figures 16-17**). The EMT in the rear-facing seat did not report any leg injuries. The vehicle came to rest on its left side and it has been reported the cot remained attached to the vehicle. This occupant probably contacted the left interior surface as the vehicle rolled over. The patient was removed from the ambulance cot by EMS personnel, placed on a backboard, and removed from the vehicle. She was transported to a local hospital with serious head injuries and hospitalized for two days before passing away.

Figure 15. Overview of cot and Occupant 04 position

Figure 16. Top-down view of seat and forward end of cot

Figure 17. Deformation to upper right corner of seat support

Attachment 1. Scene Diagram