

CRASH DATA RESEARCH CENTER

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**CALSPAN ON-SITE CHILD SAFETY SEAT
CRASH INVESTIGATION**

CASE NO: CA04-023

VEHICLE: 2003 FORD E-250 CARGO VAN

LOCATION: MARYLAND

CRASH DATE: APRIL 2004

Contract No. DTNH22-01-C-17002

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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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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
SCI CASE NO.: CA04-023
VEHICLE: 2003 FORD E-250 CARGO VAN
LOCATION: MARYLAND
CRASH DATE: APRIL 2004

BACKGROUND

This on-site investigation focused on the severity of the crash and the role of the deployed frontal air bags as an injury mechanism and cause of death for a 5-year old male child who was restrained in a Cosco belt positioning booster seat in the front right position of a 2003 Ford E-250 cargo van. The 41-year old male driver of the Ford passed a non-contact vehicle while negotiating a left curve. He lost directional control of the vehicle and departed the right road edge. The E-250 van traversed a grassy area and impacted and sheared a wooden utility pole with the front right area of the vehicle. The van continued



Figure 1. Front right view of the tree impact damage to the Ford E-250 cargo

forward and impacted a large diameter tree with the front right area which resulted in severe frontal crush (**Figure 1**) and intrusion of the front right occupant space. The van rotated clockwise and came to rest near the struck tree. The redesigned frontal air bag system in the Ford van deployed during the crash. Loose cargo in the rear of the van was displaced forward into a sheet metal partition that spanned the B-pillars of the vehicle. This contact resulted in forward displacement of the front seat backs. The front right child passenger sustained a complex liver laceration, closed head injuries, and a left rib fracture with bilateral pulmonary contusions and was transported to a local trauma center. He was later transferred to a regional pediatric trauma center where he expired three days following the crash. The belted driver sustained a forehead laceration and was treated at a local hospital and released. A 12-year old female passenger was seated on an inverted bucket in the right side cargo area of the van. She sustained a fractured right femur, a left lung contusion and multiple soft tissue injuries and was admitted to a local hospital for treatment. The van sustained severe frontal damage and was towed from the scene of the crash and impounded by the investigating police agency pending a criminal investigation.

SUMMARY

A crash reconstructionist with the investigating police agency notified NHTSA's Crash Investigation Division of the severity of the crash and the involvement of a child restrained in a belt positioning booster seat. NHTSA assigned the case to the Calspan Special Crash Investigations team on May 5, 2004 as an on-site investigative effort. Cooperation was established with the investigating officer and an on-site investigation was conducted on May 9 and 10. The vehicle, scene and booster seat were inspected during the on-site investigation.

Crash Site

The crash occurred on a two-lane state road during evening hours. At the time of the crash, the asphalt road surface was dry and the conditions were police reported as dark, but lighted. **Figure 2** is an approach view of the crash site from the van's eastbound trajectory. On an eastbound approach to the crash site, the road curved to the left. The curve terminated to a straight segment 27.6 m (90.5') west of the initial point of impact with a utility pole. The travel lanes were separated by a double yellow center line and bordered by white edge lines. The right (south) road edge consisted of a 1.1 m (3.6') wide asphalt shoulder paralleled by a shallow negative grass slope that transitioned onto a level grass area for a park. A wood rail fence paralleled the road and was located 7.7 m (25.3') south of the edge line. A utility pole, a telephone terminal box, and a large diameter tree were located within this grassy area. The pole and telephone box were replaced following the crash and were located 4.5 m and 5.1 m (14.8' and 16.7') south of the south edge line respectively. The 83.8 cm (33.0") diameter tree was centered 3.2 m (10.5') south of the referenced edge line. The posted speed limit was 64 km/h (40 mph) for the roadway.



Figure 2. Overall view of the crash site.

Vehicle – 2003 Ford E-250 Cargo Van

The subject vehicle in this crash was a 2003 Ford E-250 4x2 cargo van. The vehicle was manufactured on May 2003 and was identified by Vehicle Identification Number (VIN): 1FTNE24L23H (production number deleted). The van was configured on a 351 cm (138") wheelbase with a Gross Vehicle Weight Rating (GWVR) of 3,900 kg (8,600 lb) split 3,700 (1,678 lb) front and 2,503 kg (5,520) rear. The cargo van was manufactured with outward hinged right side and rear doors. The rear doors were affixed with windows while the side cargo doors were solid panel doors. There were no side windows aft of the B-pillars. An Altered Certification Label was affixed to the left lower B-pillar. The label identified this vehicle as altered by America's Body Company, of Cleveland, OH. The alteration consisted of a sheet metal partition that was riveted to the B-pillars, floor, and roof rib. The partition formed a barrier between the passenger compartment of the van and the cargo area. A 52 cm (20.5") wide full height pass-through was centered in the partition. The cargo area of the van contained approximately 680 kg (1,500 lb) of loose tools, equipment, and floor products (tile, adhesives, nails).

The E-250 was equipped with a 5.4 liter V-8 conventionally mounted gasoline engine linked to a four-speed automatic transmission with a column mounted shifter and rear wheel drive. The wheels were OEM steel 41x18 cm (16x7") with Michelin LTX radial mud and snow rated tires, size LT225/75R16. The manufacturer recommended tire pressures were 415 kPa (60 PSI) for the front axle and 550 kPa (80 PSI) for the rear axle. The following table identifies the tire data for this vehicle.

Position	Measured Pressure	Measure Tread Depth	Damage
LF	462 kPa (67.0 PSI)	10 mm (12/32")	None
RF	455 kPa (66.0 PSI)	10 mm (12/32")	None
LR	610 kPa (88.5 PSI)	9 cm (11/32")	None
RR	6614 kPa (89.0 PSI)	9 cm (11/32")	None

The interior of the E-250 cargo van was configured as a two passenger vehicle. The driver's seat and the front right passenger seats were box mounted high-back (integrated head restraints) bucket seats with manual track and recline adjustments. The manual belt systems consisted of continuous loop 3-point lap and shoulder belt systems with adjustable D-rings, sliding latch plates, and buckle pretensioners. The frontal air bag system consisted of redesigned air bags for the driver and front right passenger positions. The buckle pretensioners fired and the air bag system deployed during the crash sequence.

Crash Sequence

Pre-Crash

The driver of the Ford cargo van was intoxicated with a BAC of .254. He was transporting his children to his residence in his commercial cargo van that was equipped with two designated seated positions. The 5-year old male was positioned in a Cosco belt positioning booster seat in the front right position and was restrained by the vehicle's 3-point lap and shoulder belt system. The driver's 12-year old daughter was seated unrestrained on an inverted bucket on the right side of the cargo area, behind the passenger's seat. The driver was restrained by the manual belt system. The crash schematic is attached as **Figure 17** of this report.

The driver of the Ford van was traveling in an easterly direction, en route to his residence. A witness to the crash observed the Ford van pass her on a left curve at a high-rate of speed. As the driver of the van was exiting the curve, he attempted to regain the eastbound travel lane. He oversteered to the right and applied a probable counterclockwise steering input in an attempt to regain control of the vehicle. The van initiated a slight counterclockwise yaw as it departed the right road edge and descended a shallow grassy embankment as its center of gravity continued in an easterly direction. The vehicle traveled approximately 58 m (190.3') in a slight CCW yaw to impact.

Crash

The front right area of the Ford E-250 van impacted a wooden utility pole and a composite telephone terminal box (**Figure 3**). The 12 o'clock direction of force impact sheared the pole and the terminal box. The replacement pole was located 4.5 m (14.8') south of the road edge line while the terminal box was located adjacent to the pole, 5.1 m (16.7') south of the referenced edge line. These simultaneous impacts did not alter the vehicle's trajectory. The frontal air bag system probably deployed as a result of the pole impact. This vehicle was not equipped with an Event Data Recorder (EDR), therefore the specific deployment parameters are unknown. The damage profile from this impact was masked by a subsequent impact with a large diameter tree.

As the utility pole sheared, the van traveled under the fractured pole as the upper end of the pole was supported by the electric lines and telephone cables. There was no damage to the windshield, roof, or right side area to support additional contact with the pole. The van continued in an easterly direction and based on the subtle rotating tire marks that remained at the crash site, it regained a tracking attitude approximately 6.2 m (20.3') east of the struck pole. The driver apparently attempted to regain the roadway as the vehicle arced back toward the roadway.



Figure 3. Trajectory of the Ford van to impact with the utility pole and the terminal box.



Figure 4. Struck tree.

The front right area of the van impacted an 84 cm (33.0") diameter tree (**Figure 4**) that was located 26.9 m (88.3') east of the initial impact with the struck pole. The 12 o'clock direction of force impact crushed the frontal structure of the van to a maximum depth of 93 cm (36.6"). An impact speed of 68 km/h (42 mph) was computed by the Damage and Trajectory Algorithm of the WinSMASH program. The total delta V computed by WinSMASH was 60 km/h (37 mph) with a longitudinal component of -60 km/h (-37 mph) and a lateral of 0 km/h. Although the vehicle sustained overlapping impact damage to the front right area, the damage profile from the tree impact was not significantly enhanced by the pole damage. Therefore, the delta V for this impact should be considered a reasonable reconstruction of the event.

The offset right impact induced a clockwise (CW) rotation to the Ford van. Based on physical evidence found at the crash site, the Ford E-250 van rotated 23 degrees CW, coming to rest near the struck tree. At rest, the vehicle was facing in an easterly direction.

Post-Crash

As the Ford came to rest, all three occupants remained in the vehicle. As police arrived on-scene, the driver opened the left front door and unbuckled his manual restraint system and exited the vehicle in an attempt to flee the scene. He was physically restrained by the police and subsequently transported to a local hospital where he was treated for a scalp

laceration and released to police custody. He was arrested for driving violations related to this crash.

The front right child passenger was removed from the high-back booster seat by rescue personnel and transported to a local trauma center hospital where he was stabilized and diagnosed with critical level injuries. He was prepared for helicopter transfer to a regional pediatric trauma center. He was admitted to this facility for three days and was removed from a ventilator and expired.

The 12-year old female passenger was removed from the cargo area of the vehicle by rescue personnel and transported to the local trauma center where she was admitted for five days for treatment of her injuries.

The Ford van was towed from the crash site on a flatbed tow truck and transported to an enclosed facility. The vehicle was impounded by the investigating police agency and retained for this SCI investigation.

Vehicle Damage – 2003 Ford E-250 Cargo Van

Exterior

The front right area of the Ford E-250 cargo van sustained severe damage as a result of the impacts with the utility pole and the large diameter tree. An impact from an unknown source at a location other than this crash site produced minor severity damage to the left sill area of the vehicle.

This left sill impact, which resembled a lateral impact with a delineator or a guy wire; resulted in direct contact damage that began 156 cm (61.4”) forward of the left rear axle and extended 15 cm (5.75”) forward at the bottom edge of the left sill. An abrasion to the painted surface extended 37 cm (14.5”) vertically upward onto the side panel. The abrasion measured 2 cm (0.75”) in width. The guy wire-type impact resulted in an area of deformation that began 55 cm (21.75”) forward of the left rear axle and extended 152 cm (60”) forward at the sill level. The crush profile for this minor damage was as follows: C1 = 0 cm, C2 = 0.6 cm (0.25”), C3 = 1.0 cm (0.4”), C4 = 1.3 cm (0.5”), C5 = 1.3 cm (0.5”), C6 = 0 cm. The Collision Deformation Classification (CDC) for this damage was 09-LPLN-1. Based on the inspection of the scene, this damage did not occur during this crash.

The front right impact damage from the utility pole was masked by the subsequent tree impact (**Figure 5**). The creosote pole transfer on the fiberglass hood began on the vehicle’s centerline and extended 43 cm (16.75”) to the right. It should be noted that the fiberglass hood fractured and flattened out, resulting in a wider than actual direct contact damage width. The impact fractured the hood and crushed the frontal area to an unknown depth. Although



Figure 5. Frontal damage from the overlapping impacts.

the cargo van continued forward as it sheared the pole, there was no pole damage to the greenhouse or roof areas. This impact probably deployed the vehicle's redesigned frontal air bag system. The van was not equipped with an EDR to support this assumption. The CDC for this impact was 12-FZEN-9 (9 representing an unknown extent zone).

The subsequent impact with the large diameter tree resulted in severe damage to the front right area, forward of the child passenger's position. The direct contact damage began on the bumper 9 cm (3.5") right of center and extended 68 cm (26.75") to the right corner. The direct contact damage at the grille level began 16 cm (6.25") right of center and extended 71 cm (27.75") to the (deformed) leading edge of the right front fender. Maximum crush was measured at 93 cm (36.6") located 63 cm (24.75") right of center. The impact deformed the entire frontal width of the vehicle resulting in a combined direct and induced damage length of 70 cm (27.4") at bumper level. A single crush profile was documented for the overlapping damage that resulted from the utility pole and tree impacts. The crush profile at bumper level was as follows: C1 = 0 cm [-26 cm (-10.1")], C2 = 8 cm (3.1"), C3 = 90 cm (35.5"), C4 = 93 cm (36.6"), C5 = 82 cm (32.4"), C6 = 65 cm (25.5"). The CDC for this impact was 12-FZEW-6. **Figures 6 and 7** document the extent of frontal crush.



Figure 6. Lateral view documenting the extent of frontal crush.



Figure 7. Maximum crush located inboard of the right corner.

Interior

The interior damage to the Ford E-250 cargo van was rated as severe and was primarily associated with intrusion of frontal components. The restrained front occupants loaded interior components and the manual belt systems. The driver loaded the belt webbing which resulted in frictional abrasions to the seat back recline lever, the latch plate, and the D-ring. His knees loaded the knee bolster which intruded into the driver's compartment. The left knee scuffed and abraded the bolster panel 23-28 cm (9-11") inboard of the left edge of the plastic panel and 1-10 cm (0.5-3") below the top edge of the bolster. The driver's right knee scuffed and abraded the bolster 43-56 cm (17-22") inboard of the



Figure 8. Lateral view of the driver's contact points and interior deformation.

left edge and 5-17 cm (2-6.5") below the top edge. There were no fractures of the bolster panel. The driver loaded through the deployed and deflated air bag as the E-250 impacted the large diameter tree. His loading of the steering wheel rim resulted in 2 cm (0.6") of forward rim deflection at the lower aspect of the wheel. His loading force was transmitted into the energy absorbing steering column which compressed the column and separated the shear brackets from the blocks. A fabric impression (woven pattern) with a scuff mark was noted to the aft aspect of the left door panel above the armrest. The probable left elbow/arm contact point was located 67-79 cm (26.5-31.25") rearward of the leading edge of the door panel and 2-12 cm (0.6-4.75") below the beltline. **Figure 8** is a view of the driver's contact points and interior damage.

The driver's seat back was deflected forward by the separation of the aftermarket partition that was riveted between the B-pillars of the vehicle and subsequently loaded by the shelving and loose construction equipment within the cargo area of the van. The front left seat back angle was measured at 20 degrees forward of vertical. The integral head restraint of the high-back seat was deflected to a measured angle of 45 degrees. The partition loaded the front right seat back; however, the seat back remained in a reclined position, measured at 18 degrees aft of vertical.

The front right child passenger contacted the intruding knee bolster. The plastic panel separated from the sheet metal backer panel due to the severe intrusion at this location. A large right knee/leg scuff mark was located 18 cm (7") inboard of the right edge of the bolster and measured 23 cm (9.1") in length vertically. Two small scuff marks were visible on the left side of the panel. The mid scuff mark was located 24-27 cm (9.5-10.6") inboard of the right edge and 10-14 cm (3.75-5.5") below the top edge of the panel. The left scuff mark was located 38-41 cm (14.9-16.25") left of the referenced edge and 13-18 cm (5-7.25") below the top edge. There was no distinct deformation of the bolster's sheet metal backer panel. **Figure 9** is a lateral view of the intrusion of the front right occupant's space.



Figure 9. Lateral view of the intrusion into the front right occupant's space.

Maximum intrusion involved 37 cm (11.5") of rearward displacement of the right toe pan. The intrusions of the front passenger compartment are identified in the following table:

Table 1: Intrusions

Seat Position	Intruding Component	Direction	Magnitude
Driver	Upper instrument panel, right of the steering column	Longitudinal	23 cm (9")
Driver	Mid instrument panel, right of the steering column	Longitudinal	3 cm (1")
Driver	Steering wheel hub	Longitudinal	5 cm (2")
Driver	Toe pan	Longitudinal	6 cm (2.5")
Driver	Engine cover	Lateral	15 cm (6")
Front Right	Toe pan	Longitudinal	37 cm (14.5")
Front Right	Right mid knee bolster	Longitudinal	33 cm (13")
Front Right	Mid right instrument panel at air bag module cover flap	Longitudinal	29 cm (11.5")
Front Right	Right A-pillar at beltline	Longitudinal	28 cm (11")
Front Right	Upper right instrument panel	Longitudinal	21 cm (8")
Front Right	Upper right A-pillar	Longitudinal	4 cm (1.5")

Manual Safety Belt Systems

The Ford E-250 was equipped with manual 3-point lap and shoulder belts at the two front seated positions. These belt systems consisted of continuous loop webbing with a sliding latch plate. The outboard lower anchorage was bolted to the sill of the vehicle with a vinyl sleeve that covered the anchor hardware and belt stitching. The inboard buckle/pretensioner unit was affixed to the seat cushion frame. The driver's side retractor was an Emergency Locking Retractor (ELR) with a belt sensitive feature. The front right position was equipped with an ELR and Automatic Locking Retractor (ALR) with the belt sensitive feature. The B-pillar mounted D-rings were adjustable. The driver's D-ring was adjusted to the mid position while the front right D-ring was adjusted to the full-up position.

The driver was restrained by the belt system at the time of the crash. Belt usage was supported by the fired buckle pretensioner and loading evidence on the webbing and hardware components. The driver's loading of the belt system produced a frictional D-ring transfer to the belt webbing located 123-130 cm (48.25-51") above the top of the vinyl sleeve at the sill location. The latch plate produced a frictional transfer of the plastic covered latch plate onto the webbing located 57-64 cm (22.25-25") above the vinyl sleeve. Additionally, the outboard surface of the crossbar of the latch plate was abraded full width from the belt interaction. A belt webbing abrasion was also observed to the seat back recline lever that was located on the outboard aspect of the cushion, forward of the seat bight. The black plastic transferred onto the webbing at this location. The belt system remained intact as the driver unbuckled the system post-crash and exited the vehicle.

The front right 3-point belt system restrained the 5-year old child in the belt positioning booster seat. Rescue personnel cut the webbing during the extrication of the child passenger. The lap belt webbing was cut 27 cm (10.5”) above the outboard vinyl sleeve for the lower anchor. The lap belt webbing extended 66 cm (26”) through the latch plate to form the shoulder belt. The shoulder belt webbing was cut at the outboard aspect of the booster seat 79 cm (31”) above the latch plate. The remainder of the shoulder belt webbing retracted into the B-pillar. The latch plate remained buckled at the time of the SCI investigation. The buckle pretensioner fired during the crash.

Frontal Air Bag System

The Ford E-250 cargo van was equipped with redesigned frontal air bags for the driver and front right passenger positions. The air bag system deployed during the crash. The Ford was not equipped with an Event Data Recorder (EDR); therefore the specific event that resulted in the deployment was unknown. The frontal air bag system probably deployed as a result of the first impact with the utility pole due to the vehicle’s sensing of a short duration spike associated with this event.

The air bag system consisted of a passenger compartment mounted Restraints Control Module (RCM) that was mounted to the top of the transmission tunnel, aft of the cowl, an electronic satellite sensor that was mounted to the top center of the upper radiator support panel, the steering wheel mounted driver’s air bag module, the mid mount front right passenger’s air bag, and buckle pretensioners for both front belt systems.

The RCM provided the basic function of monitoring the air bag system for faults and sensing a crash of defined parameters to deploy the air bag system. The RCM did not have EDR capabilities. In this crash, the RCM detected a crash event of sufficient magnitude to fire the buckle pretensioners and deploy the frontal air bag system.



Figure 10. Deployed driver’s air bag.



Figure 11. Deployed front right passenger’s air bag.

The driver’s air bag (**Figure 10**) deployed from an H-configuration module that was contained within the four-spoke steering wheel rim. The driver air bag membrane was approximately 61 cm (24”) in diameter in its deflated state and was tethered internally by two tethers at the 12 and 6 o’clock positions. The tethers were sewn to the face of the air

bag with two rows of stitching in the 17 cm (6.75") diameter reinforcement. The bag was directly vented to the passenger compartment by two 3 cm (1") diameter ports located at the 12 o'clock position. The ports were centered 8 cm (3") forward of the peripheral seam. Although the driver's air bag was not damaged by the deployment or the crash related damage, the bag was covered with blood as the driver slumped over the bag post-crash. Due to the extensive amount of blood, there was no discernable contact evidence on the bag membrane.

The front right passenger air bag (**Figure 11**) was concealed by a single cover flap in the top and mid aspect of the right instrument panel. The cover flap was hinged at the top surface and opened at the mid instrument panel, in an upward direction. The cover flap measured 38 cm (14.75") in width and 28 cm (10.9") in height. The passenger air bag deployed from the mid mount module. The air bag membrane was not tethered and was vented by two 7 cm (2.75") diameter ports located at the lateral aspects of the bag, 22 cm (8.75") forward of the peripheral seam.

There was no damage to the deployed passenger air bag. A tissue transfer was noted to the face of the bag, located 22-27 cm (8.5-10.5") below the top apex of the bag and 12-22 cm (4.6-8.6") inboard of the right vertical seam. Blood stains were noted to the top panel of the bag.

The E-250 was equipped with buckle pretensioners that fired during the crash event. Both pretensioners consisted of a barrel that was mounted forward of the buckle unit. A pyrotechnic charge drove a cable forward that reduced the height of the belt buckle.

Child Safety Seat

The 5-year old male front right passenger was seated in a Cosco high-back belt positioning booster seat, restrained by the vehicle's 3-point lap and shoulder belt system. The booster seat was identified by Model No. 02-452-WAL and manufactured on 3/23/2002. Labeling on the booster seat identified the recommended weight requirements at 14-36 kg (30-80 lb) with height recommendations of 94-130 cm (37-51"). All manufacturers' labeling remained intact on the booster seat.

There was no integral harness system available with this child seat; therefore the seat was designed solely as a belt positioning booster seat. The seat was constructed of a one-piece plastic shell, foam padding, and the fabric covering. The outboard aspects of the seat at the right location provided a belt path for the vehicle's lap belt. At these locations, subtle whitening of the plastic shell was noted from loading of the lap belt during the crash. Additionally, woven fabric pattern imprints were visible at the belt path locations which supported use and placement of the vehicle's lap belt.

Three molded clips stacked on each side of the booster seat shell provided positioning of the vehicle's shoulder belt webbing. There was no damage to these clips on either side of the seat. Based on the lack of damage, it was doubtful that the shoulder belt was engaged in one of these clips at the time of the crash.

There was no other damage or loading evidence visible to the Cosco seat.



Figure 12. Frontal view of the Cosco high-back booster seat.



Figure 13. Belt abrasion to the right belt path of the CSS.

Occupant Demographics

Driver

Age/Sex: 41 year old/Male
 Height: 183 cm (72")
 Weight: 82 cm (180 lb)
 Manual Restraint System Usage: 3-point lap and shoulder belt system
 Usage: Vehicle inspection
 Seat Track Position: Rear track position [4 cm (1.5") forward of full rear]
 Egress From vehicle: Exited the vehicle unassisted, attempted to flee scene and was subdued by police officers
 Mode of Transport From Scene: Ambulance
 Type of Medical Treatment: Treated at a local hospital, treated and released to police custody

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Sutured laceration of the mid forehead	Minor (290602.1,7)	Steering wheel rim

Source of Injury Data – Emergency Room Records

Driver Kinematics

The 41-year old male driver of the Ford cargo van was seated with the seat track adjusted to a rear position and the seat back reclined aft of vertical. The sheet metal partition that was installed behind the front seats prevented excessive recline of the front seat backs. The driver was restrained by the manual 3-point lap and shoulder belt system. Belt usage was supported by loading evidence on the webbing from frictional engagement against the D-ring, latch plate, and recline lever at the outboard aspect of the seat cushion.

Based on the vehicle's arcing trajectory back toward the travel lanes, the driver was presumed to be in an upright posture, attempting to regain control of the vehicle. The initial impact with the utility pole probably deployed the frontal air bag system and fired the safety belt buckle pretensioners. The impact did not alter the trajectory of the van as it continued in an easterly direction on the roadside. In response to the frontal 12 o'clock impact force, the driver initiated a forward trajectory and loaded the manual belt system and the deployed air bag. The combination of restraint systems prevented the driver from potential injury.



Figure 14. Driver loading of the belt system and steering wheel rim.

The vehicle continued forward and returned to a tracking mode as the driver apparently steered the vehicle back toward the eastbound travel lane. The front right area of the Ford impacted the 84 cm (33") diameter tree resulting in a 12 o'clock impact force. This severe impact displaced the driver forward. He again loaded the manual belt system; however, at this point in time; the deployed air bag was near fully deflated. The driver's loading of the belt system produced the webbing transfers at the hard points of the belt system noted above.

The steering wheel was rotated by the engagement of the right front tire against the tree. At the time of the SCI inspection, the bottom of the steering wheel was rotated to the 10 o'clock sector. The driver's head jackknifed over the manual safety belt and the deflated air bag and impacted the upper region of the steering wheel rim. This contact resulted in the 3 cm laceration of the mid forehead.

During this kinematic response, the loose cargo in the van was displaced forward and loaded against the partition that was mounted between the B-pillars. The cargo separated the rivets from the mounting points and displaced the partition forward. The partition and loose cargo loaded the driver's seat back, deforming the seat back to a measured angle of 20 degrees forward of vertical. The driver rode down the crash forces by loading the manual belt system, steering wheel, and the knee bolster without sustaining injury. The driver loaded the wheel rim, deforming the rim 2 cm (0.6") forward and separating the shear capsules of the energy absorbing steering column. His knees contacted the intruding knee bolster as evidenced by scuff marks on both sides of the

steering assembly. The forehead laceration resulted in significant blood loss as the driver remained in the vehicle post-crash, slumped over the steering wheel. The blood pooled onto the deflated driver's air bag.

Medical Treatment

As the police arrived at the scene, the driver exited the vehicle and attempted to flee the scene. He was subdued by the officers and transported by ambulance to a local hospital where he was treated for his injury. The scalp laceration was sutured and the driver was released to police custody and arrested for driving while intoxicated.

Front Right Child Passenger

Age/Sex: 5-year old/male
 Height: Not reported
 Weight: Estimated by hospital staff at 20 kg (44 lb)
 Manual Restraint
 Usage: Positioned in a Cosco high-back belt positioning booster seat and restrained by the vehicle's manual 3-point lap and shoulder belt system
 Usage Source: Vehicle inspection, observations of the first responders to the crash site
 Seat Track Position: Mid track position [adjusted 9 cm (3.5") forward of full rear]
 Egress from Vehicle: Removed by rescue personnel
 Mode of Transport
 From Scene: Ambulance
 Type of Medical: Transported to a local hospital and transferred by helicopter to a regional pediatric trauma center where he was admitted and expired three days following the crash.

Front Right Child Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Complex laceration of the liver at the hepatic hilum and caudate	Critical (541828.5,1)	Safety belt webbing
Right tentorial subdural hematoma	Severe (140652.4,1)	Upper right instrument panel
Bilateral pulmonary contusions with right pneumothorax	Severe (441410.4,3)	Safety belt webbing
Subtle, diffuse cerebral edema	Serious (140660.3,9)	Upper right instrument panel
Mild anterior subluxation of C2/C3 (reported as a few mm)	Moderate (650204.2,6)	Upper right instrument panel
Fractured left 7 th rib	Minor (450212.1,2)	Safety belt webbing

Ecchymosis with swelling around the right orbit	Minor (290402.1,1)	Front right air bag
Ecchymosis with swelling over the right maxilla area	Minor (290402.1,1)	Front right air bag

Source of Injury Data – Initial treating trauma center records

Front Right Child Passenger Kinematics

The 5-year old male child passenger was seated in a Cosco high-back belt positioning booster seat and restrained by the vehicle’s manual 3-point lap and shoulder belt system in the front right position of the cargo van. The seat track was adjusted to a mid position that measured 9 cm (3.5”) forward of full rear. Based on an exemplar vehicle inspection, the seat track travel was 17 cm (6.5”). In this position, the pre-crash horizontal distance between the leading edge of the mid mount front right air bag module cover flap and the booster seat was approximately 61 cm (24.0”).

At impact with the utility pole, the frontal air bag system probably deployed based on the location of impact, the object struck, and the sudden deceleration experienced by the vehicle. The non-tethered air bag deployed from the mid mount position. The child passenger would have initiated a forward trajectory and loaded the manual belt system. The expanding non-tethered air bag probably contacted the face of the child passenger resulting in ecchymosis with swelling over the right orbit and maxilla areas. A subtle tissue transfer was noted to the lower aspect of the air bag membrane.

As the Ford cargo van continued in a forward direction, the front right area impacted the 84 cm (33”) diameter tree, resulting in severe frontal damage and intrusion of the passenger compartment. At this point, the deployed front right passenger air bag was nearly deflated, offering minimal, if any crash protection to the child passenger. The child passenger initiated a forward trajectory in response to the frontal impact force and loaded the manual belt system. He sustained bilateral pulmonary contusions, a left rib fracture, and a complex laceration of the liver from loading the safety belt system.

The child passenger loaded through the deflated front right air bag and contacted the intruding lower, mid and upper instrument panel. This contact sequence resulted in the closed head injuries that included the right subdural hematoma and the diffuse cerebral edema. The head contact hyperextended the head resulting in minimal subluxation of the C2/C3. **Figure 15** is a lateral view on the passenger’s position against the intruding frontal components.



Figure 15. Position of the child passenger with respect to the deployed air bag and frontal intrusion.

Medical Treatment

The child passenger was found without a pulse and with his knees drawn to his chest and his head slumped forward with his chin resting on his chest. He was removed from the cargo van by rescue personnel and placed on a backboard. The child was administered an IV, intubated, with chest compressions in an attempt to restore breathing and pulse. He was transported by ambulance to a local trauma center where he was stabilized, evaluated and diagnosed with the above listed injuries. He was prepared for helicopter transfer to a regional pediatric trauma center. The child was admitted to the pediatric trauma center for a period of three days and expired. The pediatric hospital would not provide medical records to the SCI team.

Additional Child Passenger

Age/Sex: 12-year old/Female
 Height: Not reported
 Weight: Not reported
 Position Within Vehicle: Seated on an inverted plastic bucket in the cargo area of the van behind the front right passenger
 Manual Restraint Usage: None available
 Usage Source: Vehicle inspection
 Egress from Vehicle: Removed by rescue personnel
 Mode of Transport From Scene: Transported by ambulance to a local hospital where she was admitted for five days for treatment of her injuries

Additional Child Passenger Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Mechanisms
Right mid-shaft femur fracture, closed	Serious (851814.3,1)	Aftermarket partition
Diffuse contusion of the left lateral lung	Serious (441406.3,2)	Aftermarket partition
3 cm stellate laceration of the forehead	Minor (290602.1,7)	Aftermarket partition
Abrasion left anterior thigh	Minor (890202.1,2)	Aftermarket partition
Abrasion over the left knee	Minor (890202.1,2)	Aftermarket partition
Abrasion over the right ankle	Minor (890202.1,1)	Cargo
Left frontal scalp hematoma	Minor (190402.1,2)	Aftermarket partition
Left and right chest contusions	Minor (490402.1,1; 490402.1,2)	Aftermarket partition

Source of Injury Data – Hospital records

Additional Child Passenger Kinematics

The 12-year old child passenger was seated on an inverted plastic bucket in the right rear area of the cargo compartment of the van. This was not a designated seated position; therefore, there were no restraints available to this passenger. At impact, she initiated a forward trajectory in response to the 12 o'clock direction of force. She loaded the aftermarket partition and was probably struck by loose cargo. She sustained a right mid-shaft femur fracture and a left lung contusion, in addition to multiple soft tissue injuries from loading the partition. **Figure 16** is a view from the rear of the cargo area of the van.



Figure 16. View of the cargo area, loose construction equipment, and passenger position.

This child passenger was removed from the vehicle by rescue personnel and transported to a local trauma center where she was admitted for five days for surgical repair of the femur fracture.

Figure 17: Scene Schematic.

