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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN-03-047

LOCATION - STATE

VEHICLE - 1996 TOYOTA CAMRY

CRASH DATE - November 2003

Submitted:

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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. <i>Abstract</i> <p>This report covers an on-site investigation of a crash that involved a 1996 Toyota Camry (case vehicle) and a 2000 Mack DM 690S cement mixer (other vehicle). This crash is of special interest because the case vehicle's back left (3-year-old, male) and back right (8-month-old, male) passengers, who were seated in child safety seats at the time of the crash, sustained only moderate and minor injuries, respectively, despite their involvement in a severe crash. The trafficway on which both vehicles were traveling was a two-lane, undivided, county roadway, traversing in an east-west direction. The case vehicle was traveling east in the eastbound lane, and the Mack cement mixer had been traveling west in the westbound lane. The Mack's right wheels went off the north edge of the roadway. The Mack's driver steered the vehicle back to the left and fully onto the roadway. Apparently the Mack's driver then steered the vehicle back to the right. As a result, the Mack cement mixer rolled over onto its left side. The crash sequence began in the eastbound lane of the roadway. The left side of the Mack truck impacted the eastbound lane and began to slide along the lane in a west-southwesterly direction toward the south edge of the roadway. The front of the case vehicle impacted the front engine and cab section of the Mack cement mixer, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The back left passenger was seated in a seat belt-positioning, booster child safety seat. The back seat was not adjustable. He was restrained by his available, active, three-point, lap-and-shoulder, safety belt system in conjunction with his belt-positioning booster seat. He sustained, according to his medical records and the driver's interview, a fractured left clavicle, and abrasions and contusions to his left clavicular area and bilateral anterior upper thighs-near his hips. The back right passenger was seated in a convertible child safety seat, positioned in its rear-facing configuration in a reclined position. He was restrained by his child safety seat's five-point harness system, which was secured by his available, active, three-point, lap-and-shoulder, safety belt system. He sustained, according to his medical records and the driver's interview, abrasions and contusions to his bilateral inner upper thighs-near his hips. The driver (31-year-old, female) was seated with her seat track located in its rearmost position, and the tilt steering wheel was located between its center and upmost positions. She was restrained by her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her medical records and her interview, a nonanatomic brain injury; a avulsion to her left parietal-occipital scalp; a laceration of her upper frenulum; and multiple soft tissue abrasions and contusions.</p>					
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This investigation was brought to NHTSA's attention on November 20, 2003 by an investigator with the National Transportation Safety Board in north central Texas. This crash involved a 1996 Toyota Camry (case vehicle) and a 2000 Mack DM 690S cement mixer (other vehicle). The crash occurred in November 2003, at 6:19 a.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's back left passenger [3-year-old, White (non-Hispanic) male] **and** back right passenger [8-month-old, White (non-Hispanic) male], who were seated in child safety seats at the time of the crash, sustained only moderate and minor injuries, respectively, despite their involvement in a severe crash. This contractor inspected the scene and vehicles on December 3, 2003. This contractor interviewed the driver for the case vehicle on December 2, 2003. This summary is based on the Police Crash Report, an interview with the case vehicle's driver, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

SUMMARY

Crash Environment: The trafficway on which both vehicles were traveling was a two-lane, undivided, county roadway, traversing in an east-west direction. The east-west roadway had one through lane in each direction. At the time of the crash the light condition was dark, the atmospheric condition was clear, and the road pavement was dry. Traffic density was light, and the site of the crash was primarily urban residential. In addition, there was a driveway to within a short distance of the crash site; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle was traveling east in the eastbound lane and intended to proceed straight ahead. The Mack cement mixer had been traveling west in the westbound lane and intended to continue straight ahead. According to the Police Crash Report and the interview with the case vehicle's driver, the Mack's right wheels went off the north edge of the roadway. The Mack's driver steered the vehicle back to the left and fully onto the roadway, heading toward the eastbound lane. It appears the Mack's driver then steered the vehicle back to the right. As a result of the rightward steering maneuver, the Mack cement mixer rolled over onto its left side. The crash sequence was initiated in the eastbound lane of the roadway.

Crash: The left side of the Mack truck impacted the eastbound lane of the roadway and began to slide along the eastbound lane in a west-southwesterly direction toward the south edge of the roadway. As the Mack truck was rolling over, its rear end rotated clockwise. As a result, the Mack truck was "heading" in a west-northwesterly orientation as it slid along the eastbound lane. The case vehicle's driver braked attempting to avoid the crash. The case vehicle's involvement also occurred in the eastbound lane of the roadway.

The front of the case vehicle impacted the front engine and cab section of the Mack cement mixer, which was sliding on its left side, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy.

Post-Crash: As a result of the impact, the case vehicle was immediately driven rearward, in a west-southwesterly direction, off the south edge of the roadway, and into a shallow ditch on the south roadside. The case vehicle also rotated approximately 90 degrees counterclockwise as it was redirected along its westerly path. At some time during its post-crash movement, the right rear of the case vehicle was impacted by the left and/or top sides of the Mack truck. The case vehicle came to rest in the ditch on the south roadside, heading in a northerly direction. The Mack truck continued in a west-southwesterly direction, on its left side, after impacting the case vehicle. The Mack truck continued to rotate clockwise as it traveled westward. This degree of rotation was almost certainly increased by the negative slope of the roadside ditch into which it moved. An unknown part of the Mack truck impacted the right rear of the case vehicle during its westerly movement. The Mack truck came to rest on its left side in the southerly ditch, also heading in a north-northeasterly direction at final rest.

Case Vehicle: The 1996 Toyota Camry was a front wheel drive, four-door sedan (VIN: 4T1BG12K5TU-----). The case vehicle was equipped with four wheel, anti-lock brakes.

Vehicle Exterior: Based on the vehicle inspection, the CDCs for the case vehicle were estimated to be: **11-FDEW-2** (340 degrees) and **03-RZEW-2** (90 degrees). The WinSMASH reconstruction program is not applicable to the case vehicle's impacts because the Mack truck is not CDC applicable. However, for the purposes of establishing the Barrier Equivalent Speed (**BES**) that would have produced some of the observed damage on the case vehicle **and** for providing a course estimate of the Delta Vs that it actually sustained, the WinSMASH reconstruction program, barrier algorithm, was used on both the case vehicle's highest and second severity impacts. For the highest severity (i.e., frontal) impact, the Total, Longitudinal, and Lateral Delta Vs are, respectively: 23.0 m.p.h. (14.3 m.p.h.), -21.6 km.p.h. (-13.4 m.p.h.), and +7.9 km.p.h. (+4.9 m.p.h.). For the second highest severity (i.e., right side) impact, the Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.0 km.p.h. (6.2 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and -10.0 km.p.h. (-6.2 m.p.h.). While it must be kept in mind that these values are only estimates of the actual velocity exchange that the case vehicle sustained, it should be remembered that: (1) the case vehicle collided with a relatively "soft" spot on the cement mixer (i.e., the driver's cab area), and (2) the case vehicle's initial impact was of an elongated duration because the case vehicle overrode the Mack truck's engine compartment prior to penetrating the cab area. The case vehicle most likely sustained undercarriage damage as it overrode the engine area and the contact to its roof and left side areas most likely resulted from contacting the crumpling hood of the Mack truck. Once the case vehicle reach maximum engagement (i.e., in the Mack truck's cab area), it was pushed rearward forcefully by the weight of the Mack truck. Overall, this contractor's visually estimated Delta V for the frontal impact is between 19 km.p.h. (12 m.p.h.) and 32 km.p.h. (20 m.p.h.). The case vehicle was towed due to damage.

Exterior Damage: The case vehicle's initial contact with Mack truck involved the entire front end. Direct damage extended across the entire width of the front bumper, a measured distance 140 centimeters (55.1 inches). Undeformed end width was determined to be 162 centimeters (63.8 inches). Residual maximum crush was measured as 25 centimeters (9.8 inches) at C₂. The wheelbase on the case vehicle's left side was shortened 12 centimeters (4.7 inches) while the right side was extended 7 centimeters (2.8 inches). The case vehicle's front bumper, bumper fascia,

grille, radiator, hood, and right and left headlight and turn signal assemblies were directly damaged and crushed rearward. Contact was also made to the left fender and left front door, both of which were crushed inward. Furthermore, there was direct damage to the front left portion of the roof, which was crushed downward. In addition, there was possible direct contact to the windshield; although, this is difficult to tell as the roof and all pillars were removed from the vehicle by rescue personnel. The case vehicle's secondary contact with the Mack truck involved its right rear side. Direct damage began 15 centimeters (5.9 inches) forward of the right rear axle and extended a measured distance of 120 centimeters (47.2 inches), rearward to the left rear bumper corner. The Field L was determined to be 130 centimeters (51.2 inches). Residual maximum crush was measured as 21 centimeters (8.3 inches) at C₂. The case vehicle's right quarter panel, right rear taillight and turn signal assemblies, and right rear bumper fascia—including the portion extending just under the rear quarter panel, were directly damaged and crushed inward. There was induced damage to right front and rear turn signal assemblies as well as to the hood, roof, the windshield's glazing, and the right fender. All right and left side glazing as well as the backlite were disintegrated, but it is unclear if this resulted from the crash or occupant extrication.

The case vehicle manufacturer's recommended tire size was: P195/70R14, and the case vehicle tires were the recommended size. The case vehicle's tire data are shown in the table below.

<i>Tire</i>	<i>Measured Pressure</i>		<i>Recommend Pressure</i>		<i>Tread Depth</i>		<i>Damage</i>	<i>Restricted</i>	<i>Deflated</i>
	kpa	psi	kpa	psi	milli- meters	32 nd of an inch			
LF	0	0	221	32	8	10	None	Yes	Yes
RF	0	0	221	32	8	10	None	No	Yes
LR	0	0	221	32	7	9	None	No	Yes
RR	179	26	221	32	7	9	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior revealed contact on the left side of the driver's knee bolster and on the left lower instrument panel area. Furthermore, there was contact to the right side of the driver's knee bolster, just to the right of the steering column and possibly to the underneath side of the steering column as well as the left side of center instrument panel/center console. In addition, there was contact to the driver's sun visor and the left windshield header. The vehicle's roof was intruded downward, but because of its removal, the intrusion could not be measured. Finally, there was no evidence of compression to the energy absorbing shear capsules in the steering column and no deformation to the steering wheel rim.

Supplemental Restraints: The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the

deployment to the air bag or the cover flaps. The driver's air bag was designed with four tethers, each approximately 6.5 centimeters (2.6 inches) in width. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 1:30 and 10:30 clock positions. The deployed driver's air bag was round with a diameter of 66 centimeters (26.0 inches). An inspection of the driver's air bag fabric revealed a large amount of blood on the front surface of the air bag's fabric, most notably in the upper left and lower right quadrants. In addition, blood also liberally covered the lower half of the air bag's back surface. The blood most likely came from an avulsion/laceration on the left posterior surface of the driver's scalp.

The front right passenger's air bag was located in the top of the instrument panel. An inspection of the front right air bag module's cover flap and the air bag's fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 4 centimeters (1.6 inches) in diameter, located at the 3 and 9 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 80 centimeters (31.5 inches) and a width of approximately 53 centimeters (20.9 inches). An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the front surface of the front right air bag's fabric. However, there was a blood spot on the left side surface, most likely a splatter spot from the case vehicle's driver.

Booster Child Safety Seat: The back left passenger was seated in a belt positioning booster child safety seat. The seat was manufactured by Graco Children's Products, on May 21, 2003. The seat was a Turbo booster, and the model number was **8491RGB**. In this crash the seat was used in a "backless" configuration. The booster seat was designed with two armrests, under which the vehicle's seat belt was positioned across the lower abdomen of the child.

The case vehicle's inspection revealed that the latch plate for this seating position's safety belt was the "sliding" type, and the safety belt system had a switchable retractor. The case vehicle's driver indicated that her husband had read the child seat's instruction manual but not the vehicle's manual on installation of a child safety seat using the vehicle's seat belts. However, the driver claimed that there was familiarity with the safety belt-child seat installation process. The driver indicated that she had placed the child in the seat prior to the crash. The driver does not recall doing anything to lock the vehicle's seat belt while securing the child.

The booster child safety seat was made of hard plastic, covered with soft, removable, padding. Based on inspection and the statement of the case vehicle's driver, booster child safety seat did not show any areas of stress to the plastic seat, arm rest, or belt positioning areas (e.g., scuff marks and stress fractures) and very little wear and tear to the cloth cover or padding. There was a large manufacturer's label affixed to the bottom of the seat giving the child seat's height and weight limitations [i.e., with back support—approximately 96 to 145 centimeters and 13.6 to 45 kilograms (38 and 57 inches and 30 and 100 pounds); without back support—approximately 101 to 145 centimeters and 18 to 45 kilograms (40 and 57 inches and 30 and 100 pounds)]. This label was not dated. Other warning labels were sewn onto the base, one in English and one in Spanish,

advising against use in the front seat. A final manufacturer's label was affixed to the right rear side of the base, with schematics depicting where the vehicle's belt should be placed.

Convertible Child Safety Seat: The back right passenger was seated in a convertible child safety seat that was used in its rear-facing configuration at the time of the crash. The child safety seat was manufactured by Dorel on September 7, 2003 and was identified by model name "*Touriva*" and model number **22-110-WAL**. The convertible seat was designed with a five-point harness, with two straps located above the shoulders, two at the hips, and one between the child's legs. The straps were clipped into the non-recessed buckle at the top of the crotch strap. The seat was also equipped with a top tether and lower anchor attachments for use with a LATCH system. There were three sets of slots to thread the two shoulder harness straps through. The harness straps were threaded through the middle slots, which according to the manufacturer's instructions should only be used when the seat is in the rear-facing configuration. The child seat was positioned in a slightly reclined position.

The convertible child safety seat consisted of a one-piece plastic shell. The shell had cloth covered foam padding on the back support and the seating portion. The case vehicle's inspection revealed that the latch plate for this seating position's safety belt was the "sliding" type, and the safety belt system had a switchable retractor. The case vehicle's driver indicated that her husband had read the child seat's instruction manual but not the vehicle's manual on installation of a child safety seat using the vehicle's seat belts. However, the driver claimed that there was familiarity with the safety belt-child seat installation process. The driver indicated that she had installed the child seat and had placed the child in the seat prior to the crash. The driver does not recall doing anything to lock the vehicle's seat belt while securing the child restraint. Based on the vehicle inspection and the driver's interview, the safety belt was in **Emergency Locking Retractor** (ELR) mode [i.e., versus the **Automatic Locking Retractor** (ALR) mode]. The driver indicated that the child seat was "tight" and that no "locking clip" was used on this passenger's safety belt.

A close inspection of the child safety seat revealed no apparent damage or fractures to the base or shell. There were manufacturer's warning and instruction labels on the left side (i.e., outboard side when used in the rear-facing configuration), warning the user/parent not to place this child seat in a vehicle's front right seat when the vehicle is equipped with a front right passenger air bag and where to position the vehicle's seat belts for the rear-facing configuration. There was a manufacturer's label affixed to the right side (i.e., inboard side when used in the rear-facing configuration) giving the child seat's weight limitations for both the rear-facing configuration [i.e., for both smaller infants–2.3 to 10 kilograms (5 to 22 pounds) and larger infants–10 to 15.9 kilograms (22 to 35 pounds)] **and** the forward-facing configuration [i.e., 10-18 kilograms (22-40 pounds)]. Furthermore, this label provided the overall height limitations for the seat [i.e., 48.3 to 102 centimeters (19 to 40 inches)]. In addition, this label explained the importance of securing the child restraint with a vehicle's safety belt as specified in the vehicle manufacturer's instructions. The manufacturer's instructions for this child safety seat were available on the back of the seat at the time of this contractor's inspection.

Both sides had labels that illustrated the proper way to install the vehicle's safety belts when the child safety seat was used in either the rear-facing configuration or the forward-facing configuration. None of the labels had any dates that were visible.

Other Vehicle: The 2000 Mack DM-690S was a four wheel drive (6x4), incomplete straight truck, with an offset two-door cab, configured with a cement mixer body (VIN: 1M2B221C7YM-----). The Mack truck was not equipped with any supplemental restraint systems.

Exterior Damage: Based on the available photographs, the TDCs for the Mack truck are estimated as: **00-LDAO-99** for the initial rollover impact, **00-FDHW-7** for the primary impact with the case vehicle (i.e., the Mack truck was on its left side at the time of this impact), and **00-9999-99** for its impact with the case vehicle's left quarter panel. Based on the available information, the Mack's speed prior to the crash is unknown, but the legal speed limit was 89 km.p.h. (55 m.p.h.). The Mack was towed due to damage.

Case Vehicle's Back Left Passenger: Immediately prior to the crash the case vehicle's back left passenger [3-year-old, White (non-Hispanic) male; 107 centimeters and 20 kilograms (42 inches and 44 pounds)] was seated in a seat belt-positioning, booster child safety seat in an upright position with his back against the vehicle's seat back and his feet dangling over the front edge of vehicle's seat cushion, angled downward. In addition, the exact position of his hands is unknown. There was no seat track, and the vehicle's seat back was not adjustable.

Based on this contractor's vehicle inspection and the driver's interview, the case vehicle's back left passenger was restrained by his available, active, three-point, lap-and-shoulder, safety belt system in conjunction with his belt-positioning booster seat. Furthermore, there was ample evidence of belt pattern bruising and/or abrasions to the back left passenger's torso and a fracture to his left clavicle. Although the inspection of the back left passenger's seat belt webbing, "D"-ring, and latch plate showed no clear evidence of loading, the fact that the webbing had been cut post-crash is a good indicator that the safety belt was used. Finally, the booster seat containing the back left passenger was turned/twisted leftward at final rest.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of the back left passenger's available safety belts in conjunction with his seat belt-positioning booster seat, the back left passenger most likely moved slightly forward just prior to impact. The case vehicle's primary impact with the Mack truck enabled the case vehicle's back left passenger to continue forward and slightly leftward along a path opposite the case vehicle's **340** degree Direction of Principal Force as the case vehicle decelerated. As a result, this occupant loaded his safety belts, abrading, contusing, and fracturing his left clavicle and abrading and contusing his bilateral upper thighs. After the case vehicle reached maximum engagement it was driven backwards by the weight of the Mack truck. The case vehicle also rotated approximately 90 degrees counterclockwise as it was redirected along its westerly path. As a result, this occupant moved rearward toward his seat back and to his left. At some time during its post-crash movement, the right rear of the case vehicle was impacted by the left and/or top sides of the Mack truck. As a result, this occupant most likely moved slightly to his right

along a path opposite the **90** degree Direction of Principal Force. Once again, his restraints enabled this occupant to remain near his original pre-crash position. The case vehicle came to rest in the ditch on the south roadside, heading in a northerly direction. At final rest, the back left passenger's posture is unknown, but he was conscious and, according to his medical records, was removed from the vehicle by bystanders.

The back left passenger was transported by ambulance to the hospital. He sustained a moderate injury and was treated and released. According to his medical records and the driver's interview, he sustained a fractured left clavicle, and abrasions and contusions to his left clavicular area and bilateral anterior upper thighs—near his hips. All of these injuries were attributed to the vehicle's safety belts which restrained this occupant.

Case Vehicle's Back Right Passenger: The case vehicle's back right passenger [8-month-old, White (non-Hispanic) male; 64 centimeters and 12 kilograms (25 inches, 26 pounds)] was seated in a convertible child safety seat, positioned in its rear-facing configuration in a reclined position with his back against the child seat's seat back and his feet most likely within the seat's structure. In addition, the exact position of his hands is unknown. There was no seat track, and the vehicle's seat back was not adjustable.

Based on this contractor's vehicle inspection and the driver's interview, the case vehicle's back right passenger was restrained by his child safety seat's five-point harness system, which was secured by his available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, according to the interview with the case vehicle's driver, there was evidence of belt pattern bruising and/or abrasions to the back right passenger's inner thighs from his harness straps. Although the inspection of the back right passenger's seat belt webbing, "D"-ring, and latch plate showed no clear evidence of loading, the fact that the webbing had been cut post-crash is a good indicator that the safety belt was used.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of the back right passenger's available safety belts in conjunction with his rear-facing child safety seat, the back right passenger most likely moved slightly forward (i.e., his back moving toward the front of the vehicle) just prior to impact. The case vehicle's primary impact with the Mack truck enabled the case vehicle's back right passenger to continue forward and slightly leftward along a path opposite the case vehicle's **340** degree Direction of Principal Force as the case vehicle decelerated. As a result, this occupant loaded the back of his child safety seat. After the case vehicle reached maximum engagement it was driven backwards by the weight of the Mack truck. The case vehicle also rotated approximately 90 degrees counterclockwise as it was redirected along its westerly path. As a result, this occupant moved rearward toward his seat back and to his left. During this rearward movement, this occupant most likely injured his inner thigh areas. At some time during its post-crash movement, the right rear of the case vehicle was impacted by the left and/or top sides of the Mack truck. As a result, this occupant most likely moved slightly to his right along a path opposite the **90** degree Direction of Principal Force. Once again, his harness straps in conjunction with the vehicle's safety belts enabled this occupant to remain near his original pre-crash position. The case vehicle came to rest in the ditch on the south roadside, heading in a northerly direction. At final rest, the back right

passenger's posture is unknown, but he was conscious and, according to his medical records, was removed from the vehicle by bystanders.

The back right passenger was transported by ambulance to the hospital. He sustained minor injuries and was treated and released. According to his medical records and the driver's interview, he sustained abrasions and contusions to his bilateral inner upper thighs—near his hips, most likely from the harness straps of his child safety seat.

Case Vehicle's Driver: Immediately prior to the crash the case vehicle's driver [31-year-old, White (non-Hispanic) female; 188 centimeters and 99 kilograms (74 inches, 219 pounds)] was seated in an upright posture with her back against the vehicle's seat back, her left foot on the floor, her right foot on the brake, and both hands bracing against the steering wheel's rim. Her seat track was located in its rearmost position, the vehicle's seat back was upright, and the tilt steering wheel was located between its center and upmost positions.

Based on this contractor's vehicle inspection, the case vehicle's driver (i.e., mother of back seat passengers) was restrained by her available, active, three-point, lap-and-shoulder, safety belt system; the belt system was equipped with a retractor-mounted pretensioner housed within the "B"-pillar. Furthermore, there was evidence of belt pattern bruising and/or abrasions to the driver's torso. Although the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no clear evidence of loading, the fact that the webbing had been cut post-crash indicates that the safety belt was used. The actuation of the seat belt pretensioner could not be assessed because the belt webbing was cut.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of her available safety belts, the driver most likely moved slightly forward just prior to impact. The case vehicle's primary impact with the Mack truck enabled the case vehicle's driver to continue forward and slightly leftward along a path opposite the case vehicle's **340** degree Direction of Principal Force as the case vehicle decelerated. As a result, this occupant loaded her safety belts and contacted her deploying driver air bag and knee bolster. As the case vehicle went up and over the engine compartment of the Mack truck, the case vehicle's roof was directly contacted and most likely pushed downward where it was contacted by the posterior portion of the driver's scalp. It is unclear exactly what contacted the case vehicle's roof but, in this contractor's opinion, it was most likely the hood of the Mack truck. After the case vehicle reached maximum engagement it was driven backwards by the weight of the Mack truck. The case vehicle also rotated approximately 90 degrees counterclockwise as it was redirected along its westerly path. As a result, this occupant moved rearward toward her seat back and to her left. At some time during its post-crash movement, the right rear of the case vehicle was impacted by the left and/or top sides of the Mack truck. As a result, this occupant most likely moved slightly to her right along a path opposite the **90** degree Direction of Principal Force. It is at this time that the blood was most likely deposited on the left side of the deployed front right passenger air bag's fabric. The driver's safety belts enabled this occupant to remain near her original pre-crash position. The case vehicle came to rest in the ditch on the south roadside, heading in a northerly direction. At final rest, the driver's posture is unknown but, according to her medical records, she was unconscious and was removed from the vehicle by the emergency medical technicians.

The driver was transported by helicopter to the hospital. She sustained a moderate injury and was treated and released. According to her medical records and her interview, the injuries she sustained included: a nonanatomic brain injury; a avulsion/laceration to her left parietal-occipital scalp; abrasions and contusions to her face; a laceration of her upper frenulum; contusions to her chest and lower abdomen; abrasions and contusions to her left shoulder; bilateral knee contusions, and a contusion to the bottom of her right foot.

Mack's Occupant: According to the Police Crash Report, the Mack's driver [34-year-old, Black (non-Hispanic) male] was not using his available, active, three-point, lap-and-shoulder, safety belt system. The driver was transported by ambulance to the county medical examiner's office after being declared "dead at the scene". He sustained police-reported "K" (fatal) injuries as a result of this crash. The case vehicle penetrated the cab area of the Mack truck, most likely striking the driver.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was a two-lane, undivided, county roadway, traversing in an east-west direction. The east-west roadway had one through lane in each direction (**Figures 1 and 2**). The county roadway was straight and level (i.e., there was a perceptible unmeasured slope positive to the east in the case vehicle's direction of travel (**Figure 1**); likewise, there was a perceptible unmeasured slope positive to the west in the Mack's direction of travel (**Figure 2**), and a minimal hill crest near the point of impact). On the other hand, the ditch in which both vehicles came to rest had a 4.9% grade negative to the south (i.e., a downgrade perpendicular to the case vehicle's direction of travel), near the area of impact. The pavement was bituminous, but traffic polished, and the width of the eastbound lane was 3.8 meters (12.5 feet) and the westbound lane was 3.3 meters (10.8 feet). The shoulders were essentially not improved [i.e., 0.10 to 0.15 meters (4-6 inches) of bituminous surface preceding the earthen area], and the roadway was not bordered by curbs. Pavement markings consisted of a single broken yellow centerline for both the east and westbound traffic, augmented by a single solid yellow "no passing" line for both the east westbound traffic prior to the minimal hill crest.

In addition, faded solid white edge lines were present. The estimated coefficient of friction was



Figure 1: Case vehicle's eastward travel path in eastbound lane; Note: level roadway with slight perceptible upgrade (case photo #01)



Figure 2: Mack truck's westward travel path in westbound lane; Note: truck's right tires went onto the north shoulder and level roadway with slight perceptible upgrade in westbound direction (case photo #12)

0.55. Traffic controls consisted of two diamond-shaped warning signs (one orange, one yellow), located on the north side of the roadway, positioned for westbound traffic. The orange sign could not be determined while the yellow sign warned of a four-leg intersection ahead. The statutory speed limit was 89 km.p.h. (55 m.p.h.). No regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was dark, the atmospheric condition was clear, and the road pavement was dry. Traffic density was light, and the site of the crash was primarily urban residential. In addition, there was a driveway within a short distance of the crash site; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle was traveling east in the eastbound lane (**Figure 1** above) and intended to proceed straight ahead. The Mack cement mixer had been traveling west in the westbound lane (**Figure 2** above) and intended to continue straight ahead. According to the Police Crash Report and the interview with the case vehicle's driver, the Mack's right wheels went off the north edge of the roadway. The Mack's driver steered the vehicle back to the left and fully onto the roadway, heading toward the eastbound lane. It appears the Mack's driver then steered the vehicle back to the right. As a result of the rightward steering maneuver, the Mack cement mixer rolled over onto its left side. The crash sequence was initiated in the eastbound lane of the roadway.

Crash: The left side of the Mack truck (i.e., specifically, the cement tank of the mixer) impacted the eastbound lane of the roadway (**Figure 3**) and began to slide along the eastbound lane in a west-southwesterly direction toward the south edge of the roadway. As the Mack truck was rolling over, its rear end rotated clockwise (**Figure 4**). As a result, the Mack truck was "heading" in a west-northwesterly orientation as it slid along the eastbound lane. The case vehicle's driver braked attempting to avoid the crash (**Figure 5** below). The case vehicle's involvement also occurred in the eastbound lane of the roadway.



Figure 3: On-scene view of Mack truck's westerly travel path across centerline before rolling over and depositing tire scuffs and scrapes in eastbound lane; Note: POI mark indicates area where Mack's cab struck pavement and final rest position on south roadside (case photo #13a)



Figure 4: Impact evidence (circle) on south edge of pavement from Mack truck's left rear as a result of truck's rollover in eastbound lane; Note: POI mark indicates cab's impact area (case photo #14)



Figure 5: Case vehicle's eastbound travel path at point of impact (blue arrow) with Mack truck which had rolled onto its left side (red arrows) and was sliding in a west-southwesterly direction (case photo #03)



Figure 6: Damage to case vehicle's front, both at and above bumper levels, as a result of vehicle's penetration over Mack truck's engine compartment and into cab area; Note: damage occurred to left side and most likely undercarriage as well (case photo #25)



Figure 7: Mack truck's damaged engine and cab areas, viewed from left of front, as a result of case vehicle's penetration impact while Mack was on its left side (case photo #110)



Figure 8: Case vehicle's point of impact (blue arrow) and post-crash travel path; Note: backward deflection path (red line) of rear tire skid mark (case photo #05)

The front (**Figure 6**) of the case vehicle impacted the front engine and cab section (**Figure 7**) of the Mack cement mixer, which was sliding on its left side, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy.

Post-Crash: As a result of the impact, the case vehicle was immediately driven rearward (**Figure 5** and **Figure 8**), in a west-southwesterly direction, off the south edge of the roadway, and into a shallow ditch on the south roadside (**Figure 9** below). The case vehicle also rotated approximately 90 degrees counterclockwise as it was redirected along its westerly path. At some time during its post-crash movement, the right rear of the case vehicle was impacted by the left and/or top sides of the Mack truck. The case vehicle came to rest in the ditch on the south roadside, heading in a northerly direction (**Figures 10** and **11** below). The Mack truck continued in a west-southwesterly direction, on its left side, after impacting the case vehicle. The Mack truck continued to rotate clockwise as it traveled westward (**Figure 12** below). This degree of

rotation was almost certainly increased by the negative slope of the roadside ditch into which it moved. An unknown part of the Mack truck impacted the right rear of the case vehicle during its westerly movement. The Mack truck came to rest on its left side in the southerly ditch (**Figure 13** below), also heading in a north-northeasterly direction at final rest (**Figure 9**).

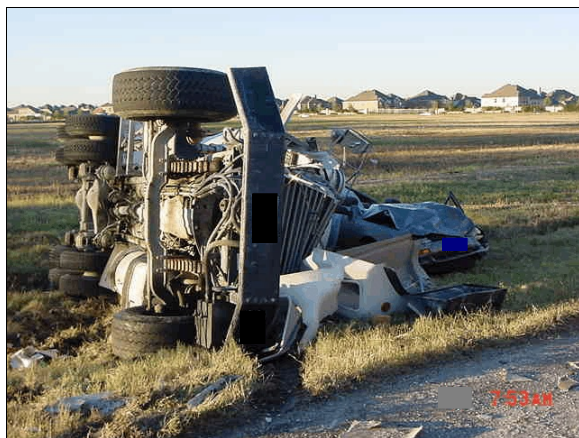


Figure 9: On-scene southwesterly view of final rest positions of Mack truck (on left side) and case vehicle on south roadside (case photo #06a)



Figure 10: On-scene southeasterly view of final rest positions of Mack truck (background) and case vehicle (foreground); Note: case vehicle's roof and been removed for extrication purposes (case photo #07)



Figure 11: On-scene northern view of final rest positions of case vehicle (left) and Mack truck (right); Note: case vehicle's roof removed for extrication purposes (case photo #08)

CASE VEHICLE

The 1996 Toyota Camry was a front wheel drive, five-passenger, four-door sedan (VIN: 4T1BG12K5TU-----) equipped with a 2.2L, I-4 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front disc and rear drum, four-wheel, anti-lock system. The case vehicle's wheelbase was 262 centimeters (103.1 inches), and the odometer reading at



Figure 12: On-scene view of Mack truck's west-southwesterly path on its left side, after rolling over; Note: Mack rotated clockwise as it slid into impact with case vehicle and toward final rest position on south roadside (case photo #15a)

inspection was 191,658 kilometers (119,091 miles).

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable back bench seat with integral head restraints for the back outboard seating positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the front and back outboard positions; and a two-point, lap belt system at the back center position. The front seat belt systems were equipped with manually operated, upper anchorage adjusters for the "D"-rings. Both the driver and front right passenger positions had their upper anchorage adjusters located in the upmost positions. The vehicle was equipped with knee bolsters for both the driver and front right seating positions. There was contact and deformation to the driver's knee bolster on both sides of the steering column. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver and front right passenger seating positions. Both frontal air bags deployed as a result of the case vehicle's frontal impact with the Mack truck.



Figure 13: On-scene northwesterly view of Mack truck's final rest position on south roadside (case photo #19)

CASE VEHICLE DAMAGE

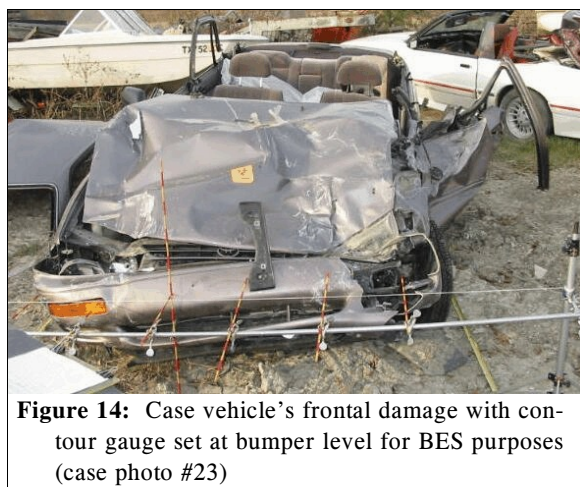


Figure 14: Case vehicle's frontal damage with contour gauge set at bumper level for BES purposes (case photo #23)

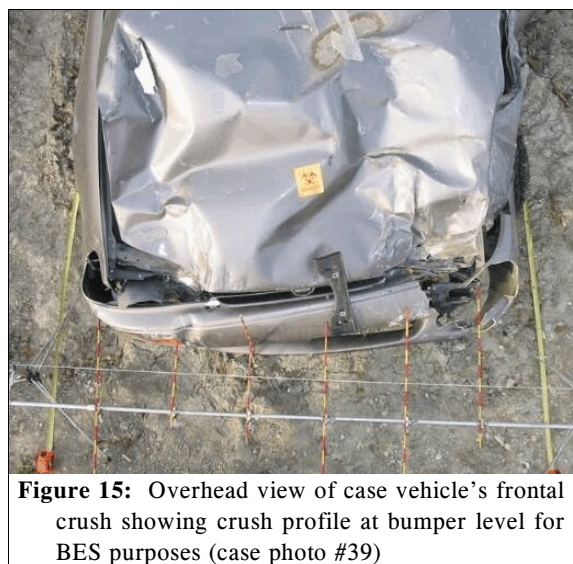


Figure 15: Overhead view of case vehicle's frontal crush showing crush profile at bumper level for BES purposes (case photo #39)

Exterior Damage: The case vehicle's initial contact with Mack truck involved the entire front end (**Figure 14**). Direct damage extended across the entire width of the front bumper, a measured distance 140 centimeters (55.1 inches). Undeformed end width was determined to be 162 centimeters (63.8 inches). Residual maximum crush was measured as 25 centimeters (9.8 inches) at C₂ (**Figure 15**). The table below shows the case vehicle's crush profile.

Units	Event	Direct Damage		Field L	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	2	140	25	140	13	25	21	14	4	0	0	0
in		55.1	9.8	55.1	5.1	9.8	8.3	5.5	1.6	0.0	0.0	0.0
cm	3	120	21	130	8	21	15	7	4	0	-178	-173
in		47.2	8.3	51.2	3.2	8.3	5.9	2.8	1.6	0.0	-70.1	-68.1



Figure 16: Case vehicle's front and left side damage viewed from front of left with roof, cut for extrication purposes, placed back on top of body (case photo #25a)

The wheelbase on the case vehicle's left side was shortened 12 centimeters (4.7 inches) while the right side was extended 7 centimeters (2.8 inches). The case vehicle's front bumper, bumper fascia, grille, radiator, hood, and right and left headlight and turn signal assemblies were directly damaged and crushed rearward (**Figure 6** above). Contact was also made to the left fender and left front door, both of which were crushed inward (**Figure 16**). Furthermore, there was direct damage to the front left portion of the roof, which was crushed downward (**Figure 17**). In addition, there was possible direct contact to the windshield; although, this is difficult to tell as the roof and all pillars were removed from the vehicle by rescue personnel.

The case vehicle's secondary contact with the Mack truck involved its right rear side. Direct damage began 15 centimeters (5.9 inches) forward of the right rear axle and extended a measured distance of 120 centimeters (47.2 inches), rearward to the left rear bumper corner (**Figure 18**). The Field L was determined to be 130 centimeters (51.2 inches). Residual maximum crush was



Figure 17: Case vehicle's roof, removed for extrication purposes, showing direct damage above driver's seating area most likely from contact with hood of Mack truck (case photo #23a)



Figure 18: Damage to case vehicle's right quarter panel (3rd event) from impact by unknown portion of Mack truck's left side during vehicle's counter-clockwise rotation to final rest (case photo #32)

measured as 21 centimeters (8.3 inches) at C₂ (**Figure 19**). The table above shows the case vehicle's crush profile. The case vehicle's right quarter panel, right rear taillight and turn signal assemblies, and right rear bumper fascia—including the portion extending just under the rear quarter panel, were directly damaged and crushed inward. There was induced damage to right front and rear turn signal assemblies as well as to the hood, roof, the windshield's glazing, and the right fender. All right and left side glazing as well as the backlite were disintegrated, but it is unclear if this resulted from the crash or occupant extrication.

The case vehicle manufacturer's recommended tire size was: P195/70R14, and the case vehicle tires were the recommended size. The case vehicle's tire data are shown in the table below.

Interior Damage: Inspection of the case vehicle's interior revealed contact on the left side (**Figure 20** below) of the driver's knee bolster and on the left lower instrument panel area. Furthermore, there was contact to the right (**Figure 21** below) side of the driver's knee bolster, just to the right of the steering column and possibly to the underneath side of the steering column as well as the left side of center instrument panel/center console. In addition, there was contact to the driver's sun visor and the left windshield header (**Figure 22** below). The vehicle's roof was intruded downward, but because of its removal, the intrusion could not be measured. Finally, there was no evidence of compression to the energy absorbing shear capsules in the steering column and no deformation to the steering wheel rim.



Figure 19: Overhead view of case vehicle's right side damage showing crush profile for BES purposes (case photo #34)

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	0	0	221	32	8	10	None	Yes	Yes
RF	0	0	221	32	8	10	None	No	Yes
LR	0	0	221	32	7	9	None	No	Yes
RR	179	26	221	32	7	9	None	No	No

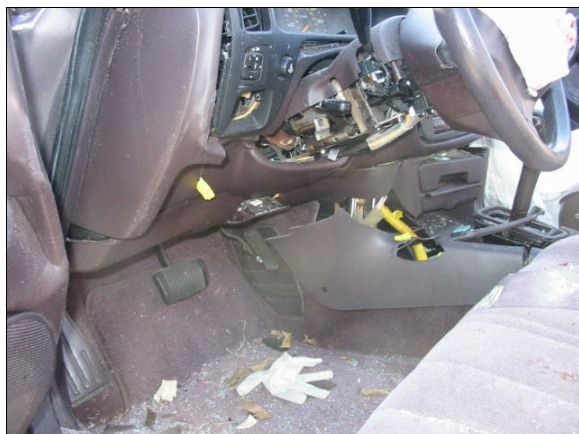


Figure 20: Case vehicle's driver seating area showing contact evidence on knee bolster and lower left instrument panel (case photo #56)

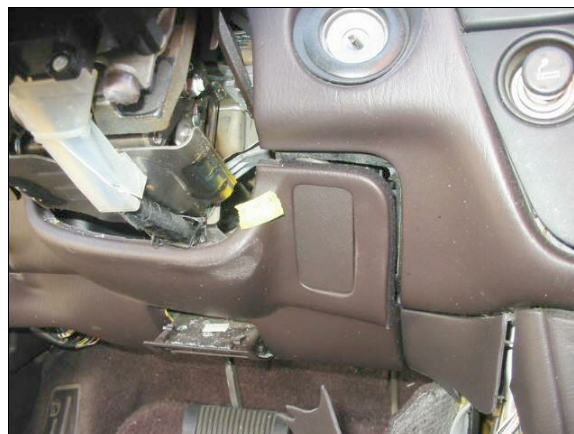


Figure 21: Close-up of contact evidence (i.e., scuff) on case vehicle's driver knee bolster, just right of steering column (case photo #58)

Damage Classification: Based on the vehicle inspection, the CDCs for the case vehicle were estimated to be: **11-FDEW-2 (340 degrees)** and **03-RZEW-2 (90 degrees)**. The WinSMASH reconstruction program is not applicable to the case vehicle's impacts because the Mack truck is not CDC applicable. However, for the purposes of establishing the Barrier Equivalent Speed (BES) that would have produced some of the observed damage on the case vehicle **and** for providing a course estimate of the Delta Vs that it actually sustained, the WinSMASH reconstruction program, barrier algorithm, was used on both the case vehicle's highest and second severity impacts. For the highest severity (i.e., frontal) impact, the Total, Longitudinal, and Lateral Delta Vs are, respectively: 23.0 m.p.h. (14.3 m.p.h.), -21.6 km.p.h. (-13.4 m.p.h.), and +7.9 km.p.h. (+4.9 m.p.h.). For the second highest severity (i.e., right side) impact, the Total, Longitudinal, and Lateral Delta Vs are, respectively: 10.0 km.p.h. (6.2 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and -10.0 km.p.h. (-6.2 m.p.h.). While it must be kept in mind that these values are only estimates of the actual velocity exchange that the case vehicle sustained, it should be remembered that: (1) the case vehicle collided with a relatively "soft" spot on the cement mixer (i.e., the driver's cab area), and (2) the case vehicle's initial impact was of an elongated duration because the case vehicle overrode the Mack truck's engine compartment prior to penetrating the cab area. The case vehicle most likely sustained undercarriage damage as it overrode the engine area, and the contact to its roof (Figures 16 and 17 above) and left side areas most likely resulted from contacting the crumpling hood of the Mack truck. Once the case vehicle reach maximum engagement (i.e., in the Mack truck's cab area), it was pushed rearward forcefully by the weight of the Mack truck (Figure 8 above). Overall, this contractor's visually estimated Delta V for the frontal impact is between 19 km.p.h. (12 m.p.h.) and 32 km.p.h. (20 m.p.h.). The case vehicle was towed due to damage.



Figure 22: Overhead view of interior surface of case vehicle's roof showing contact evidence on driver's sun visor and roof's windshield header (case photo #62)

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal air bags at the driver and front right passenger positions. Both frontal air bags deployed as a result of the frontal impact with the Mack truck (**Figures 23** and **24**). The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical "H"-configuration cover flaps made of thick vinyl with overall dimensions of 15 centimeters (5.9 inches) at the horizontal seam and 6 centimeters (2.4 inches) vertically for the upper flap and 7 centimeters (2.8 inches) vertically for the lower flap. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with four tethers, each approximately 6.5 centimeters (2.6 inches) in width. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 1:30 and 10:30 clock positions. The deployed driver's air bag was round with a diameter of 66 centimeters (26.0 inches). The distance between the mid-center of the driver's seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 25 centimeters (9.8 inches). An inspection of the driver's air bag fabric revealed a large amount of blood on the front surface of the air bag's fabric (**Figure 25**), most notably in the upper left and lower right quadrants. In addition, blood also liberally covered the lower half of the air bag's back surface (**Figure 26** below). The blood most likely came from an avulsion/laceration on the left posterior surface of the driver's scalp.

The front right passenger's air bag was located in the top of the instrument panel. There was a single, essentially rectangular, modular cover flap. The cover flap was made of a thick semi-pliable vinyl, thicker than the vinyl on the



Figure 23: Elevated view of case vehicle's driver seating area showing deployed driver air bag (case photo #43)



Figure 24: Elevated view of case vehicle's front right seating area showing deployed front right air bag (case photo #45)

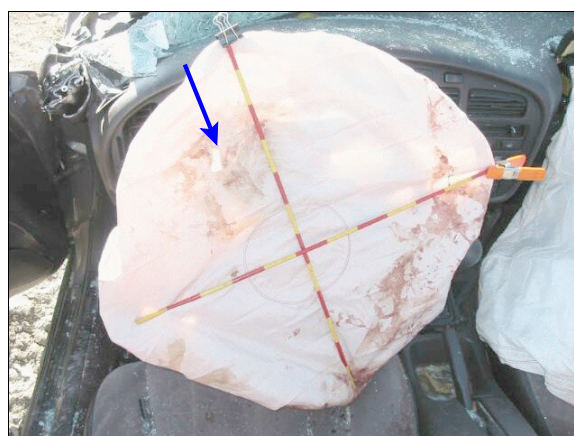


Figure 25: Case vehicle's deployed driver air bag showing copious blood evidence on air bag's front surface; Note: hole (arrow) in upper left quadrant toward 11 o'clock position (case photo #50)

driver's module. The flap's dimensions were 36 centimeters (14.2 inches) at the lower horizontal seam and 17 centimeters (6.7 inches) along both vertical seams. The profile of the case vehicle's instrument panel was flush with the leading edge of the cover flap. An inspection of the front right air bag module's cover flap and the air bag's fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 4 centimeters (1.6 inches) in diameter, located at the 3 and 9 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 80 centimeters (31.5 inches) and a width of approximately 53 centimeters (20.9 inches). There was no distance (i.e., touched seat back) between the mid-center of the front right seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion. An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the front surface of the front right air bag's fabric (**Figure 27**). However, there was a blood spot on the left side surface (**Figure 28**), most likely a splatter spot from the case vehicle's driver.

BOOSTER CHILD SAFETY SEAT

The back left passenger was seated in a belt positioning booster child safety seat (**Figure 29** below). The seat was manufactured by Graco Children's Products, on May 21, 2003. The seat was a Turbo booster, and the model number was **8491RGB** (**Figure 30** below). In this crash the seat was used in a "backless" configuration. The booster seat was designed with two armrests, under which the vehicle's seat belt was positioned across the lower abdomen of the child.

The case vehicle's inspection revealed that the latch plate for this seating position's safety belt



Figure 26: Case vehicle's deployed driver air bag showing copious blood stains on back lower half (case photo #53)



Figure 27: Elevated view of front surface of case vehicle's deployed front right air bag showing no evidence of occupant contact (case photo #65)



Figure 28: Left side surface—relative to the front right seating position, of case vehicle's deployed front right air bag, showing blood (arrow) on surface near vent port, most likely from driver (case photo #66)

was the “sliding” type, and the safety belt system had a switchable retractor. The case vehicle’s driver indicated that her husband had read the child seat’s instruction manual but not the vehicle’s manual on installation of a child safety seat using the vehicle’s seat belts. However, the driver claimed that there was familiarity with the safety belt-child seat installation process. The driver indicated that she had placed the child in the seat prior to the crash. The driver does not recall doing anything to lock the vehicle’s seat belt while securing the child.

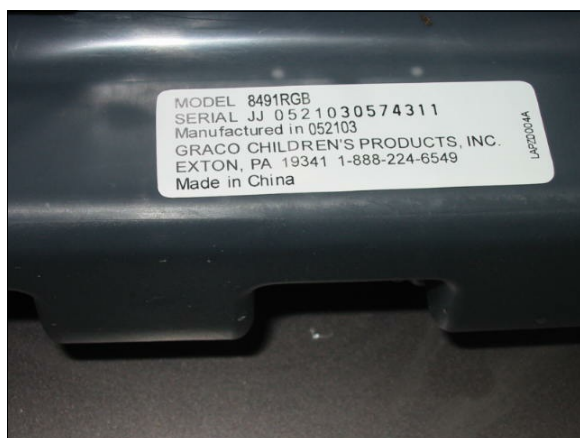


Figure 30: Label containing model and serial number for Graco child booster seat used by case vehicle’s back left passenger (case photo #105)

The booster child safety seat was made of hard plastic, covered with soft, removable, padding. Based on inspection and the statement of the case vehicle’s driver, booster child safety seat did not show any areas of stress to the plastic seat, arm rest, or belt positioning areas (e.g., scuff marks and stress fractures) and very little wear and tear to the cloth cover or padding. There was a large manufacturer’s label affixed to the bottom of the seat (**Figure 31**) giving the child seat’s height and weight limitations [i.e., with back support—approximately 96 to 145 centimeters and 13.6 to 45 kilograms (38 and 57 inches and 30 and 100 pounds); without back support—approximately 101 to 145 centimeters and 18 to 45 kilograms (40 and 57 inches and 30 and 100 pounds)]. This label was not dated. Other warning labels were



Figure 29: Front of Graco child booster seat used by case vehicle’s back left passenger; Note: seat cushion (i.e., blue on black) folds upward providing “limited” back support for specific children (case photo #99)

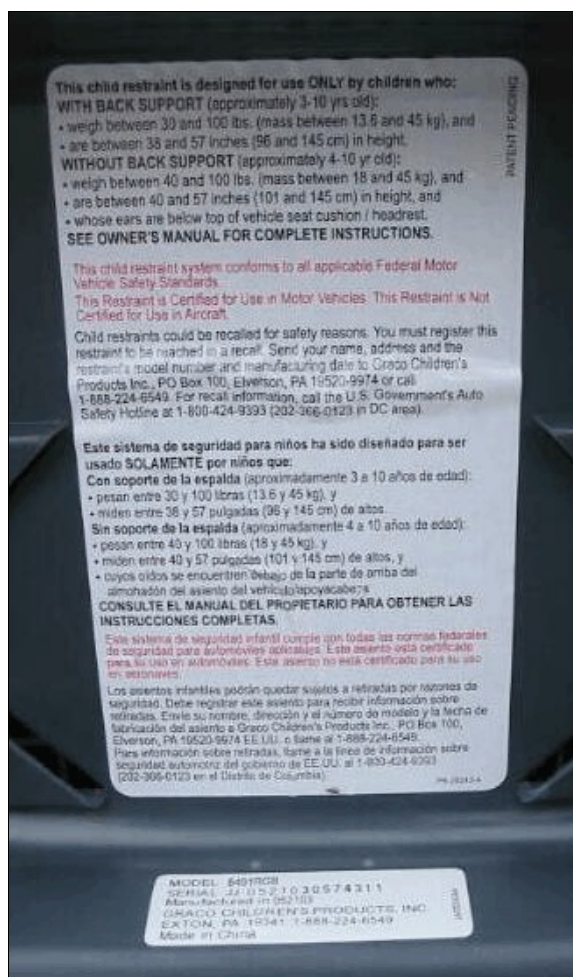


Figure 31: Close-up of instruction label on back side of Graco booster seat used by case vehicle’s back left passenger (case photo #104)

sewn onto the base, one in English and one in Spanish, advising against use in the front seat. A final manufacturer's label was affixed to the right rear side of the base, with schematics depicting where the vehicle's belt should be placed (**Figure 32**).

CONVERTIBLE CHILD SAFETY SEAT



Figure 34: Left side label containing model number and date of manufacture for case vehicle's convertible child safety seat used in rear-facing configuration by back right passenger; Note: instructions for placement of safety belt (case photo #92)

The back right passenger was seated in a convertible child safety seat that was used in its rear-facing configuration at the time of the crash (**Figure 33**). The child safety seat was manufactured by Dorel on September 7, 2003 and was identified by model name "*Touriva*" and model number **22-110-WAL** (**Figure 34**). The convertible seat was designed with a five-point harness, with two straps located above the shoulders, two at the hips, and one between the child's legs. The straps were clipped into the non-recessed buckle at the top of the crotch strap (**Figure 35**). The seat was also equipped with a top tether and lower anchor attachments for use with a LATCH system (**Figures 36 and 37** below). There were three sets of slots to thread the two shoulder harness straps through. The harness straps were threaded through the middle slots (**Figure 33**), which according to the manufacturer's instructions should only be used



Figure 32: Right side of Graco child booster seat used by case vehicle's back left passenger showing warning label, instructions for securing seat with vehicle's safety belts, and red positioning device for placement of actual seat belt (case photo #102)



Figure 33: Front of Dorel Touriva convertible child seat used in rear-facing configuration by case vehicle's back right passenger (case photo #80)



Figure 35: Close-up of five-point, harness system (i.e., fastened) from case vehicle's convertible child safety seat, used in rear-facing configuration by back right passenger (case photo #81)

when the seat is in the rear-facing configuration. The child seat was positioned in a slightly reclined position.

The back right passenger was seated in a convertible child safety seat that was used in its rear-facing configuration at the time of the crash (Figure 33 above). The child safety seat was manufactured by Dorel on September 7, 2003 and



Figure 37: Close-up of manufacturer's label on left side of case vehicle's convertible child safety seat used in rear-facing configuration by back right passenger showing proper method for securing seat's LATCH attachments to vehicle while in rear-facing configuration (case photo #93)



Figure 36: Back surface of case vehicle's Dorel Touriva convertible child safety seat, used in its rear-facing configuration by back right passenger, showing both upper (forward-facing-blue arrow) and lower (rear-facing-red arrow) LATCH attachments and location of instruction booklet (case photo #86)

was identified by model name "*Touriva*" and model number **22-110-WAL** (Figure 34 above). The convertible seat was designed with a five-point harness, with two straps located above the shoulders, two at the hips, and one between the child's legs. The straps were clipped into the non-recessed buckle at the top of the crotch strap (Figure 35 above). The seat was also equipped with a top tether and lower anchor attachments for use with a LATCH system (Figures 36 and 37). There were three sets of slots to thread the two shoulder harness straps through. The harness straps were threaded through the middle slots (Figure 33 above), which according to the manufacturer's instructions should only be used when the seat is in the rear-facing configuration. The child seat was positioned in a slightly reclined position.

The convertible child safety seat consisted of a one-piece plastic shell. The shell had cloth covered foam padding on the back support and the seating portion. The case vehicle's inspection revealed that the latch plate for this seating position's safety belt was the "sliding" type, and the safety belt system had a switchable retractor. The case vehicle's driver indicated that her husband

had read the child seat's instruction manual but not the vehicle's manual on installation of a child safety seat using the vehicle's seat belts. However, the driver claimed that there was familiarity with the safety belt-child seat installation process. The driver indicated that she had installed the child seat and had placed the child in the seat prior to the crash. The driver does not recall doing anything to lock the vehicle's seat belt while securing the child restraint. Based on the vehicle inspection and the driver's interview, the safety belt was in **Emergency Locking Retractor (ELR)** mode [i.e., versus the **Automatic Locking Retractor (ALR)** mode]. The driver indicated that the child seat was "tight" and that no "locking clip" was used on this passenger's safety belt.

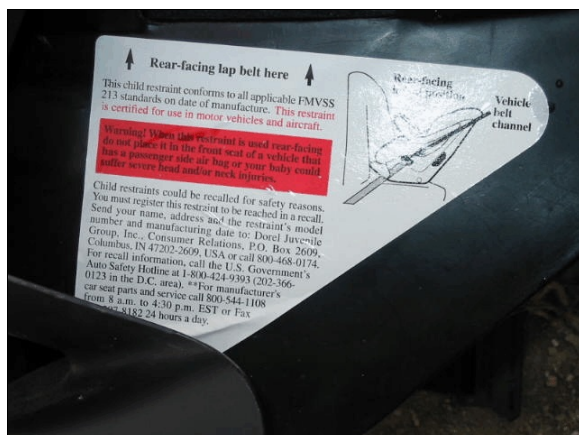


Figure 39: Close-up of manufacturer's label on left side of case vehicle's convertible child safety seat used by back right passenger showing location for correct placement of vehicle's safety belts when seat used in rear-facing configuration and warning (red background) against use of seat in front right position (case photo #91)

A close inspection of the child safety seat revealed no apparent damage or fractures to the base or shell (**Figure 36** above and **Figure 38**). There were manufacturer's warning and instruction labels on the left side (i.e., outboard side when used in the rear-facing configuration), warning the user/parent not to place this child seat in a vehicle's front right seat when the vehicle is equipped with a front right passenger air bag and where to position the vehicle's seat belts for the rear-facing configuration (**Figure 39**). There was



Figure 38: Right side of case vehicle's convertible child safety seat used by back right passenger in rear-facing configuration showing applicable manufacturer's labels (case photo #90)

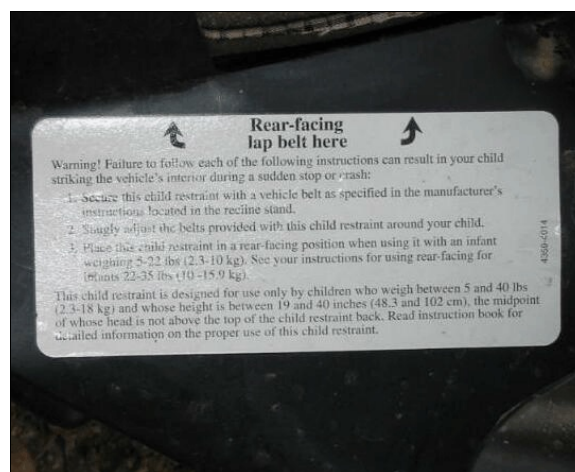


Figure 40: Close-up of manufacturer's label on right side of case vehicle's convertible child safety seat used in rear-facing configuration by back right passenger showing proper location for securing vehicle's safety belts and applicable height and weight limitations for both rear-facing and forward-facing configurations (case photo #97)

a manufacturer's label affixed to the right side (i.e., inboard side when used in the rear-facing configuration) giving the child seat's weight limitations (**Figure 40** above) for both the rear-facing configuration [i.e., for both smaller infants–2.3 to 10 kilograms (5 to 22 pounds) and larger infants–10 to 15.9 kilograms (22 to 35 pounds)] **and** the forward-facing configuration [i.e., 10-18 kilograms (22-40 pounds)]. Furthermore, this label provided the overall height limitations for the seat [i.e., 48.3 to 102 centimeters (19 to 40 inches)]. In addition, this label (**Figure 40** above) explained the importance of securing the child restraint with a vehicle's safety belt as specified in the vehicle manufacturer's instructions. The manufacturer's instructions for this child safety seat were available on the back of the seat at the time of this contractor's inspection (**Figure 36** above).

Both sides had labels that illustrated the proper way to install the vehicle's safety belts when the child safety seat was used in either the rear-facing configuration or the forward-facing configuration. None of the labels had any dates that were visible.

CASE VEHICLE BACK LEFT PASSENGER KINEMATICS

Immediately prior to the crash the case vehicle's back left passenger [3-year-old, White (non-Hispanic) male; 107 centimeters and 20 kilograms (42 inches and 44 pounds)] was seated in a seat belt-positioning, booster child safety seat in an upright position with his back against the vehicle's seat back and his feet dangling over the front edge of vehicle's seat cushion, angled downward. In addition, the exact position of his hands is unknown. There was no seat track, and the vehicle's seat back was not adjustable.

Based on this contractor's vehicle inspection and the driver's interview, the case vehicle's back left passenger was restrained by his available, active, three-point, lap-and-shoulder, safety belt system in conjunction with his belt-positioning booster seat. Furthermore, there was ample evidence of belt pattern bruising and/or abrasions to the back left passenger's torso and a fracture to his left clavicle. Although the inspection of the back left passenger's seat belt webbing, "D"-ring, and latch plate showed no clear evidence of loading, the fact that the webbing had been cut post-crash is a good indicator that the safety belt was used (**Figure 41**). Finally, the booster seat containing the back left passenger was turned/twisted leftward at final rest.



Figure 41: Webbing of case vehicle's back left safety belt showing extrication cuts (case photo #71)

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of the back left passenger's available safety belts in conjunction with his seat belt-positioning booster seat, the back left passenger most likely moved slightly forward just prior to impact. The case vehicle's primary impact with the Mack truck enabled the case vehicle's back left passenger to continue forward and slightly leftward along a path opposite the case vehicle's 340 degree Direction of Principal Force as the case vehicle decelerated. As a

result, this occupant loaded his safety belts, abrading, contusing, and fracturing his left clavicle and abrading and contusing his bilateral upper thighs. After the case vehicle reached maximum engagement it was driven backwards by the weight of the Mack truck. The case vehicle also rotated approximately 90 degrees counterclockwise as it was redirected along its westerly path. As a result, this occupant moved rearward toward his seat back and to his left. At some time during its post-crash movement, the right rear of the case vehicle was impacted by the left and/or top sides of the Mack truck. As a result, this occupant most likely moved slightly to his right toward the 90 degree Direction of Principal Force. Once again, his restraints enabled this occupant to remain near his original pre-crash position. The case vehicle came to rest in the ditch on the south roadside, heading in a northerly direction. At final rest, the back left passenger's posture is unknown, but he was conscious and, according to his medical records, was removed from the vehicle by bystanders.

CASE VEHICLE BACK LEFT PASSENGER INJURIES

The back left passenger was transported by ambulance to the hospital. He sustained a moderate injury and was treated and released. According to his medical records and the driver's interview, he sustained a fractured left clavicle, and abrasions and contusions to his left clavicular area and bilateral anterior upper thighs—near his hips. All of these injuries were attributed to the vehicle's safety belts which restrained this occupant.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Fracture left clavicle, not further specified	moderate 752200.2,2	Torso portion of safety belt system	Certain	Emergency room records
2	Abrasion, small, left shoulder, over clavicle	minor 790202.1,2	Torso portion of safety belt system	Certain	Emergency room records
3	Contusion left shoulder, presumably over left clavicle	minor 790402.1,2	Torso portion of safety belt system	Certain	Emergency room records
4	Abrasions, small, bilateral anterior thighs at the hips	minor 890202.1,3	Lap portion of safety belt system	Certain	Emergency room records
5	Contusions, minor, bilateral upper thighs	minor 890402.1,3	Lap portion of safety belt system	Certain	Interviewee (driver)

CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS

The case vehicle's back right passenger [8-month-old, White (non-Hispanic) male; 64 centimeters and 12 kilograms (25 inches, 26 pounds)] was seated in a convertible child safety seat, positioned in its rear-facing configuration in a reclined position with his back against the child seat's seat back and his feet most likely within the seat's structure. In addition, the exact position of his hands is unknown. There was no seat track, and the vehicle's seat back was not adjustable.

Based on this contractor's vehicle inspection and the driver's interview, the case vehicle's back right passenger was restrained by his child safety seat's five-point harness system, which was secured by his available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, according to the interview with the case vehicle's driver, there was evidence of belt pattern bruising and/or abrasions to the back right passenger's inner thighs from his harness straps. Although the inspection of the back right passenger's seat belt webbing, "D"-ring, and latch plate showed no clear evidence of loading, the fact that the webbing had been cut post-crash is a good indicator that the safety belt was used (**Figure 42**).



Figure 42: Webbing of case vehicle's back right safety belt showing extrication cuts (case photo #71a)

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of the back right passenger's available safety belts in conjunction with his rear-facing child safety seat, the back right passenger most likely moved slightly forward (i.e., his back moving toward the front of the vehicle) just prior to impact. The case vehicle's primary impact with the Mack truck enabled the case vehicle's back right passenger to continue forward and slightly leftward along a path opposite the case vehicle's **340** degree Direction of Principal Force as the case vehicle decelerated. As a result, this occupant loaded the back of his child safety seat. After the case vehicle reached maximum engagement it was driven backwards by the weight of the Mack truck. The case vehicle also rotated approximately 90 degrees counterclockwise as it was redirected along its westerly path. As a result, this occupant moved rearward toward his seat back and to his left. During this rearward movement, this occupant most likely injured his inner thigh areas. At some time during its post-crash movement, the right rear of the case vehicle was impacted by the left and/or top sides of the Mack truck. As a result, this occupant most likely moved slightly to his right toward the **90** degree Direction of Principal Force. Once again, his harness straps in conjunction with the vehicle's safety belts enabled this occupant to remain near his original pre-crash position. The case vehicle came to rest in the ditch on the south roadside, heading in a northerly direction. At final rest, the back right passenger's posture is unknown, but he was conscious and, according to his medical records, was removed from the vehicle by bystanders.

CASE VEHICLE BACK RIGHT PASSENGER INJURIES

The back right passenger was transported by ambulance to the hospital. He sustained minor injuries and was treated and released. According to his medical records and the driver's interview, he sustained abrasions and contusions to his bilateral inner upper thighs—near his hips, most likely from the harness straps of his child safety seat.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasions, 5.0 cm (2 in), bilateral inner thighs	minor 890202.1,3	Child safety seat harness straps	Probable	Interviewee (driver)
2	Contusions, 5.0 cm (2 in), bilateral inner thighs	minor 890402.1,3	Child safety seat harness straps	Probable	Interviewee (driver)

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [31-year-old, White (non-Hispanic) female; 188 centimeters and 99 kilograms (74 inches, 219 pounds)] was seated in an upright posture with her back against the vehicle's seat back, her left foot on the floor, her right foot on the brake, and both hands bracing against the steering wheel's rim. Her seat track was located in its rearmost position, the vehicle's seat back was upright, and the tilt steering wheel was located between its center and upmost positions.

Based on this contractor's vehicle inspection, the case vehicle's driver (i.e., mother of back seat passengers) was restrained by her available, active, three-point, lap-and-shoulder, safety belt system; the belt system was equipped with a retractor-mounted pretensioner housed within the "B"-pillar. Furthermore, there was evidence of belt pattern bruising and/or abrasions to the driver's torso. Although the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no clear evidence of loading, the fact that the webbing had been cut post-crash indicates that the safety belt was used (**Figure 43**). The actuation of the seat belt pretensioner could not be assessed because the belt webbing was cut.



Figure 43: Webbing of case vehicle's driver safety belt showing extrication cuts (case photo #60)

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of her available safety belts, the driver most likely moved slightly forward just prior to impact. The case vehicle's primary impact with the Mack truck enabled the case vehicle's driver to continue forward and slightly leftward along a path opposite the case vehicle's 340 degree Direction of Principal Force as the case vehicle decelerated. As a result, this occupant loaded her safety belts and contacted her deploying driver air bag and the knee bolster. As the case vehicle went up and over the engine compartment of the Mack truck, the case vehicle's

roof was directly contacted and most likely pushed downward where it was contacted by the posterior portion of the driver's scalp. It is unclear exactly what contacted the case vehicle's roof but, in this contractor's opinion, it was most likely the hood of the Mack truck. After the case vehicle reached maximum engagement it was driven backwards by the weight of the Mack truck. The case vehicle also rotated approximately 90 degrees counterclockwise as it was redirected along its westerly path. As a result, this occupant moved rearward toward her seat back and to her left. At some time during its post-crash movement, the right rear of the case vehicle was impacted by the left and/or top sides of the Mack truck. As a result, this occupant most likely moved slightly to her right toward the 90 degree Direction of Principal Force. It is at this time that the blood was most likely deposited on the left side of the deployed front right passenger air bag's fabric. The driver's safety belts enabled this occupant to remain near her original pre-crash position. The case vehicle came to rest in the ditch on the south roadside, heading in a northerly direction. At final rest, the driver's posture is unknown but, according to her medical records, she was unconscious and was removed from the vehicle by the emergency medical technicians.

CASE VEHICLE DRIVER INJURIES

The driver was transported by helicopter to the hospital. She sustained a moderate injury and was treated and released. According to her medical records and her interview, the injuries she sustained included: a nonanatomic brain injury; a avulsion/laceration to her left parietal-occipital scalp; abrasions and contusions to her face; a laceration of her upper frenulum; contusions to her chest and lower abdomen; abrasions and contusions to her left shoulder; bilateral knee contusions, and a contusion to the bottom of her right foot.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury (amnesic to events) with loss of consciousness prior to arrival	moderate 160410.2,0	Left roof side rail	Probable	Emergency room records
2	Avulsion/laceration, 4 cm (1.6 in), left parietal-occipital scalp	minor 190802.1,6	Left roof side rail	Probable	Emergency room records
3	Abrasions, multiple, to face, not further specified, including one on left side of mouth	minor 290202.1,0	Air bag, driver's	Certain	Emergency room records
4	Contusion {ecchymosis}, 12.7 cm (5 in) right side of face under right eye	minor 290402.1,1	Air bag, driver's and eyewear	Probable	Emergency room records
5	Laceration upper frenulum of mouth	minor 243099.1,8	Steering wheel rim	Possible	Emergency room records
6	Contusion {bruise} right breast	minor 490402.1,1	Air bag, driver's	Possible	Emergency room records
7	Contusion central chest, not further specified	minor 490402.1,4	Torso portion of safety belt system	Probable	Interviewee (same person)

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
8	Contusion across lower abdomen, not further specified	minor 590402.1,8	Lap portion of safety belt system	Probable	Interviewee (same person)
9	Abrasions, multiple, left shoulder	minor 790202.1,2	Torso portion of safety belt system	Certain	Emergency room records
10	Contusion left shoulder, not further specified	minor 790402.1,2	Torso portion of safety belt system	Probable	Interviewee (same person)
11	Contusion right knee with swelling, not further specified	minor 890402.1,1	Knee bolster, driver's	Certain	Emergency room records
12	Contusion {bruise} left knee, not further specified	minor 890402.1,2	Knee bolster, driver's, left of steering column	Certain	Interviewee (same person)
13	Contusion {bruise} 2.5 cm (1 in) bottom of right foot	minor 890402.1,1	Foot controls	Probable	Interviewee (same person)

OTHER VEHICLE

Based on the VIN and manufacturer's specifications, the 2000 Mack DM-690S was a four wheel drive (6x4), two-passenger, incomplete straight truck, with an offset two-door cab, configured with a cement mixer body (VIN: 1M2B221C7YM-----). Standard equipment was an E7-350 engine and a Mack six-speed manual transmission with overdrive and triple counter shaft. Braking was achieved by a power-assisted, dual air brake system. The Mack's wheelbase was 511 centimeters (201 inches), and the odometer reading is unknown because the Mack's interior was not inspected. The Mack truck was not equipped with any supplemental restraint systems.



Figure 44: Mack truck's damaged front viewed from right of front; Note: truck was sliding along on its left side when case vehicle struck and overrode engine compartment, penetrating into cab area (case photo #116)



Figure 45: Mack truck's damaged cab area, viewed from back of left; Note: front of case vehicle penetrated into truck's cab while Mack was sliding along on its left side (case photo #113)

Damage Classification: Based on the available photographs, the TDCs for the Mack truck are estimated as: **00-LDAO-99** for the initial rollover impact, **00-FDHW-7** for the primary impact with the case vehicle (i.e., the Mack truck was on its left side at the time of this impact—**Figures 44 and 45** above), and **00-9999-99** for its impact with the case vehicle’s left quarter panel. Based on the available information, the Mack's speed prior to the crash is unknown, but the legal speed limit was 89 km.p.h. (55 m.p.h.). The Mack was towed due to damage.

Mack’s Occupant: According to the Police Crash Report, the Mack’s driver [34-year-old, Black (non-Hispanic) male] was not using his available, active, three-point, lap-and-shoulder, safety belt system. The driver was transported by ambulance to the county medical examiner’s office after being declared “dead at the scene”. He sustained police-reported “K” (fatal) injuries as a result of this crash. The case vehicle penetrated the cab area of the Mack truck, most likely striking the driver.

