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ON-SITE CHILD AIR BAG-RELATED FATALITY INVESTIGATION

CASE NUMBER - IN98-027
LOCATION - ARKANSAS
VEHICLE - 1995 TOYOTA COROLLA DX
CRASH DATE - September, 1998

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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> This report covers an on-site investigation of an air bag deployment crash that involved a 1995 Toyota Corolla DX (case vehicle) and a 1990 Freightliner, truck-tractor with Fruehauf trailer (other vehicle). This crash is of special interest because the case vehicle's restrained, but unsecured, front right passenger (19-month-old female) who was in a forward facing child safety seat, sustained a critical injury from the deploying front right passenger air bag, resulting in her death. The case vehicle was traveling northeast in the northeastbound lane of a two-lane, undivided, state highway. The tractor-trailer was stopped with the tractor (power unit) facing southwest in the southwestbound lane of the same two-lane roadway and was in the process of backing the semi-trailer (animal trailer) into a commercial driveway. The semi-trailer was obliquely oriented directly across the northeastbound travel lane of the roadway. The crash occurred in the northeastbound lane of the Tee-shaped junction of the state roadway and the driveway. The front left corner of the case vehicle impacted the left dolly wheel attached to the undercarriage of the semi-trailer. The case vehicle's front left narrow end engagement extended down the left side before snagging on the left front wheel rim. The snagging action to the left front wheel caused the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle rotated approximately 45 degrees counterclockwise post-impact and came to rest in contact with the tractor-trailer, heading northward. The front right passenger was seated slightly reclined in a forward facing child safety seat, and the front right seat track was located in its middle position. She was restrained in the child seat by its shoulder harness and "T"-shield, but the child safety seat was not secured by the available, active, three-point, lap-and-shoulder, safety belt system. She sustained, according to her available medical records, critical injuries which included: a critical nonanatomic brain injury, a cervical fracture {obvious} at the C ₅ -C ₇ level with severance of the spinal cord, and a contusion {bruising, hematoma} with swelling on her lateral neck {unknown aspect}. The driver (21-year-old female) was seated with her seat track located between its middle and rearmost positions, and the tilt steering wheel was located between its middle and down-most positions. The driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. She sustained, according to her interview, minor injuries which included: a contusion on her temple (aspect unknown), an abrasion to her chin, and a contusion and laceration to her right knee.					
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TABLE OF CONTENTS

IN98-027

Page No.

BACKGROUND 1

SUMMARY 1

CRASH CIRCUMSTANCES 5

CASE VEHICLE: 1995 TOYOTA COROLLA DX 6

 CASE VEHICLE DAMAGE 7

 AUTOMATIC RESTRAINT SYSTEM 8

 CHILD SAFETY SEAT 10

 CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS 12

 CASE VEHICLE FRONT RIGHT PASSENGER INJURIES 13

 CASE VEHICLE DRIVER KINEMATICS 14

 CASE VEHICLE DRIVER INJURIES 15

OTHER VEHICLE: 1990 FREIGHTLINER 6X4 TRUCK-TRACTOR WITH SEMI-TRAILER 15

CRASH DIAGRAM 16

SELECTED PHOTOGRAPHS

 Figure 1: Southwestward view of case vehicle’s northeastbound travel path 5

 Figure 2: Case vehicle’s northeastward travel path just prior to impact 5

 Figure 3: On-scene view of case vehicle at final rest 5

 Figure 4: On-scene view of case vehicle’s impact with dolly wheels of
 Fruehauf semi-trailer 6

 Figure 5: Case vehicle’s very narrow frontal impact viewed from left
 of front 6

 Figure 6: Case vehicle’s very narrow frontal impact viewed down left side 6

 Figure 7: Case vehicle’s left fender and left front wheel damage 7

 Figure 8: On-scene view looking southwest in northeastbound lane of case
 vehicle’s and Fruehauf trailer’s final rest positions 7

 Figure 9: Case vehicle’s very narrow front left damaged viewed from right
 of front 7

 Figure 10: Case vehicle’s deployed driver air bag and driver’s greenhouse
 area 8

	<u>Page No.</u>
SELECTED PHOTOGRAPHS (Continued)	
Figure 11: Close-up of scuffing to case vehicle's right "A"-pillar	8
Figure 12: Case vehicle's deployed driver air bag	9
Figure 13: Close-up of evidence of left side of case vehicle's front right air bag module's cover flap	9
Figure 14: Case vehicle's deformed front right passenger air bag module's cover flap	9
Figure 15: Case vehicle's deployed front right passenger air bag	10
Figure 16: Front of forward facing child safety seat that was unsecured in case vehicle's front right seating position	10
Figure 17: Close-up of backside of forward facing child safety seat unsecured in case vehicle's front right seating position	11
Figure 18: Close-up of right side of forward facing child safety seat unsecured in case vehicle's front right seating position	11
Figure 19: On-scene view showing case vehicle's child safety seat not secured by safety belt system	12

This on-site investigation was brought to NHTSA's attention on October 29, 1998 by an attorney representing the family of the deceased front right passenger. This crash involved a 1995 Toyota Corolla DX (case vehicle) and a 1990 Freightliner, truck-tractor with Fruehauf trailer (other vehicle). The crash occurred in September 1998, at 10:50 p.m., in Arkansas and was investigated by the state police department. This crash is of special interest because the case vehicle's restrained, but unsecured, front right passenger [nineteen-month-old, White (non-Hispanic) female] who was in a forward facing child safety seat, sustained a critical injury from the deploying front right passenger air bag, resulting in her death. This contractor inspected the scene and case vehicle on 5-6 November, 1998. This contractor interviewed the driver for the case vehicle on July 27, 1999. This report is based on the Police Crash Report; interviews with the investigating police officer, a first responder, and the case vehicle's driver; scene and vehicle inspections; occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle had just crested a hill and was traveling northeast in the northeastbound lane of a two-lane, undivided, state highway. The rural roadway section was not illuminated at night time, and the case vehicle intended to continue in its northeastward path of travel. The tractor-trailer was stopped with the tractor (power unit) facing southwest in the southwestbound lane of the same two-lane, undivided, state roadway and was in the process of backing the semi-trailer (animal trailer) into a commercial driveway. The semi-trailer was obliquely oriented directly across the northeastbound travel lane of the roadway. The case vehicle's driver did not immediately observe the tractor-trailer blocking the roadway until she was approximately 20 meters (66 feet) from impact. The tractor-trailer's driver flashed his headlights and began activating his horn, hoping to alert the case vehicle's driver to the presence of his trailer blocking the roadway. Immediately prior to the crash, the case vehicle's driver steered slight to the right and braked, leaving 8.8 meters (29 feet) of superimposed skid marks just prior to impact. The crash occurred in the northeastbound lane of the Tee-shaped junction of the state roadway and the commercial driveway.

The front left corner of the case vehicle impacted the left dolly wheel attached to the undercarriage of the truck-tractor's semi-trailer. The case vehicle's front left narrow end engagement extended down the left side before snagging on the left front wheel rim. The case vehicle's initial engagement with the flat base of the trailer's left dolly wheel resulted in slicing damage to the front left bumper corner at the turn signal housing. The snagging action to the left front wheel caused the case vehicle to achieve the deployment threshold and resulted in the deployment of the case vehicle's driver and front right passenger supplemental restraints (air bags). The case vehicle rotated approximately 45 degrees counterclockwise post-impact and came to rest in contact with the tractor-trailer, heading northward.

The 1995 Toyota Corolla was a front wheel drive, four-door sedan (VIN: 1NXAE09B1SZ-----). The case vehicle was not equipped with anti-lock brakes. Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FLEE-5**. No

reconstruction program was used on this crash because it did not involve two CDC-applicable vehicles; however, this contractor's visually estimated Delta V is between 21 km.p.h. (13 m.p.h.) and 27 km.p.h. (17 m.p.h.). The case vehicle was towed due to damage.

The case vehicle's contact with the semi-trailer involved the front left corner. Direct damage began 55.5 centimeters (21.9 inches) left of the case vehicle's center and extended, a measured distance of 18 centimeters (7.1 inches), to the left front bumper corner. Maximum crush was measured as 95 centimeters (37.4 inches) down the left side. The wheelbase on the case vehicle's left side was shortened 14 centimeters (5.5 inches) while the right side was shortened approximately 1 centimeters (0.4 inches). The case vehicle's front bumper fascia, front left turn signal assembly, hood, left front side marker, and left fender were directly damaged and crushed rearward. The case vehicle's left front tire was damaged, deflated, and physically restricted. The left fender and left front door also sustained induced damage. The windshield's glazing sustained a stress cracks and the left front window glazing was disintegrated from the impact

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 air bag 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 without any tethers. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 63 centimeters (24.8 inches). Inspection of the driver's air bag revealed a small blood drop and either a tiny clump of skin or mucous, not readily apparent, to the lower right quadrant just below the center and toward the 6 o'clock position.

An inspection of 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 flaps and air bag 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's fabric. However, the deployment path of air bag module's cover flap was momentarily blocked by the top of the forward facing child safety seat. The blockage resulted in deformation to the left half of 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 4.5 centimeters (1.8 inches) in diameter, located at the 8 and 4 o'clock positions. The deployed front right air bag was slightly rectangular with a height of approximately 49 centimeters (19.3 inches) and a width of approximately 47 centimeters (18.5 inches). An inspection of the front right passenger's air bag fabric revealed two areas of contact evidence, not readily apparent (e.g., areas of oil/skin transfer), to the front right air bag on the front portion, down the left side of the bag and inward of the left seam. The upper area measured 5 x 15 centimeters (2.0 x 5.9 inches) and the other, larger area directly below it measuring 15 x 19 centimeters (5.9 x 7.5 inches).

Inspection of the case vehicle's interior revealed a skin transfer and indentation on the driver's sun visor and scuffs to the glove box door and front right passenger's knee bolster. In addition the rearview mirror was askew from contact with the deploying front right passenger air bag, and there was a contact to the right "A"-pillar from the child safety seat.

The child safety seat used by the case vehicle's front right passenger was manufactured by Century on May 27, 1997 and was identified by Model number 4263NZF. The involved convertible child safety seat was improperly used at the time of the crash (i.e., the CSS was not secured by the available three-point, lap-and-shoulder, safety belt system). The convertible safety seat was designed to be used as either a rearward facing infant restraint for infants under 69 centimeters and 9 kilograms (27 inches, 20 pounds) or as a forward facing safety seat for infants between 69-102 centimeters and 9-18 kilograms (27-40 inches, 20-40 pounds). The child safety seat consisted of plastic one-piece shell with a pivoting carrying handle attached to the sides which had been removed. The seat was equipped with a shoulder harness and "T"-shield which was attached to the shell and correctly threaded through the upper most slots of the shell back. There were three different height levels that the webbing could be adjusted to, depending on the child's height. The shell had a foam pad on the back support portion, providing a soft surface for the infants back. The seat was also designed with two different slots on the seating portion (i.e., between the child's legs) to insert the harness tongue, again depending on the size of the child. Overall, the child seat showed extensive wear and tear to the padding and shell itself, even though the manufactured date was only approximately 16 months prior to the crash. The back support portion was cracked from the top extending down approximately 15 centimeters (5.9 inches) to the top slot the left harness webbing was positioned through. There was another crack along the outside of the right back support bar starting approximately 4 centimeters (1.6 inches) down from the top and extending downward approximately 21 centimeters (8.3 inches).

The 1990 Freightliner (VIN: 1FU YDX YB3LH-----) is a rear wheel drive, 6 x 4, truck-tractor pulling a 45 foot Fruehauf semi-trailer (VIN: 1H2P04527TW-----). Based on the available photographs, the Truck Deformation Classification (TDC) for the tractor-trailer was determined to be **10-LTFN-A**. The truck-tractor and semi-trailer were driven from the scene.

Immediately prior to the crash the case vehicle's front right passenger was seated slightly reclined with her back against the seat back, her feet hanging down over the front edge of the child safety seat, and both arms on her lap. The front right seat track was located in its middle position, and the seat back was slightly reclined (measured at 57 degrees, with 90 degrees being vertical) so that the angled back of the child safety seat was flush against the seat back.

The case vehicle's front right passenger [71 centimeters and 14 kilograms (28 inches, 30 pounds)] was restrained in a forward facing child seat by a shoulder harness and "T"-shield, but the child safety seat was not secured by the available, active, three-point, lap-and-shoulder, safety belt system. At the time of the crash the child restraint was positioned in the front right seat in a forward facing position with the shell's back flush against the seat back. Furthermore, the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading. In addition, photographs taken on-scene by a freelance photographer showed the child safety seat unrestrained. It should be noted that if the case vehicle's seat belt system had been secured to the safety seat as required it still would not have prevented the seat from flipping forward at impact since the system's webbing retractor was not in the automatic locking mode (ALR).

The case vehicle's driver steered slightly to the right and braked sharply, attempting to avoid the crash. The driver's rightward steering was negated when the case vehicle's brakes locked up. As a result of these attempted avoidance maneuvers and the nonuse of the available safety belts with the child safety seat, the child seat and the restrained front right child passenger most likely tipped forward and slightly to the left toward the front right air bag's module. In addition, the child moved forward in the seat loading the seat's harness just prior to impact. The initial narrow end engagement and subsequent wheel interaction (i.e., similar to a sideswiping impact that starts on the side but results in pocketing) resulted in the air bag deploying late during the sequence of the impact. This delayed deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V—i.e., ramp versus spike). This delayed deployment enabled the unrestrained forward facing child safety seat to tip forward, even closer to the front right air bag module just prior to the deployment of the air bag. The case vehicle's impact with the tractor-trailer caused the top of the tipping child safety seat to move near or on top of the air bag module. Given the approximately 0 degree Direct of Principal Force, the top of the seat—just left of center, was contacted by the left (i.e., as you look at the flap) side of the deploying front right passenger air bag module's cover flap. The top of the tipping child seat was redirected backwards by the cover flap allowing the front of the deploying air bag to contact at least the front right passenger's neck, causing the child safety seat and restrained front right passenger to be lifted upwards and driven backwards into the front right seat back. The bottom right side of the child safety seat most likely contacted the right "A"-pillar, scuffing it as the child seat was driven backwards. After striking the seat back the child seat most likely dropped downwards into the front right seat's cushion. It is unclear exactly how the crack on the child seat's right side was produced. Presumably, at final rest the child was slumped forward in the child safety seat with the child safety seat positioned back near its original pre-crash position.

The front right passenger was removed from the car seat by the case vehicle's driver and was transported to the hospital in a vehicle which happened to be passing by. She sustained critical injuries and was pronounced dead 25 minutes after arrival at the hospital (40 minutes post-crash). There was no autopsy performed on the front right passenger. Based on the emergency room records, the injuries sustained by the case vehicle's front right passenger included: a critical nonanatomic brain injury, a cervical fracture {obvious} at the C₅-C₇ level with severance of the spinal cord, and a contusion {bruising, hematoma} with swelling on lateral neck {unknown aspect}. This occupant's primary cervical injuries were caused by her contact with the case vehicle's front right passenger air bag.

The case vehicle's driver [21-year-old, White (non-Hispanic) female; 178 centimeters and 82 kilograms (70 inches, 180 pounds)] was seated in an upright posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. Her seat track was located between its middle and rearmost positions, her seat back was slightly reclined, and the tilt steering wheel was located between its middle and down-most positions.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. An inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading on the "D"-ring from the belt webbing.

The driver accompanied the front right passenger to the hospital. She sustained minor injuries but did not seek treatment. Her self-reported injuries included: a contusion on her temple (aspect unknown), an abrasion to her chin, and a contusion and laceration to her right knee.

CRASH CIRCUMSTANCES



Figure 1: Southwestward view of case vehicle's northeastbound travel path to impact; Note: highlighted right front tire mark (case photo #03a)



Figure 2: Case vehicle's northeastward travel path just prior to impact with Freightliner's Fruehauf trailer backing into driveway (case photo #01)

The case vehicle had just crested a hill (**Figure 1**) and was traveling northeast in the northeastbound lane of a two-lane, undivided, state highway (**Figure 2**). The rural roadway section was not illuminated at night time, and the case vehicle intended to continue in its northeastward path of travel. The tractor-trailer was stopped with the tractor (power unit) facing southwest in the southwestbound lane of the same two-lane, undivided, state roadway and was in the process of backing the semi-trailer (animal trailer) into a commercial driveway. The semi-trailer was obliquely oriented directly across the northeastbound travel lane of the roadway. The case vehicle's driver did not immediately observe the tractor-trailer blocking the roadway until she was approximately 20 meters (66 feet) from impact. The tractor-trailer's driver flashed his headlights and began activating his horn, hoping to alert the case vehicle's driver to the presence of his trailer blocking the roadway. Immediately prior to the crash, the case vehicle's driver steered slight to the right and braked, leaving 8.8 meters (29 feet) of superimposed skid marks just prior to impact (**Figure 3**). The crash occurred in the northeastbound lane of the Tee-shaped junction of the state roadway and the commercial driveway; see **CRASH DIAGRAM** below.

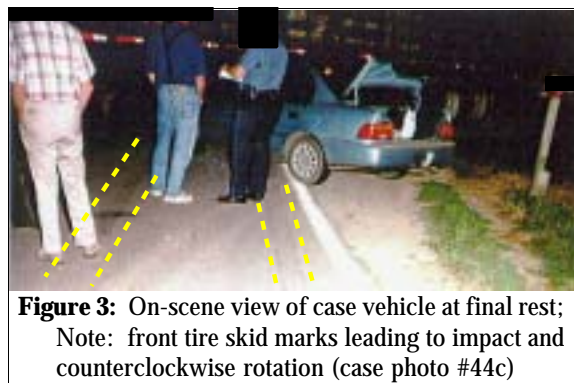


Figure 3: On-scene view of case vehicle at final rest; Note: front tire skid marks leading to impact and counterclockwise rotation (case photo #44c)

The state highway was straight and level (i.e., actual slope was +0.6%, positive to the northeast) in the case vehicle's direction of travel, at the area of impact (**Figure 2**). The pavement was bituminous, and the width of the roadway was 2.95 meters (9.7 feet). The shoulders were not improved (i.e., grassy) and measured 2.8 meters (9.2 feet) wide. Pavement markings

southwest of the impact area consisted of a single broken yellow centerline for both northeast and southwestbound traffic, augmented by a single, broken yellow “no passing” line for southwestbound traffic. The travel lanes northeast of the area of impact were separated only by a single, broken yellow line. In addition, solid white edge lines were present. The estimated coefficient of friction was 0.70. There were no visible traffic controls in the immediate area. The statutory speed limit was 89 km.p.h. (55 m.p.h.), but no regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was dark, but illuminated by overhead street lamps at the area of impact, the atmospheric condition was clear, and the road pavement was dry. However, the driveway tractor-trailer was backing into was illuminated by an overhead light approximately 10 meters (33 feet) east of the roadway’s edge. There was no other traffic present, and the site of the crash was rural commercial and/or agricultural.

The front left corner (**Figure 4** and **Figure 5**) of the case vehicle impacted the left dolly wheel attached to the undercarriage of the truck-tractor's semi-trailer. The case vehicle’s front left narrow end engagement extended down the left side before snagging on the left front wheel rim. The case vehicle’s initial engagement with the flat base of the trailer's left dolly wheel resulted in slicing damage to the front left bumper corner at the turn signal housing (**Figure 6**). The snagging action to the left front wheel (**Figure 7** below) caused the case vehicle to achieve the deployment threshold and resulted in the deployment of the case vehicle's driver and front right passenger supplemental restraints (air bags). The case vehicle rotated approximately 45 degrees counterclockwise post-impact and came to rest in contact with the tractor-trailer, heading northward (**Figure 4** and **Figure 8** below).

CASE VEHICLE

The 1995 Toyota Corolla DX was a front wheel drive, five-passenger, four-door sedan VIN: 1NXAE09B1SZ-----) equipped with a 1.8L, I-4



Figure 4: On-scene view of case vehicle at final rest against trailer’s dolly wheels; Note: case vehicle rotated approximately 45 degrees counterclockwise after impact (case photo #45)



Figure 5: Case vehicle’s very narrow frontal impact with Fruehauf trailer; Note: yellow tape marks beginning (front bumper) and ending (left fender) of direct damage (case photo #08)



Figure 6: Reference line view down case vehicle’s left side showing narrow direct damage to front left corner (case photo #11)

engine and a four-speed automatic transmission. The case vehicle was not equipped with anti-lock brakes. Braking was achieved by a power-assisted, front disc and rear drum system. The case vehicle's wheelbase was 247 centimeters (97.2 inches), and the odometer reading at inspection 149,185 kilometers (92,699 miles).



Figure 7: Case vehicle's front left damage viewed from left of front; Note: left front wheel rim snagged during narrow corner engagement (case photo #12)



Figure 8: On-scene view looking southwestward in northeastbound lane at final rest positions of case vehicle and Fruehauf trailer (case photo #46)

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 case vehicle's front right safety belt system had a switchable retractor. The front seat belt systems were equipped with manually operated height adjusters for the "D"-rings. The driver's anchor was located in its middle position and the front right anchor was located in down-most position. The vehicle was equipped with knee bolsters for both the driver and front right passenger, neither of which were deformed from contact. 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 tractor-trailer.

CASE VEHICLE DAMAGE

The case vehicle's contact with the semi-trailer involved the front left corner (**Figure 9**). Direct damage began 55.5 centimeters (21.9 inches) left of the case vehicle's center (**Figure 5** above) and extended, a measured distance of 18 centimeters (7.1 inches), to the left front bumper corner (**Figure 6** above). The field L went from the front left bumper corner to the right, a distance of 127 centimeters (50.0 inches). Maximum crush was measured as 95 centimeters



Figure 9: Case vehicle's very narrow front left damage viewed from right of front; Note: yellow tape marks direct damage (case photo #16)

(37.4 inches) down the left side (**Figure 7** above). The wheelbase on the case vehicle's left side was shortened 14 centimeters (5.5 inches) while the right side was shortened approximately 1 centimeters (0.4 inches). The case vehicle's front bumper fascia, front left turn signal assembly, hood, left front side marker, and left fender were directly damaged and crushed rearward. The case vehicle's left front tire was damaged, deflated, and physically restricted (**Figure 7** above). The left fender and left front door also sustained induced damage. The windshield's glazing sustained a stress crack laterally across the top of the windshield and a stress fracture near the right "A"-pillar. In addition, the left front window glazing was disintegrated from the impact (**Figure 5** above).

The wheelbase on the case vehicle's left side

Inspection of the case vehicle's interior revealed a skin transfer and indentation on the driver's sun visor (**Figure 10**) and scuffs to the glove box door and front right passenger's knee bolster. In addition the rearview mirror was askew from contact with the deploying front right passenger air bag, and there was a contact to the right "A"-pillar from the child safety seat (**Figure 11**). Finally, the energy absorbing steering column showed no evidence of compression.



Figure 10: Case vehicle's deployed driver air bag and greenhouse area showing indentation and skin evidence on driver's sun visor (case photo #19)

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FLEE-5**. No reconstruction program was used on this crash because it did not involve two CDC-applicable vehicles; however, this contractor's visually estimated Delta V is between 21 km.p.h. (13 m.p.h.) and 27 km.p.h. (17 m.p.h.). The case vehicle was towed due to damage.



Figure 11: Close-up of scuffing to case vehicle's right "A"-pillar from contact by child safety seat and stress fracture to right side of windshield's glazing (case photo #23)

AUTOMATIC RESTRAINT SYSTEM

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 air bags deployed as a result of the snagging impact between the semi-trailer's dolly wheels and the left front tire/rim. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of symmetrical "H"-configuration

cover flaps made of thick vinyl with overall dimensions of 15 centimeters (5.9 inches) at the horizontal seam and 7 centimeters (2.8 inches) vertically for both the upper and lower flaps. An inspection of the air bag module's cover flaps and air bag 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 without any tethers. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 63 centimeters (24.8 inches). Inspection of the driver's air bag revealed a small blood drop and either a tiny clump of skin or mucous, not readily apparent, to the lower right quadrant just below the center and toward the 6 o'clock position (**Figure 12**).



Figure 12: Case vehicle's deployed driver air bag showing contact evidence in right lower quadrant; Note: steering wheel has been rotated clockwise (case photo #25)

An inspection of 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 vinyl over a thin metal frame. The flap's dimensions were 35 centimeters (13.8 inches) at the lower horizontal seam and 12 centimeters (4.7 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 flaps and air bag 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's fabric. However, the deployment path of air bag module's cover flap was momentarily blocked by the top of the forward facing child safety seat. The blockage resulted in deformation to the left half of the cover flap and what appeared to be a possible oil smear and two longitudinal scuffs (**Figure 13** and **Figure 14**). The two longitudinal scuffs were towards the deformed left side and started at the leading edge of the cover flap. Both scuffs were 2 centimeters (0.8 inches) wide and appear to have resulted from coming in contact with the plastic frame of the child safety seat. The oil smear was towards the rear of the cover flap



Figure 13: Close-up of evidence on left side of case vehicle's front right passenger air bag module's cover flap from contact with top of forward facing child safety seat (case photo #29)



Figure 14: Case vehicle's deformed front right passenger air bag module's cover flap; Note: flap deformed from contact with forward facing child safety seat seen in background (case photo #31)

and most likely are not related because the front right passenger has no known injuries that were related to 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 4.5 centimeters (1.8 inches) in diameter, located at the 8 and 4 o'clock positions. The deployed front right air bag was slightly rectangular with a height of approximately 49 centimeters (19.3 inches) and a width of approximately 47 centimeters (18.5 inches). An inspection of the front right passenger's air bag fabric revealed two areas of contact evidence, not readily apparent (e.g., areas of oil/skin transfer), to the front right air bag on the front portion, down the left side of the bag and inward of the left seam (**Figure 15**). The upper area measured 5 x 15 centimeters (2.0 x 5.9 inches) and the other, larger area directly below it measuring 15 x 19 centimeters (5.9 x 7.5 inches).



Figure 15: Case vehicle's deployed front right passenger air bag showing skin and grease smears down left side of front portion (case photo #27)

CHILD SAFETY SEAT

The child safety seat used by the case vehicle's front right passenger was manufactured by Century on May 27, 1997 and was identified by Model number 4263NZF (**Figure 16**). The involved convertible child safety seat was improperly used at the time of the crash (i.e., the CSS was not secured by the available three-point, lap-and-shoulder, safety belt system). The convertible safety seat was designed to be used as either a rearward facing infant restraint for infants under 69 centimeters and 9 kilograms (27 inches, 20 pounds) or as a forward facing safety seat for infants between 69-102 centimeters and 9-18 kilograms (27-40 inches, 20-40 pounds). The child safety seat consisted of plastic one-piece shell with a pivoting carrying handle attached to the sides which had been removed. The seat was equipped with a shoulder harness and "T"-shield which was attached to the shell and correctly threaded through the upper most slots of the shell back. There were three different height levels that the webbing could be adjusted to, depending on the child's height. The shell had a foam pad on the back support portion, providing a soft surface for the infants back. The seat was also designed



Figure 16: Front of forward facing child safety seat that was secured in case vehicle's front right seating position; Note: crack (arrow) to top of seat (case photo #32)

with two different slots on the seating portion (i.e., between the child's legs) to insert the harness tongue, again depending on the size of the child. Overall, the child seat showed extensive wear and tear to the padding and shell itself, even though the manufactured date was only approximately 16 months prior to the crash. The back support portion was cracked from the top extending down approximately 15 centimeters (5.9 inches) to the top slot the left harness webbing was positioned through (**Figure 17**). There was another crack (**Figure 18**) along the outside of the right back support bar starting approximately 4 centimeters (1.6 inches) down from the top and extending downward approximately 21 centimeters (8.3 inches).

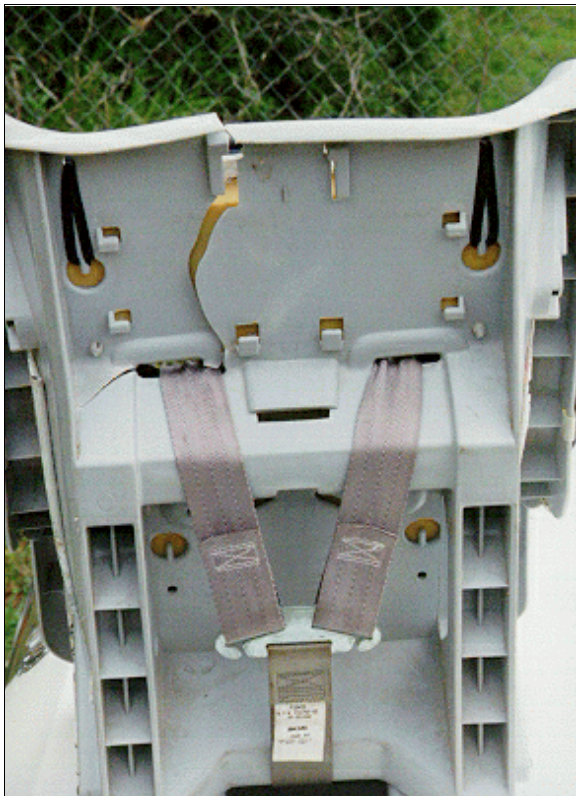


Figure 17: Close-up of backside of forward facing child safety seat secured in case vehicle's front right seating position; Note: seat cracked from impact with front right air bag module's cover flap (case photo #37)



Figure 18: Close-up of right side of forward facing child safety seat secured in case vehicle's front right seating position; Note: crack radiating down side of rear back support bar (case photo #35)

A warning label was affixed to the left side (inboard side when used in the forward facing position) of the child safety seat which warned against placing the rearward facing restraint in the front seat of a vehicle that was equipped with a passenger side air bag. The white and yellow label with black writing further advises that serious injury or death could occur if an air bag inflates against a rear facing child restraint. This yellow warning label was dated 4/95. There was also a manufacturer's label affixed to the left side giving the height and weight limitations when positioned in both the rearward facing and forward facing positions (described above) as well as a sketch of proper belt placement in either position. This label was dated 5/97.

A second warning label was affixed to the right side (outboard side when used in the forward facing position) of the child safety seat which warned the user to follow the usage instructions or your child could strike the vehicle's interior during a sudden stop or crash. The warning continues to explain the importance of securing the child restraint with a vehicle belt as specified in the manufacturer's instructions and snugly adjusting the belts provided with the child safety seat around the infant. The manufacturer's instructions which were suppose to be located on the back of the seat were missing at the time of this contractor's inspection. This label was dated 4/95.

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash the case vehicle's front right passenger [niece; nineteen-month-old, White (non-Hispanic) female; 71 centimeters and 14 kilograms (28 inches, 30 pounds)] was seated slightly reclined with her back against the seat back, her feet hanging down over the front edge of the child safety seat, and both arms on her lap. The front right seat track was located in its middle position, and the seat back was slightly reclined (measured at 57 degrees, with 90 degrees being vertical) so that the angled back of the child safety seat was flush against the seat back.

The case vehicle's front right passenger was restrained in a forward facing child seat by a shoulder harness and "T"-shield, but the child safety seat was not secured by the available, active, three-point, lap-and-shoulder, safety belt system. At the time of the crash the child restraint was positioned in the front right seat in a forward facing position with the shell's back flush against the seat back. Furthermore, the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading. In addition, photographs taken on-scene by a freelance photographer showed the child safety seat unrestrained (**Figure 19**). It should be noted that if the case vehicle's seat belt system had been secured to the safety seat as required it still would not have prevented the seat from flipping forward at impact since the system's webbing retractor was not in the automatic locking mode (ALR).



Figure 19: On-scene photo of case vehicle's interior from outside front right door; Note: child safety seat not secured by belt system (case photo #48)

The case vehicle's driver steered slightly to the right and braked sharply, attempting to avoid the crash. The driver's rightward steering was negated when the case vehicle's brakes locked up. As a result of these attempted avoidance maneuvers and the nonuse of the available safety belts with the child safety seat, the child seat and the restrained front right child passenger most likely tipped forward and slightly to the left toward the front right air bag's module. In addition, the child moved forward in the seat loading the seat's harness just prior to impact. The initial narrow

end engagement and subsequent wheel interaction (i.e., similar to a sideswiping impact that starts on the side but results in pocketing) resulted in the air bag deploying late during the sequence of the impact. This delayed deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V—i.e., ramp versus spike). This delayed deployment enabled the unrestrained forward facing child safety seat to tip forward, even closer to the front right air bag module just prior to the deployment of the air bag. The case vehicle's impact with the tractor-trailer caused the top of the tipping child safety seat to move near or on top of the air bag module. Given the approximately 0 degree Direct of Principal Force, the top of the seat—just left of center (**Figures 16 and 17** above), was contacted by the left (i.e., as you look at the flap) side of the deploying front right passenger air bag module's cover flap (**Figures 13 and 14** above). The top of the tipping child seat was redirected backwards by the cover flap allowing the front of the deploying air bag to contact at least the front right passenger's neck, causing the child safety seat and restrained front right passenger to be lifted upwards and driven backwards into the front right seat back. The bottom right side of the child safety seat most likely contacted the right "A"-pillar, scuffing it as the child seat was driven backwards. After striking the seat back the child seat most likely dropped downwards into the front right seat's cushion. It is unclear exactly how the crack on the child seat's right side was produced (**Figure 18** above). Presumably, at final rest the child was slumped forward in the child safety seat with the child safety seat positioned back near its original pre-crash position.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right passenger was removed from the car seat by the case vehicle's driver and was transported to the hospital in a vehicle which happened to be passing by. She sustained critical injuries and was pronounced dead 25 minutes after arrival at the hospital (40 minutes post-crash). There was no autopsy performed on the front right passenger. Based on the emergency room records, the injuries sustained by the case vehicle's front right passenger included: a critical nonanatomic brain injury, a cervical fracture {obvious} at the C₅-C₇ level with severance of the spinal cord, and a contusion {bruising, hematoma} with swelling on her lateral neck {unknown aspect}. This occupant's primary cervical injuries were caused by her contact with the case vehicle's front right passenger air bag.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury—unconsciousness, unresponsive, and flaccid	160824.5 critical	Air bag, front right passenger's	Probable	Emergency room records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
2	Severance of spinal cord with fracture {obvious} at C ₅ -C ₇ level	640264.5 ¹ critical	Air bag, front right passenger's	Probable	Emergency room records
3	Contusion {bruising, hematoma} with swelling on lateral neck, aspect not specified	390402.1 minor	Air bag, front right passenger's	Certain	Emergency room records

CASE VEHICLE DRIVER KINEMATICS

The case vehicle's driver [21-year-old, White (non-Hispanic) female; 178 centimeters and 82 kilograms (70 inches, 180 pounds)] was seated in an upright posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel. The case vehicle's driver may have attempted to brace her arms against the steering wheel just prior to impact. Her seat track was located between its middle and rearmost positions, her seat back was slightly reclined, and the tilt steering wheel was located between its middle and down-most positions.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. An inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading on the "D"-ring from the belt webbing.

The case vehicle's driver steered slightly to the right and braked sharply, attempting to avoid the crash. The driver's rightward steering was negated when the case vehicle's brakes locked up. As a result of these attempted avoidance maneuvers and the nonuse of her available safety belts, the driver most likely moved slightly forward and upward just prior to impact. The initial narrow end engagement and subsequent wheel interaction (i.e., similar to a sideswiping impact that starts on the side but results in pocketing) resulted in the air bag deploying late during the sequence of the impact. This delayed deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V--i.e., ramp versus spike). This delayed deployment enabled the unrestrained driver to continue forward and slightly upward toward the case vehicle's 0 degree Direction of Principal Force as the case vehicle decelerated. The driver loaded her deploying driver air bag and deposited contact evidence (i.e., mucous splatter) on the air bag's front surface. The vehicle inspect did not reveal any evidence of compression to the energy absorbing shear capsules in the base of the steering column and no deformation to the

¹ The choice of injury code is difficult because the NASS CDS Injury Coding manual presumes, first, that one knows whether the spinal cord lesion is either a contusion or a laceration (i.e., no option for unknown is provided; although severance translates to laceration, the certainty is at best "probable"), and second, whether there was a complete or an incomplete cord syndrome. Because the only available medical record is an Emergency Room report in which this occupant was declared "dead-on-arrival" and the diagnoses are based on the doctor's experience (i.e., there was no subsequent invasive examination performed and no radiographic records were provided), the syndrome issue is not discernable (i.e., you cannot determine the difference in a dead person). In the absence of protocol, this contractor chooses to assume that the syndrome was complete.

steering wheel rim. The driver most likely was lifted upwards as the air bag continue to expand and contacted the sun visor prior to rebounding back off the deploying air bag toward the interior surface of the driver’s door as the case vehicle rotated counterclockwise. Although she most likely contacted the driver door, the door’s glazing was most likely disintegrated as a result of the impact forces. Furthermore, the driver reported no injuries consistent with glazing contact or interaction. As the case vehicle came to rest, the driver moved back to her right remaining in her seat. The case vehicle’s driver does not recall her exact posture at final rest.

CASE VEHICLE DRIVER INJURIES

The driver accompanied the front right passenger to the hospital. She sustained minor injuries but did not seek treatment. Her self-reported injuries included: a contusion on her temple (aspect unknown), an abrasion to her chin, and a contusion and laceration to her right knee.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Contusion {knot} on temple [Aspect = Unknown]	190402.1 minor	Sun visor, driver’s	Probable	Interviewee (same person)
2	Abrasion {burn} to chin, not further specified	290202.1 minor	Air bag, driver’s	Certain	Interviewee (same person)
3	Contusion {bruise} right knee	890402.1 minor	Center instrument panel and below	Probable	Interviewee (same person)
4	Laceration {cut} right knee	890600.1 minor	Center instrument panel and below	Probable	Interviewee (same person)

OTHER VEHICLE

The 1990 Freightliner was a rear wheel drive, five-passenger, four-door, 6 x 4, truck-tractor pulling a 45 foot Fruehauf semi-trailer (VIN: 1H2P04527TW-----) equipped with a Caterpillar 3406 engine and air brakes.

Based on the available photographs, the Truck Deformation Classification (TDC) for the tractor-trailer was determined to be **10-LTFN-A**. The truck-tractor and semi-trailer were driven from the scene.

CRASH DIAGRAM

IN98-027

