INDIANA UNIVERSITY
TRANSPORTATION RESEARCH CENTER
School of Public and Environmental Affairs
222West Second Street
Bloomington, Indiana 47403-1501
(812) 855-3908 Fax: (812) 855-3537

ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN98-014
LOCATION - TEXAS
VEHICLE - 1995 FORD EXPLORER XL
CRASH DATE - February, 1998

Submitted:

January 28, 2002

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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.

Technical Report Documentation Page

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On-site air bag deployment investigation involving a 1995 Ford Explorer XL, four-door, compact utility, with manual safety belts and dual front air bags, and a 1990 International truck-tractor with semi-trailer

16. *Abstract*

This report covers an on-site investigation of an air bag deployment crash that involved a 1995 Ford Explorer (case vehicle) and a 1990 International truck-tractor with Great Dane semi-trailer (other vehicle). This crash is of special interest because the case vehicle's front right passenger (six-month-old female), who was neither restrained nor secured in a rear facing child safety seat, sustained critical brain injuries when her child seat was redirected by the deploying front right passenger air bag, resulting in her death. The case vehicle had just exited an interstate highway and was entering a channelized, right-hand, turn lane. The other vehicle had previously entered the turn lane and was slowing to a stop, waiting to enter a divided, U.S. trafficway. The crash occurred in the channelized turn lane. The front of the case vehicle impacted the underride guard on the back of the trailer, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The front right passenger was laying reclined and unrestrained in a rear facing, Evenflo "Joyride," child safety seat with her head oriented toward the front right air bag module. The front right seat track was located in its rearmost position. The child safety seat was also not secured by the available, active, three-point, lap-and-shoulder, safety belt system. She sustained, according to her medical records: a critical nonanatomic brain injury with prolonged unconsciousness; skull fractures to her basilar skull, occipital bone, and right parietal bone; severe cerebral edema; epidural, subdural, and subarachnoid hemorrhages; and a contusion to her posterior scalp. The infant's injuries were caused by the case vehicle's roof and occurred as a result of the child seat being redirected upward by the deploying front right passenger air bag. The case vehicle's driver (25-year-old female) was seated, leaning forward applying makeup, with her seat track located between its middle and forward-most positions, and the tilt steering wheel was located in its middle position. She was most likely restrained by her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her interview and medical records, minor injuries which included: abrasions to her lips and chin; contusions to her left shoulder, left upper chest, and across her lower abdomen; and a laceration to the webbing of her left hand between her ring and little fingers. The back right passenger (son; 2-year-old male) was seated but his seat track was not adjustable and he was not using his available, active, three-point, lap-and-shoulder, safety belt system. He did not sustain any injuries as a result of this crash.

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TABLE OF CONTENTS

IN98-014

Page No.

SELECTED PHOTOGRAPHS (Continued)

BACKGROUND

IN98-014

This on-site investigation was brought to NHTSA's attention on February 9, 1998 by an investigator with the National Transportation Safety Board. This crash involved a 1995 Ford Explorer (case vehicle) and a 1990 International truck-tractor with Great Dane semi-trailer (other vehicle). The crash occurred in February, 1998, at 9:23 a.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's front right passenger [six-month-old, White (Hispanic) female], who was neither restrained nor secured in a rear facing child safety seat, sustained critical brain injuries when her child seat was redirected by the deploying front right passenger air bag, resulting in her death. This contractor interviewed the driver of the case vehicle on February 11, 1998. This contractor inspected the scene and case vehicle on 10-11 February, 1998. This report is based on the Police Crash Report, interviews with the case vehicle's driver and the investigating police officer, scene and vehicle inspections, occupant medical records, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle had just exited an interstate highway, traveling northward in the outside northbound lane of a three-lane, one-way, frontage road. The case vehicle had entered a channelized, right-hand, turn lane intending to traveling east on a six-lane, divided, U.S. trafficway. The other vehicle which had also exited the interstate highway and entered the channelized, right-hand, turn lane, was slowing to a stop, waiting to enter the same six-lane, divided, U.S. trafficway. Immediately prior to the crash the case vehicle's driver braked (without depositing any skid marks), attempting to avoid impacting the back end of the trailer. The crash occurred in the channelized turn lane, near the mouth of the merging area between the channelized lane and eastbound roadway of the U.S. trafficway; see **CRASH DIAGRAM** below.

The front of the case vehicle impacted the underride guard on the back of the Great Dane's trailer, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle and the tractor-trailer came to rest essentially at impact.

The 1995 Ford Explorer XL was a rear wheel drive , 4 x 2, four-door, compact utility vehicle (VIN: 1FMDU32X3SZ------). The case vehicle was equipped with four-wheel, anti-lock brakes. Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDMW-4 (0).** The WinSMASH reconstruction program could not be used, first, because of the underride-type impact configuration, and second, because one vehicle is out-of-scope. 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 tractor-trailer involved the entire front width of the vehicle and exhibited a distinct heavy truck underride type pattern. Direct damage extended from bumper corner to bumper corner, a measured distance of 151 centimeters (59.5 inches), across the entire width of the hood. Direct damage to the hood extended rearward 81 centimeters (31.9 inches). Maximum crush on the hood was measured as 62 centimeters (24.4 inches) at C_6. Maximum crush to the case vehicle's grille area was measured as 23 centimeters (9.1 inches) between C_3 and C_4.

Direct damage to the bumper involved the top surface only (i.e., scratches). Direct damage began at the front right bumper corner and extended, 97 centimeters (38.2 inches), along the bumper to the left. There was no measurable crush to the front bumper. Neither the wheelbase on the case vehicle's left nor right sides was shortened. The case vehicle's front bumper fascia, grille, hood, radiator, right headlight and turn signal assemblies, and right fender were directly damaged and crushed rearward. None of the case vehicle's tires were physically restricted or deflated.

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; however, there was a scuff, possibly previous to this crash, and makeup on the driver air bag module's top cover flap. The driver's air bag was designed with four tethers, each approximately 2 cm (0.8 inches) in width. The driver's air bag had two vent ports, approximately 1.5 centimeters (0.6 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 60 centimeters (23.6 inches). Inspection of the deployed driver's air bag indicated that there was blood and a large amount of makeup evidence readily apparent on the front surface of the air bag. Specifically, there was a 7 x 9 centimeter (2.8 x 3.5 inch) area of makeup with blood located in the left upper quadrant toward the 10 o'clock position. Furthermore, there was a 9 x 8 centimeter (3.5 x 3.1 inch) area of makeup just outside the center of the air bag in the right upper quadrant toward the 1:30 o'clock position. Finally, there were scattered blood drops located between the center and perimeter of the air bag toward the 6 o'clock position.

The front right passenger's air bag was located in the middle of the instrument panel. An inspection of the front right air bag module's cover flap 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; however, the faint outline of the child safety seat's handle could be seen, to the naked eye, transversely across the lower portion of the air bag module's cover flap. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 5 centimeters (2.0 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 48 centimeters (18.9 inches) and a width of approximately 93 centimeters (36.6 inches). An inspection of the front right air bag revealed no contact evidence readily apparent on the air bag's fabric.

Inspection of the case vehicle's interior revealed that there was a scuff (i.e., possibly skin or makeup) along the roof over the driver's seating area and on the driver's sun visor. Scuffs (i.e., possibly skin) were also present along the roof over the front right passenger's seating area and on the front right sun visor. Furthermore, there was an unknown liquid (e.g., saliva from the baby) present on the front surface of the front right seat's back support, and there was a scuff on the back surface of the front right seat's back support from contact by the back right passenger. In addition, the back surface of the rear view mirror was contacted by the child safety seat and the seat's blanket as a result of the seat's being lifted upwards by the deploying front right passenger air bag. The right side of the rearview mirror was rotated into the windshield, cracking the glazing. Finally, the upper portion of the steering wheel rim was bend backwards, 1.5 centimeters

(0.6 inches), as a result of the driver loading the air bag, momentarily blocking the air bag's forward expansion, and causing the air bag to expand backwards bending the rim. The steering column's shear capsules were not accessible.

The 1990 International, COF-9700 was a dual rear wheel drive, 6 x 4, Cab Over Engine (COE), Set Back Axle (SBA), truck-tractor (VIN: 1HSRKGUR6LH------). The 1981 Great Dane trailer (VIN: 1GRAE9020BS------) was a 13.7 meter (45 foot), 2-axle semi-trailer. Based on the available photographs, the TDC for tractor-trailer was determined to be: **06-BDLW-A (180)** (maximum crush is unknown). The International truck-tractor was driven from the scene.

Immediately prior to the crash the case vehicle's front right passenger [61 centimeters and 11 kilograms (24 inches, 24 pounds)] was laying reclined with her back against the back of the rear facing, Evenflo "Joyride," child safety seat (RFCSS). The child safety seat can be converted to an infant carrier. The child's head was pointed toward the right instrument panel and front right air bag module. The child's feet were oriented toward the seat back. The exact position of the child's hands are unknown. This contractor believes that the pre-crash position of the child safety seat in the case vehicle was at an approximate 25 degree angle (i.e., it should have been positioned at a 45 degree angle). Just prior to the crash, the rear facing child safety seat was most likely positioned close to the front right seat back. However, the evidence on the front right air bag module's cover flap indicates that at least on one, if not more, occasions, the child seat had been positioned in this vehicle such that the seat handle was leaning against the front right passenger air bag module's cover flap. This could have occurred because of the way the child seat was placed in the front right position or because the front right seat track was closer to the instrument panel and air bag module. The case vehicle's driver does not recall the exact placement of the child safety seat prior to the crash. When the back of the child seat was located so as to be leaning against the front right air bag module's cover flap, the foot portion of the RFCSS, where the infant's feet would have been, would have been located approximately 10.2 centimeters (4 inches) forward of the upright, front right seat back. According to the manufacture's use guidelines, printed on a sticker attached to the seat, the maximum height and weight allowed for a child using this seat is: height up to 66.0 centimeters and weight up to 9.1 kilograms (26 inches and 20 pounds). The front right infant passenger exceeded the weight limitation. The front right seat track was located in its rearmost position.

The case vehicle's front right infant passenger was unrestrained in a rear facing child safety seat which was also not secured by the available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was no evidence of belt pattern bruising or abrasions to the child's body. In addition, the inspection of the front right passenger's seat belt webbing, metal "D"-ring, and latch plate showed no evidence of loading or usage during the crash. An inspection of the Evenflo "Joyride" child safety seat showed no signs of damage from interacting with the front right air bag module's cover flap. This strongly supports the notion that at the time of the air bag's deployment, the cover flap missed the child safety seat.

The case vehicle's driver braked, at the last second, attempting to avoid the crash. The driver's braking maneuver, independent of the nonuse of any safety restraint systems–either in the child seat or in the vehicle, had little or no effect on the infant's movement in the child safety seat.

In addition, the braking did not cause the back of the child safety seat to move significantly forward toward the front right air bag module's cover flap immediately prior to deployment. The case vehicle's impact with the trailer's underride guard enabled the unsecured rear facing child safety seat, with the unrestrained six-month old, front right infant passenger, to tilt forward and slightly leftward toward the 0 degree Direction of Principal Force as the case vehicle decelerated. Because the damage on the case vehicle was primarily above the bumper, the underride type damage 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). As the air bag deployed, the child safety seat and infant occupant were lifted (i.e., ramped) upwards by the deploying air bag. The top right edge of the child safety seat (from the infant occupant's perspective–front left edge from the case vehicle's perspective) contacted the back right corner of the rearview mirror, knocking the mirror into the windshield, fracturing the glazing. The blanket that was covering the safety seat's infant occupant had a black transfer mark with a flake of black plastic from the rearview mirror still attached. As the air bag attained full deployment, the top back portion of the infant's head and the child safety seat contacted the roof. The infant separated from the child safety seat and was propelled backwards where she most likely struck the top of the front right seat's integral headrest. Next, the infant fell back on top of the rear facing child safety seat which had fallen to the seat and, finally, tumbled into the floor pan area. At final rest the child was laying in the floor pan of the front right passenger seating position. The case vehicle's driver immediately picked up the infant, held her in her lap, and then called 911. The child safety seat came to rest in the front right seat up against the right instrument panel.

The front right occupant was transported by ambulance to the hospital. She sustained critical head injuries and was hospitalized prior to being pronounced brain dead approximately 24 hours post-crash. Based on her medical records, she sustained: a critical nonanatomic brain injury with unconsciousness greater than 24 hours; skull fractures involving her posterior basilar fossa, occipital bone with depression, and right parietal bone; severe cerebral edema; hemorrhages, both epidural and subdural, and subarachnoid; and a contusion to her posterior scalp. The infant's injuries were caused by the case vehicle's roof and occurred as a result of the child seat being redirected upward by the deploying front right passenger air bag.

According to the case vehicle's driver [25-year-old, White (Hispanic) female; 168 centimeters and 102 kilograms (66 inches, 225 pounds)], she was seated upright 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. Based on this contractor's investigation, it is more likely that the driver was applying her makeup just prior to the crash; this would explain why the case vehicle's driver did not see the tractor-trailer slowing in front of her. Therefore, the most likely scenario in this contractor's opinion is that the driver was seated leaning forward with her lower back against the seat back, her left foot on the floor, her right foot barely pressing on the brake, her left hand holding the steering wheel rim and her makeup compact, and her right hand holding a brush used to apply the makeup. In addition to the makeup evidence found on the air bag's module and fabric (discussed above), there was also makeup accessories in the floor pan on the driver and front right passenger sides. Furthermore, a brush used to apply eye makeup was found on the left instrument panel near the odometer and other gauges. The driver's seat track was located between its middle

and forward-most positions, the seat back was upright, and the tilt steering wheel was located in its middle position.

The case vehicle's driver was reportedly restrained by her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was self-reported evidence of belt pattern bruising (i.e., contusions latent to her emergency room visit) to the driver's body that were consistent with restraint usage; however, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading. This later fact can be explained by the prolonged deployment sequence.

The driver was transported by a relative to the hospital. She sustained minor injuries and was treated and released. According to her interview and medical records, she sustained: abrasions to her lips and chin; contusions to her left shoulder, left upper chest, and across her lower abdomen; and a laceration to the webbing of her left hand between her ring and little fingers that required 7 stitches. The laceration on her hand resulted in blood being present on the driver's air bag, seat cushion, and door sill; however, no blood was found on the seat belt webbing.

Immediately prior to the crash the case vehicle's driver (i.e., mother) believes that the back right passenger [son; 2-year-old, White (Hispanic) male; 91 centimeters and 18 kilograms (36 inches, 40 pounds)] was seated in an upright posture with his back against the seat back, his feet dangling over the front edge of the seat's cushion, angled downward. However, the exact position of his hands is unknown. His seat track and seat back were not adjustable; although, the seat backs could be folded down.

The case vehicle's back right passenger was not using his available, active, three-point, lap-and-shoulder, safety belt system. The inspection of the back right passenger's seat belt webbing, metal "D"-ring, and latch plate showed no evidence of loading. According to the available evidence, he was not transported by ambulance to the hospital and no follow-up medical treatment was sought. The case vehicle's back right passenger did not sustain any injuries as a result of this crash.

CRASH CIRCUMSTANCES

Figure 1: On-scene north-northeast view of channelized right-hand turn lane showing case vehicle and tractor-trailer at final rest (case photo #01)

The case vehicle had just exited an interstate highway, traveling northward in the outside northbound lane of a three-lane, one-way, frontage road. The case vehicle had entered a channelized, right-hand, turn lane (**Figure 1**) intending to traveling east on a six-lane, divided, U.S. trafficway. The other vehicle which had also exited the interstate highway and entered the channelized, right-hand, turn lane, was slowing to a stop, waiting to enter the same six-lane, divided, U.S. trafficway. Immediately prior to the crash the case vehicle's driver braked (without depositing any skid marks), attempting to avoid impacting the back end of the trailer. The crash

occurred in the channelized turn lane, near the mouth of the merging area (**Figure 2**) between the channelized lane and eastbound roadway of the U.S. trafficway; see **CRASH DIAGRAM** below.

Figure 2: On-scene northeast view of channelized right-hand turn lane showing case vehicle and tractor-trailer at final rest (case photo #03)

The channelized turn lane from the interstate highway exit ramp was curved to the right for northbound-to-eastbound traffic and level (i.e., actual slope was 1.5%, positive to the northeast) at the area of impact. The channelized roadway's super-elevation was measured at 3.1%. The pavement was grooved concrete, and the width of the travel lane for both vehicles was 7.1 meters (23.4 feet). The southeast side of the northeastbound channel had a 0.4 meter (1.3 foot) paved shoulder prior to the adjacent 15.2 centimeter (6 inch) high barrier curb, and the northwest side had no shoulder but a 20.3 centimeter (8 inch) barrier curb prior to the unprotected, raised concrete gore. No pavement markings were present except for a delineated pedestrian crosswalk in the middle of the channelized turn lane. In addition, no edge lines were present. The estimated coefficient of friction was 1.20%. A regulatory YIELD sign (Manual on Uniform Traffic Control Devices, R1-2) was located prior to the merging area where the channelized lane joined the eastbound roadway. The speed limit approaching the channelized turn lane was 72 km.p.h. (45 m.p.h.). However, no regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was daylight, the atmospheric condition was cloudy, and the road pavement was dry. Traffic density was moderate, and the site of the crash was urban and primarily undeveloped.

Figure 3: Case vehicle's underride (above bumper) damage pattern viewed from right of center with contour gauge present (case photo #17)

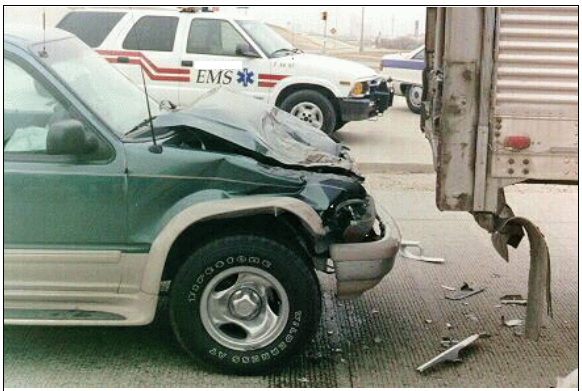


Figure 4: On-scene view of case vehicle and Great Dane's trailer at final rest; Note: trailer's underride guard damaged and bent underneath trailer (case photo #04)

The front of the case vehicle (**Figure 3**) impacted the underride guard on the back of the Great Dane's trailer (**Figure 4**), bending it forward and causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle and the tractor-trailer came to rest essentially at impact.

The 1995 Ford Explorer XL was a rear wheel drive, 4 x 2, five-passenger, four-door compact utility (VIN: 1FMDU32X3SZ------) equipped with a 4.0L, V-6 engine and a five-speed automatic transmission with overdrive. Braking was achieved by a power-assisted, front and rear disc, four-wheel, anti-lock system. The case vehicle's wheelbase was 283 centimeters (111.5 inches), and the odometer reading at inspection was 75,744 kilometers (47,065 miles).

Inspection of the vehicle's interior revealed adjustable front bucket seats with integral head restraints; a non-adjustable 60/40 split bench seat with folding backs with adjustable 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 height adjusters for the "D"-rings. The vehicle was equipped with knee bolsters for both the driver and front right passenger, neither of which showed any deformation. 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 front underriding impact with the tractor-trailer.

CASE VEHICLE DAMAGE

The case vehicle's contact with tractor-trailer involved the entire front width of the vehicle and exhibited a distinct heavy truck underride type pattern (**Figure 3** above). Direct damage extended from bumper corner to bumper corner, a measured distance of 151 centimeters (59.5 inches), across the entire width of the hood. Direct damage to the hood extended rearward 81 centimeters (31.9 inches). Maximum (i.e., residual) crush on the hood was measured as 62 centimeters (24.4 inches) at C_6. Maximum residual crush to the case vehicle's grille area was measured as 23 centimeters (9.1 inches) between C_3 and C_4. Direct damage to the bumper involved the top surface only (i.e., scratches). Direct damage began at the front right bumper corner and extended, 97 centimeters (38.2 inches), along the bumper to the left. There was no measurable crush to the front bumper. Neither the wheelbase on the case vehicle's left nor right sides was shortened. The case vehicle's front bumper fascia, grille, hood, radiator, right headlight and turn signal assemblies, and right fender were directly damaged and crushed rearward. None of the case vehicle's tires were physically restricted or deflated.

Figure 5: Vertical view from right of contact evidence on case vehicle's sun visors and roof (case photo #23)

Figure 6: Unknown body fluids on case vehicle's front right seat back most likely from front right infant passenger (case photo #28a)

Inspection of the case vehicle's interior revealed that there was a scuff (i.e., possibly skin or makeup) along the roof over the driver's seating area and on the driver's sun visor (**Figure 5** above). Scuffs (i.e., possibly skin) were also present along the roof over the front right passenger's seating area and on the front right sun visor (**Figure 5** above). Furthermore, there was an unknown liquid (e.g., saliva from the baby) present on the front surface of the front right seat's back support (**Figure 6**) and there was a scuff on the back surface of the front right seat's back support from contact by the back right passenger (**Figure 7**). There were blood smears to the driver's seat cushion and door sill. In addition, the back surface of the rear view mirror was contacted by the child safety seat and the seat's blanket as a result of the seat being lifted upwards by the deploying front right passenger air bag (**Figure 8**). The right side of the rearview mirror was rotated into the windshield, cracking the glazing. Finally, the upper portion of the steering wheel rim was bent toward the left instrument panel, 1.5 centimeters (0.6 inches), as a result of the driver loading the air bag, momentarily blocking the air bag's forward expansion, and causing the air bag to expand against and bend the steering wheel rim. This contractor was not allowed to pull apart the knee bolster; as a result the energy absorbing shear capsules could not be assessed.

Figure 7: Case vehicle's back seating area showing scuff to front right seat back from unrestrained back right passenger (case photo #28b)

Figure 8: Backside of case vehicle's rearview mirror which was contacted by child safety seat after being lifted upwards by deploying front right passenger's air bag; Note: driver's side of mirror cracked windshield's glazing (case photo #22)

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDMW-4 (0).** The WinSMASH reconstruction program could not be used, first, because of the underride-type impact configuration, and second, because one vehicle is out-of-scope. 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 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 front underride impact with the tractor-trailer. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of roughly asymmetrical "H"-configuration cover flaps made of thick vinyl. The top cover flap was hexagonal in shape with dimensions of 24 centimeters (9.4 inches) along the top horizontal seam and 9 centimeters (3.5 inches) vertically on each side. The bottom cover flap was somewhat rectangular, except that the bottom surface was curvilinear. The width of the horizontal curved bottom dimension was 18 centimeters (7.1 inches) and 5 centimeters (2.0 inches) vertically for each side. 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; however, there was a scuff, possibly previous to this crash, and makeup on the driver air bag module's top cover flap. The driver's air bag was designed with four tethers, each approximately 2 cm (0.8 inches) in width. Each tether was connected to the circular center and stitched to the interior of the driver's air bag. The driver's air bag had two vent ports, approximately 1.5 centimeters (0.6 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 60 centimeters (23.6 inches). Inspection of the deployed driver's air bag indicated that there was blood and a large amount of makeup evidence readily apparent on the front surface of the air bag (**Figure 9**). Specifically, there was a 7 x 9 centimeter (2.8 x 3.5 inch) area of makeup with blood located in the left upper quadrant toward the 10 o'clock position. Furthermore, there was a 9 x 8 centimeter (3.5 x 3.1 inch) area of makeup just outside the center of the air bag in the right upper quadrant toward the 1:30 o'clock position. Finally, there were scattered blood drops located between the center and perimeter of the air bag toward the 6 o'clock position.

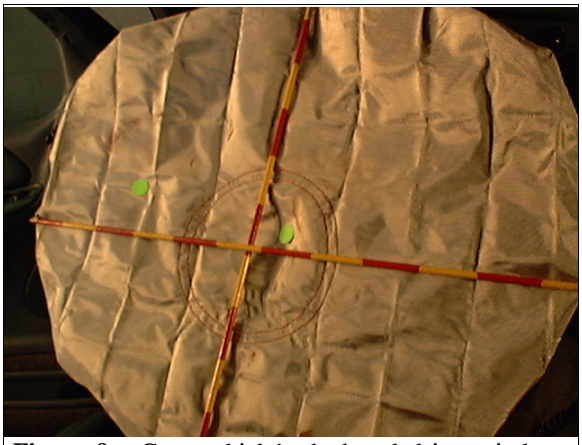


Figure 9: Case vehicle's deployed driver air bag showing areas containing makeup smears (i.e., dots) and blood transfers (case photo #21)

The front right passenger's air bag was located in the middle of the instrument panel. There was a single, essentially rectangular, modular cover flap. The cover flap was made of a thick vinyl over a thick cardboard type frame. The flap's dimensions were 37 centimeters (14.6 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 resulted in a 1 centimeter (0.4 inch) setback of the leading edge of the cover flap relative to the protruding right instrument panel. An inspection of the front right air bag module's cover flap 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; however, the faint outline of the child safety seat's handle could be seen, to the naked eye, transversely across the lower portion of the air bag module's cover flap. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 5 centimeters (2.0 inches) in diameter, located at the 10 and 2 o'clock positions.

The deployed front right air bag was rectangular with a height of approximately 48 centimeters (18.9 inches) and a width of approximately 93 centimeters (36.6 inches). An inspection of the front right air bag revealed no contact evidence readily apparent on the air bag's fabric (**Figures 10** and **11**).

Figure 10: Top surface of case vehicle's deployed front right passenger air bag showing no obvious evidence of damage or contact (case photo #30)

Figure 11: Front surface of case vehicle's deployed front right passenger air bag showing no obvious evidence of damage or contact (case photo #29)

CHILD SAFETY SEAT

The child safety seat was manufactured by Evenflo on May 4, 1995 and was identified by "Joyrider" Model number **203153J1**. This child safety seat was designed to be used as a rearward facing infant seat. The child seat consisted of plastic one-piece shell with a pivoting carrying handle attached to the sides at the mid point of the shell. The shell had a foam pad on the back support portion, providing a soft surface for the infant. The child seat was manufactured with a three-point harness which was attached to the shell, but the infant was not restrained by the seat's available harness at the time of the crash. In addition, the child safety seat was not secured by the available, active, three-point, lap-and-shoulder, safety belt system.

A warning label was affixed to the left side of the child safety seat (i.e., inboard side when used in the rearward facing position) which warned against placing the rearward facing restraint in the front seat of a vehicle that was equipped with a front right passenger air bag. The bright 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 5/95. There was also a manufacturers label affixed to the left side giving the height and weight limitations [i.e., 2.3-9.1 kilograms and 48-66 centimeters (5-20 pounds and 19-26 inches)] as well as a sketch of the seat's proper placement when in the front seat and in the back center seat, using a locking clip. This label was dated 3/93.

A second warning label was affixed to the right side of the child safety seat (i.e., outboard side when used in the rearward facing position) which warned the user to follow the usage instructions and that "failure to follow each of the following instructions can result in your child striking 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. This label was dated 3/93. 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.

There was no discernable damage to the infant child safety seat as a result of this crash (**Figures 12** and **13**).

Figure 12: Backside of case vehicle's infant child safety seat showing no evidence of damage to seat during crash sequence (case photo #42)

Figure 13: Overhead view of interior shell of case vehicle's infant child safety seat showing no evidence of damage to seat during crash; Note: seat cover removed (case photo #44)

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash the case vehicle's front right passenger [61 centimeters and 11 kilograms (24 inches, 24 pounds)] was laying reclined with her back against the back of the rear facing, Evenflo "Joyride," child safety seat (RFCSS). The child safety seat can be converted to an infant carrier. The child's head was pointed toward the right instrument panel and front right air bag module. The child's feet were oriented toward the seat back. The exact position of the child's hands are unknown. This contractor believes that the pre-crash position of the child safety seat in the case vehicle was at an approximate 25 degree angle (i.e., it should have been positioned at a 45 degree angle). Just prior to the crash, the rear facing child safety seat was most likely positioned close to the front right seat back. However, the evidence on the front right air bag module's cover flap indicates that at least on one, if not more, occasions, the child seat had been positioned in this vehicle such that the seat handle was leaning against the front right passenger air bag module's cover flap. This could have occurred because of the way the child seat was placed in the front right position or because the front right seat track was closer to the instrument panel and air bag module. The case vehicle's driver does not recall the exact placement of the child safety seat prior to the crash. When the back of the child seat was located so as to be leaning against the front right air bag module's cover flap, the foot portion of the RFCSS, where the infant's feet would have

Figure 14: Case vehicle's front seating area showing deployed air bags and child safety seat's location in front right seat (case photo #37)

been, would have been located approximately 10.2 centimeters (4 inches) forward of the upright, front right seat back (**Figure 14** above). According to the manufacture's use guidelines, printed on a sticker attached to the seat, the maximum height and weight allowed for a child using this seat is: height up to 66.0 centimeters and weight up to 9.1 kilograms (26 inches and 20 pounds). The front right infant passenger exceeded the weight limitation. The front right seat track was located in its rearmost position.

The case vehicle's front right infant passenger was unrestrained in a rear facing child safety seat which was also not secured by the available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was no evidence of belt pattern bruising or abrasions to the child's body. In addition, the inspection of the front right passenger's seat belt webbing, metal "D"-ring, and latch plate showed no evidence of loading or usage during the crash. An inspection of the Evenflo "Joyride" child safety seat showed no signs of damage from interacting with the front right air bag module's cover flap (**Figure 15**). This strongly supports the notion that at the time of the air bag's deployment, the cover flap missed the child safety seat.

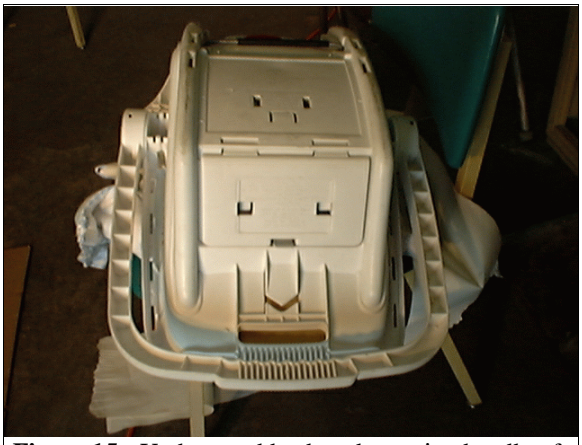


Figure 15: Undamaged back and carrying handle of case vehicle's rear facing child safety seat which was toward front right air bag module's cover flap (case photo #43)

The case vehicle's driver braked, at the last second, attempting to avoid the crash. The driver's braking maneuver, independent of the nonuse of any safety restraint systems–either in the child seat or in the vehicle, had little or no effect on the infant's movement in the child safety seat. In addition, the braking did not cause the back of the child safety seat to move significantly forward toward the front right air bag module's cover flap immediately prior to deployment. The case vehicle's impact with the trailer's underride guard enabled the unsecured rear facing child safety seat, with the unrestrained six-month old, front right infant passenger, to tilt forward and slightly leftward toward the 0 degree Direction of Principal Force as the case vehicle decelerated. Because the damage on the case vehicle was primarily above the bumper, the underride type damage 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). As the air bag deployed, the child safety seat and infant occupant were lifted (i.e., ramped) upwards by the deploying air bag. The top right edge of the child safety seat (from the infant occupant's perspective—front left edge from the case vehicle's perspective) contacted the back right corner of the rearview mirror (**Figure 8** above), knocking the mirror into the windshield, fracturing the glazing. The blanket that was covering the safety seat's infant occupant had a black transfer mark with a flake of black plastic from the rearview mirror still attached. As the air bag attained full deployment, the top back portion of the infant's head and the child safety seat contacted the roof (**Figure 16** below). The infant separated from the child safety seat and was propelled backwards where she most likely struck the top of the front right seat's integral headrest. Next, the infant fell back on top of the rear facing child safety

seat which had fallen to the seat and, finally, tumbled into the floor pan area. At final rest the child was laying in the floor pan of the front right passenger seating position. The case vehicle's driver immediately picked up the infant, held her in her lap, and then called 911. The child safety seat came to rest in the front right seat up against the right instrument panel (**Figure 14** above).

Figure 16: Case vehicle's right sun visor and roof contacts from child safety seat and seat's infant (case photo #26)

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right occupant was transported by ambulance to the hospital. She sustained critical head injuries and was hospitalized prior to being pronounced brain dead approximately 24 hours post-crash. Based on her medical records, she sustained: a critical nonanatomic brain injury with unconsciousness greater than 24 hours; skull fractures involving her posterior basilar fossa, occipital bone with depression, and right parietal bone; severe cerebral edema; hemorrhages, both epidural and subdural, and subarachnoid; and a contusion to her posterior scalp. The infant's injuries were caused by the case vehicle's roof and occurred as a result of the child seat being redirected upward by the deploying 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 with unconsciousness greater than 24 hours; in addition, pupils fixed and dilated, flaccid, unresponsive to painful stimuli, GCS=3	160214.5 critical	Front right roof	Probable	Hospitalization records
2	Fracture into posterior fossa of basilar skull, extending toward foramen magnum	150200.3 serious	Front right roof	Probable	Hospitalization records
3	Fracture, depressed[1], occipital skull	150404.3 serious	Front right roof	Probable	Hospitalization records
4	Fracture right parietal skull	150402.2 moderate	Front right roof	Probable	Hospitalization records
5	Hemorrhage, diffuse, epidural, not further specified [Aspect = Unknown[2]]	140630.4 severe	Front right roof	Probable	Hospitalization records

[1] The inner table on one side of the fracture line, lined-up with the outer table on the other side (i.e., approximately 2-3 millimeters of depression).

[2] The "best fit" aspect is "Posterior".

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
6	Hemorrhage, subdural, on occipital and extending to right parietal, temporal, and frontal aspects; size not specified [Aspect = Right]	140650.4 severe	Front right roof	Probable	Hospitalization records
7	Edema, cerebral, severe[3], location not further specified [Aspect = Unknown]	140674.5 critical	Front right roof	Probable	Hospitalization records
8	Hemorrhage, subarachnoid, extensive, between gyri and sulci	140684.3 serious	Front right roof	Probable	Emergency room records
9	bilaterally with blood surrounding the midbrain[4]; however, the quadrigeminal plate and ambient cisterns are difficult to identify	140684.3 serious	Front right roof	Probable	
10	Contusion {hematoma}, "silver dollar size", posterior scalp	190402.1 minor	Front right roof	Probable	Emergency room records

[3] According to the Death Summary, it was the cerebral edema that resulted in "brain death, loss of brain perfusion". The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:

perfusion (per-fu´zhen): 1. the act of pouring over or through, especially the passage of a fluid through the vessels of a specific organ.

[4] The "best fit" aspect is either "Posterior" or "Inferior" because the subarachnoid hemorrhage is associated with the posterior skull fracture. Even though hemorrhage was noted in both the right and left hemispheres, it appears to be more prominent in-and-around the brain stem and the cisterns between the third and fourth ventricles. The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:

cistern (sis´tern): a closed space serving as a reservoir for fluid; see also *cisterna*.

ambient c.: cisterna ambiens.

cisterna (sis-ter´na) **pl.** ***cister´nae***: a cistern -- a closed space serving as a reservoir for lymph or other body fluid, especially one of the enlarged subarachnoid spaces containing cerebrospinal fluid.

c. am´biens: the subarachnoid space surrounding the midbrain; it connects the cisterna venae magnae cerebri with the cisterna interpeduncularis. Called also *c. mesencephalicum*.

c. interpeduncula´ris: interpeduncular cistern -- a dilatation of the subarachnoid space between the cerebral peduncles; called also *basal cistern*.

c. mesencepha´licum: c. ambiens.

fissure (fish´ar): any cleft or groove, normal or otherwise; especially a deep fold in the cerebral cortex which involves the entire thickness of the brain wall. Compare *sulcus*.

gyrus (ji´ras) pl. ***gyri (ji´ri)***: one of the convolutions of the surface of the brain caused by infolding of the cortex; see ***gyri cerebri***.

g. cerebra´les: cerebral gyri; the tortuous convolutions of the surface of the cerebral hemisphere, caused by infolding of the cortex and separated by the fissures or sulci. Many are constant enough that they have been given special names. Called also *gyri cerebri* and *gyri of cerebrum*.

g. ce´rebri, gyri of cerebrum: gyri cerebrales.

sulcus (sul´kas) pl. ***sul´ci (sul´si)***: a groove, trench, or furrow; a general term for such a depression, especially one of those on the surface of the brain, separating the gyri. Compare *fissure*.

According to the case vehicle's driver [25-year-old, White (Hispanic) female; 168 centimeters and 102 kilograms (66 inches, 225 pounds)], she was seated upright 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. However, based on this contractor's investigation, it is more likely that the driver was applying her makeup just prior to the crash; this would explain why the case vehicle's driver did not see the tractor-trailer slowing in front of her. Therefore, the most likely scenario, in this contractor's opinion, is that the driver was seated leaning forward with her lower back against the seat back, her left foot on the floor, her right foot barely pressing on the brake, her left hand holding the steering wheel rim and her makeup compact, and her right hand holding a brush used to apply the makeup. The driver may also have tried to brace with her left arm. In addition to the makeup evidence found on the air bag's module and fabric (discussed above), there were also makeup accessories in the floor pan on the driver and front right passenger sides. Furthermore, a brush used to apply eye makeup was found on the left instrument panel near the odometer and other gauges. The driver's seat track was located between its middle and forward-most positions, the seat back was upright, and the tilt steering wheel was located in its middle position.

The case vehicle's driver was reportedly restrained by her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was self-reported evidence of belt pattern bruising (i.e., contusions latent to her emergency room visit) to the driver's body that were consistent with restraint usage; however, the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading. This later fact can be explained by the prolonged deployment sequence.

The case vehicle's driver braked, at the last second, attempting to avoid the crash. The driver's braking maneuver, independent of the use of her safety restraint system, had little or no effect on her movement immediately prior to crash. The case vehicle's impact with the trailer's underride guard enabled the driver to move forward and slightly upwards, loading her safety belts, as she moved toward the 0 degree Direction of Principal Force as the case vehicle decelerated. Because the case vehicle's damage was primarily above the bumper, the underride type damage 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). In addition to loading her safety belts, the case vehicle's driver contacted her deploying air bag, depositing on the air bag makeup smears from her compact and blood from the facial abrasions she sustained (**Figure 9** above). In addition, because of her close proximity to the air bag module at the time of the air bag's deployment, the resistance caused by the driver to the air bag's expansion caused the air bag to expand towards the left instrument panel and deform the upper portion of the steering wheel rim. As the air bag deployed, it knocked her makeup kit upwards depositing makeup on the sun visor and roof areas. As the case vehicle was coming to rest, the driver rebounded backwards from the deploying air bag into her seat back. At final rest the driver remained in her seat leaning to the left.

The driver was transported by a relative to the hospital. She sustained minor injuries and was treated and released. According to her interview and medical records, she sustained: abrasions to her lips and chin; contusions to her left shoulder, left upper chest, and across her lower abdomen; and a laceration, requiring 7 stitches, to the webbing of her left hand between her ring and little fingers. The laceration on her hand resulted in blood being present on the driver's air bag, seat cushion, and door sill; however, no blood was found on the seat belt webbing.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasion lips, not further specified	290202.1 minor	Air bag, driver's	Certain	Emergency room records
2	Abrasion chin, location not specified	290202.1 minor	Air bag, driver's	Certain	Emergency room records
3	Contusion left upper chest	490402.1 minor	Torso portion of safety belt system	Probable	Interviewee (same person)
4	Contusion across lower abdomen and hips	590402.1 minor	Lap portion of safety belt system	Probable	Interviewee (same person)
5	Contusion left shoulder	790402.1 minor	Torso portion of safety belt system	Probable	Interviewee (same person)
6	Laceration, small [3.0 cm (1.2 in)], fourth interspace (i.e., between 4th and 5th fingers) left hand	790602.1 minor	Left instrument panel and below	Possible	Emergency room records

CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS

Immediately prior to the crash the case vehicle's driver (i.e., mother) believes that the back right passenger [son; 2-year-old, White (Hispanic) male; 91 centimeters and 18 kilograms (36 inches, 40 pounds)] was seated in an upright posture with his back against the seat back and his feet dangling over the front edge of the seat's cushion, angled downward. However, the exact position of his hands is unknown. His seat track and seat back were not adjustable; although, the seat backs could be folded down.

The case vehicle's back right passenger was not using his available, active, three-point, lap-and-shoulder, safety belt system. The inspection of the back right passenger's seat belt webbing, metal "D"-ring, and latch plate showed no evidence of loading.

The case vehicle's driver braked, at the last second, attempting to avoid the crash. As a result of this "last second" attempted avoidance maneuver and independent of the nonuse of any safety restraint systems, the driver's braking maneuver had little or no affect on the back right passenger's movement immediately prior to crash. The case vehicle's impact with the trailer's

underride guard enabled the unrestrained, two-year-old, back right passenger to move forward out of his seat, toward the 0 degree Direction of Principal Force, and into the back of the front right passenger's seat back as the case vehicle decelerated. At final rest the back right passenger was lying in an unknown position on the floor in front of the back seat.

CASE VEHICLE BACK RIGHT PASSENGER INJURIES

According to the available evidence, he was not transported by ambulance to the hospital and no follow-up medical treatment was sought. Furthermore, he left the scene with a relative. The case vehicle's back right passenger did not sustain any injuries as a result of this crash.

OTHER VEHICLE

The 1990 International COF-9700 was a dual rear wheel drive, 6 x 4, Cab Over Engine (COE), Set Back Axle (SBA) two-passenger (with sleeper cab), two-door, truck-tractor (VIN: 1HSRKGUR6LH------) equipped with a 14.0L, Cummins diesel engine and a thirteen (standard)-speed manual transmission. Braking was achieved by a power-assisted, dual air brake system. The case vehicle's wheelbase and odometer reading are unknown because the truck-tractor was not inspected. The 1981 Great Dane trailer (VIN: 1GRAE9020BS------) was a stainless steel, straight frame, van-dry freight, 13.7 meter (45 foot), two-axle semi-trailer.

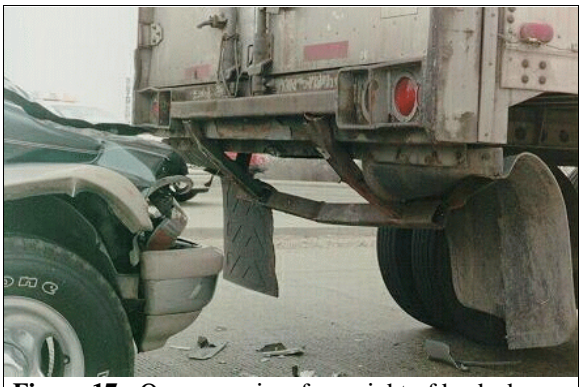
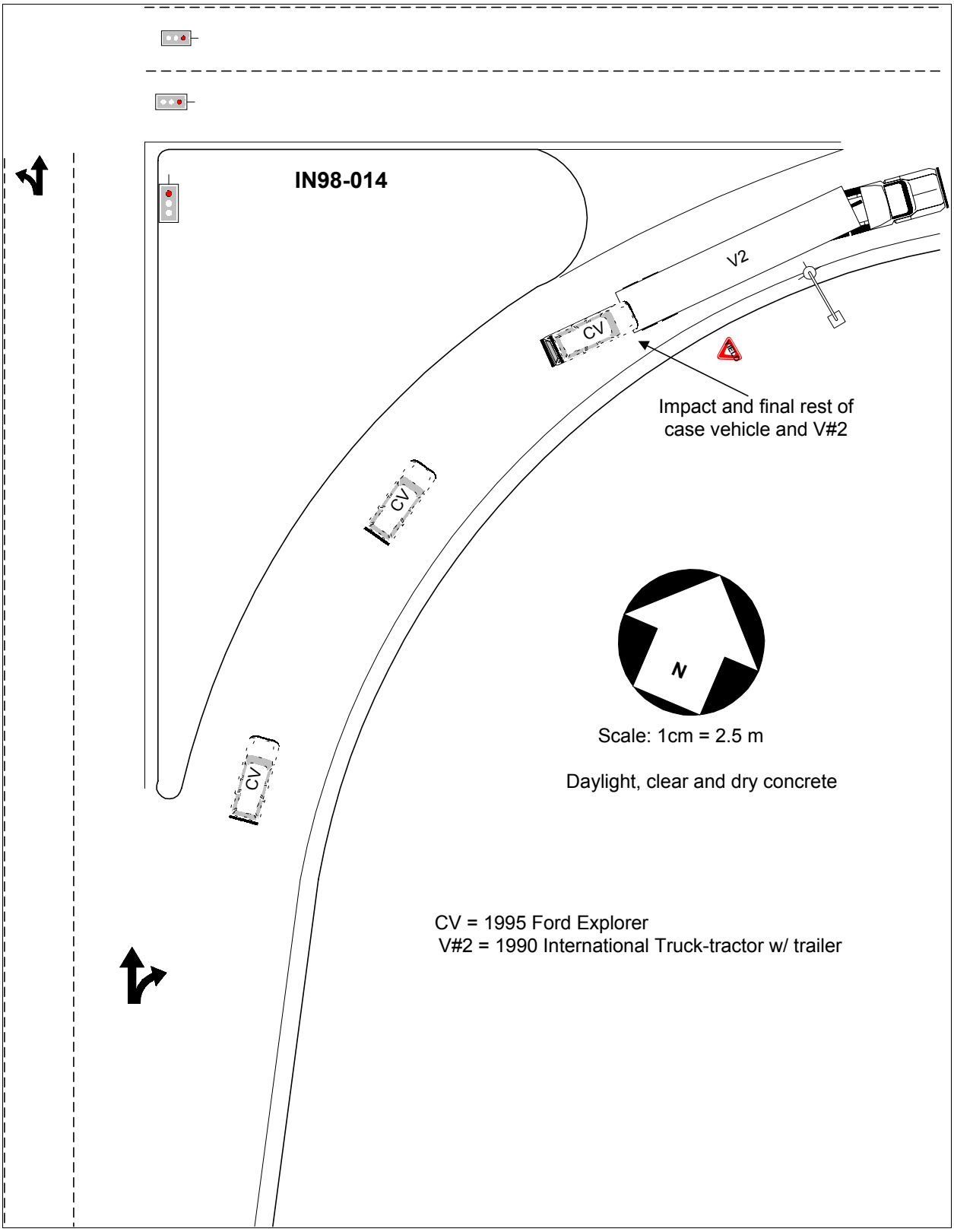


Figure 17: On-scene view from right of back showing Great Dane trailer's deformed underride guard and underride damage to case vehicle's front (case photo #51)

Figure 18: On-scene view from back showing Great Dane's deformed underride guard; Note: broken welds on underride guard (case photo #53)

Based on the available photographs (**Figures 17** and **18**), the direct damage to the trailer involved the back underride guard which was pushed underneath the bed of the trailer. The TDC for tractor-trailer was determined to be: **06-BDLW-A (180)**–maximum crush is unknown. No reconstruction program was used on this crash because this tractor-trailer combination is out-of-scope. The International truck-tractor was driven from the scene.


IN98-014
V2
CV
CV
CV
Impact and final rest of
case vehicle and V#2
N
Scale: 1cm = 2.5 m
Daylight, clear and dry concrete
CV = 1995 Ford Explorer
V#2 = 1990 International Truck-tractor w/ trailer