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ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN98-016
LOCATION - ILLINOIS
VEHICLE - 1995 HYUNDAI SONATA GL
CRASH DATE - February, 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.

Technical Report Documentation Page

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15. *Supplementary Notes*
On-site air bag deployment investigation involving a 1995 Hyundai Sonata GL, four-door sedan, with manual safety belts and dual front air bags, a 1994 Oldsmobile Cutlass Ciera S, and a 1994 Honda Accord LX

16. *Abstract*
This report covers an on-site investigation of an air bag deployment crash that involved a 1995 Hyundai Sonata GL (case vehicle), a 1994 Oldsmobile Cutlass Ciera S (1st Other Vehicle), and a 1991 Honda Accord LX (2nd Other Vehicle). This crash is of special interest because the case vehicle's, unrestrained, front right passenger (4-year-old female), sustained a fatal cervical injury from her deploying front right passenger air bag. The case vehicle was traveling southward in the inside, southbound lane of a four-lane, undivided, city street (i.e., there were two southbound lanes and two northbound lanes). The Honda was traveling ahead of the Oldsmobile, and both had been traveling south in the same lane of the same roadway as the case vehicle when they came to a stop at the four-leg intersection. The crash occurred in the inside southbound lane of the roadway. The front of the case vehicle impacted and underrode the back of the Oldsmobile, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. As a result, the Oldsmobile was pushed forward into the back of the Honda. The police first learned of this crash two hours after it occurred. The front right passenger was presumably seated with her head turned toward the driver and her seat track located between its middle and rearmost positions. She was not using her available, active, three-point, lap-and-shoulder, safety belt system, and sustained, according to her autopsy a laceration of her cervical spinal cord between C_1 and C_2 with atlantoaxial dislocation, diffuse cerebral edema, a right intraventricular hemorrhage, bilateral lacerations to her vertebral arteries, facial abrasions, and a contused anterior neck. This occupant's primary cervical injury was most likely caused by her contact with the case vehicle's front right passenger air bag. The driver (47-year-old female) was presumably seated with her seat track located in its rearmost position, and the tilt steering wheel was located in its upmost position. She was not using her available, active, three-point, lap-and-shoulder, safety belt system and did not sustain any injuries as a result of this crash.

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This on-site investigation was brought to NHTSA's attention on or before February 20, 1998, by one of the NHTSA's regional offices. This crash involved a 1995 Hyundai Sonata GL (case vehicle), a 1994 Oldsmobile Cutlass Ciera S (1st Other Vehicle), and a 1991 Honda Accord LX (2nd Other Vehicle). The crash occurred in February, 1998, at 2:50 p.m., in Illinois, and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's unrestrained, front right passenger [4-year-old, Black (unknown if Hispanic) female], sustained a fatal cervical injury from her deploying front right passenger air bag. This contractor inspected the case vehicle on February 25, 1998, and the scene on February 26, 1998. This contractor was unable to contact any of the drivers involved in this crash. This report is based on the Police Crash Report, inspection of the scene and case vehicle, occupant kinematic principles, the autopsy performed on the case vehicle's front right passenger, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling essentially southward in the inside, southbound lane of a four-lane, undivided, city street and intended to continue its southerly travel path (i.e., there were two southbound lanes and two northbound lanes). Both the Oldsmobile and the Honda had been traveling south in the same lane of the same roadway as the case vehicle. The Honda was ahead of the Oldsmobile. The Oldsmobile and the Honda had both come to a stop at a four-leg intersection, intending to continue in their southerly travel paths once the traffic signal light changed. Based upon the underride impact configuration, the case vehicle's driver most likely braked just prior to the impact, causing the front of her vehicle to dip downwards. According to the Police Crash Report, the case vehicle's driver indicated that she was not aware of the impending collision. The crash occurred in the inside southbound lane of the roadway. The case vehicle's pre-impact travel speed is unknown, whereas the Oldsmobile and the Honda were stopped in traffic.

The front of the case vehicle impacted and underrode the back of the Oldsmobile, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. As a result of the initial crash event, the Oldsmobile was pushed forward causing the front of the Oldsmobile to impact the back of the Honda. According to the Police Crash Report, the police first learned of this crash two hours after it occurred. Consequently all vehicles had been moved before it was investigated. All three vehicles most likely came to rest slightly forward (i.e., southward) from their location at which they were initially struck; see **CRASH DIAGRAM** below.

The 1995 Hyundai Sonata GL was a front wheel drive, four-door sedan (VIN: KMHCF24F5SU------). Four-wheel, anti-lock brakes are an option for this model, but it is unknown if the case vehicle was so equipped. Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-2 (0)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 22.6 km.p.h. (14.0 m.p.h.), -22.6 km.p.h. (-14.0 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). Although the case vehicle was moved from the roadway and parked at the scene, it was towed from its parked location due to damage.

The case vehicle's contact with the Oldsmobile involved almost the entire front surface. Direct damage began at the front left bumper corner and extended, a measured distance of 148 centimeters (58.3 inches), along the front bumper. Maximum crush was measured along the hood edge as 43 centimeters (16.9 inches) at C_1. However, the maximum residual crush was only 19 centimeters (7.5 inches) between C_3 and C_4. The case vehicle's front bumper fascia, grille, hood, radiator, right and left headlight assemblies, left turn signal assembly, and left fender were directly damaged and crushed rearward. None of the case vehicle's tires were physically restricted or deflated. The right turn signal assembly and both the right and left fenders sustained induced damage as well. The sunroof was buckled upward from the roof.

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 with two tethers, each approximately 13 centimeters (5.1 inches) wide, and they were attached to the center circular stitching. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed driver's air bag was elliptical with a height of approximately 53 centimeters (20.9 inches) and a width of approximately 64 centimeters (25.2 inches). Inspection of the driver's air bag revealed a facial makeup smear just outside the center circular stitching toward the 6 o'clock position.

The front right passenger's air bag was located in the middle of the instrument panel (i.e., the air bag module was in transition between the top and middle of the instrument panel, with the majority located in the middle). 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 obvious evidence of damage during the deployment to the air bag module's cover flap. However, there appeared to be some black scuffs on the lower left quadrant [7 x 20 centimeters (2.8 x 7.9 inches)] of the front right air bag's fabric and an area of obliquely oriented scuffs [21 x 20 centimeters (8.3 x 7.9 inches)] on the top surface of the air bag's fabric. These scuffs most likely resulted during the deployment from contact with the underneath surface of the module's cover flap. The front right passenger's air bag was designed with two tethers, each 5 centimeters (2.0 inches) wide and running transversely across the width the air bag's fabric near the top and bottom portions of the bag's front surface. The front right air bag had no vent ports. The deployed front right air bag was rectangular with a height of approximately 42 centimeters (16.5 inches) and a width of approximately 52 centimeters (20.5 inches). An inspection of the front right air bag's fabric revealed that no obvious contact evidence was readily apparent (e.g., oil/skin transfers or blood) on the air bag's front or top surfaces.

Inspection of the case vehicle's interior revealed what appeared to be a body oil transfer to the steering wheel rim. Furthermore, there were transfers, initially suspected to be skin, to the driver's knee bolster and to the front right windshield's glazing. Likewise, it was initially thought that there were four possible contact areas (i.e., body oil and skin transfers) on the front right air bag module's cover flap. However, the available medical evidence does not support direct contact between the front right child passenger and the module's cover flap. Furthermore, there is no deformation to the cover flap that indicates occupant loading. The most solid contact evidence was

found on the sun visors. On the driver's sun visor there was a makeup smudge and on the front right sun visor there appeared to be a blood stain. Furthermore, there was a scrape and a hair deposit on the driver's side of the forward-mounted, overhead interior light controls. In addition, there were suspected body oil transfers on the center instrument panel and right "A"-pillar. The interior inspection found no evidence of intrusion to the occupant compartment and no evidence of loading to the steering column.

The 1994 Oldsmobile Cutlass Ciera S was a front wheel drive, four-door sedan (VIN: 1G3AG55MXR6------). The Oldsmobile was equipped with four-wheel, anti-lock brakes and a driver (only) air bag that reportedly did not deploy. The Oldsmobile was inspected by the police at the driver's residence. Based on the available police photographs, the CDCs for the Oldsmobile are estimated as: **06-BDEW-1 (180)** and **12-FDLN-1 (0)**. The Oldsmobile was driven from the scene.

The 1994 Honda Accord LX was a front wheel drive, four-door sedan (VIN: JHMCD5632RC------). Four-wheel, anti-lock brakes are an option for this model, but it is unknown if the Honda was so equipped. The Honda was equipped with driver and front right passenger supplemental restraints (air bags) which most likely did not deploy because the impact was to this vehicle's back surface. The Honda was not inspected by the police. With no available photographs, the CDC for the Honda was not estimable. The Honda was driven from the scene.

Immediately prior to the crash the exact posture of the case vehicle's front right passenger [4-year-old, Black (unknown if Hispanic) female; 108 centimeters and 20 kilograms (42.5 inches, 45 pounds)] is unknown. Presumably she was seated in a reclined posture with her back against the seat back and her feet dangling over the front edge of the seat's cushion, angled downward. This passenger's head may have been turned toward the driver because a conversation was on-going between them. The exact position of her hands is unknown, but available evidence suggests that she was playing with a musical toy just prior to the crash. According to the vehicle inspection, her seat track was located between its middle and rearmost positions, and the seat back was slightly reclined.

The case vehicle's front right passenger (i.e., granddaughter of driver) was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was no evidence of belt pattern bruising and/or abrasions to the front right passenger's body, and the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no detectable evidence of loading. In addition, the safety belt's webbing had been positioned underneath the inboard side of the front right seat's adjustable head restraint so as to keep the webbing "snug" against the seat back.

According to the Police Crash Report, the case vehicle's driver had turned her head toward the front right passenger and was conversing with her about tying the child's shoes. As a result, the driver indicated that she was unaware of the impending impact; however, based on the case vehicle's underride damage pattern, the case vehicle's driver most likely braked sharply just prior to the crash. As a result of this attempted avoidance maneuver and the nonuse of the front right passenger's available safety belts, the front right passenger most likely moved forward and upward

just prior to impact. The case vehicle's impact with the Oldsmobile enabled the case vehicle's front right passenger to continue forward and upward toward the case vehicle's **0** degree Direction of Principal Force as the case vehicle decelerated. Because the damage on the case vehicle was primarily above the bumper and produced an underride impact pattern, this 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). This delay also enable the front right passenger to be near the front right air bag module at the moment of deployment. In this contractor's opinion, based on the available evidence, the child passenger, who was most likely moving head-first toward the air bag module, impacted the air bag as it was deploying causing this passenger's fatal cervical lesions. Furthermore, as the child loaded the air bag it caused the top surface of the bag to expand against the underneath surface of the air bag module's cover flap causing the observed striations. In addition, the air bag served as a ramp, redirecting the child upwards into the front right sun visor. The child's musical toy most likely flew out of the child's grip striking the windshield's glazing in a narrow point contact, passing over the module's cover flap before it deployed. The child may or may not have also contacted the right "A"-pillar with an extremity during her upward movement. As the case vehicle decelerated to rest, the front right passenger rebounded backwards into her seat back. After striking her seat back she moved back forwards into the front foot well area where, according to the Police Crash Report, she was reportedly observed at final rest. The front right passenger's exact posture at final rest is unknown.

The front right occupant was removed from the vehicle by the case vehicle's driver and/or other family, who were following the case vehicle. She was transported by private vehicle to a nearby hospital. The child was subsequently transferred to a trauma center and hospitalized. She sustained fatal injuries and was pronounced brain dead 7½ hours post-crash. The injuries sustained by the case vehicle's front right passenger included: a laceration of her cervical spinal cord between C_1 and C_2 with atlantoaxial dislocation, diffuse cerebral edema, a right intraventricular hemorrhage, bilateral lacerations to her vertebral arteries, facial abrasions, and a contused anterior neck. This occupant's primary cervical injury was most likely caused by her contact with the case vehicle's front right passenger air bag.

The exact posture of the case vehicle's driver [47-year-old, (unknown race and or ethnic origin) female; unknown height and weight] is unknown. Presumably, she was seated in a reclined posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and at least one of her hands on the steering wheel. Her seat track was located in its rearmost position, the seat back was slightly reclined, and the tilt steering wheel was located in its upmost position.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. Inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no detectable evidence of loading; however, there was evidence (i.e., a crease) on the webbing that indicated that this belt has been used in the past. The driver (i.e., grandmother) was transported (i.e., accompanied the front right passenger) by private vehicle to the hospital. The case vehicle's driver did not sustain any injuries as a result of this crash.

The Oldsmobile's driver [27-year-old (unknown race and/or ethnic origin) male; unknown height and weight] was indicated to have been wearing his available, active, three-point, lap and shoulder belt. He reportedly sustained no injuries and, thus, was not transported to a medical facility.

The restraint, injury, and transport status of the Honda's driver [20-year-old (unknown race and/or ethnic origin) male; unknown height and weight] was not reported on the Police Crash Report. Based on the available evidence, he sustained no injuries and, thus, did not seek medical attention.

CRASH CIRCUMSTANCES

Figure 1: Follow-up police photo looking south-southeastward at approximate location of impact in inside southbound lane (case photo #01)

The case vehicle was traveling essentially southward in the inside, southbound lane of a four-lane, undivided, city street (**Figure 1**) and intended to continue its southerly travel path (i.e., there were two southbound lanes and two northbound lanes). Both the Oldsmobile and the Honda had been traveling south in the same lane of the same roadway as the case vehicle. The Honda was ahead of the Oldsmobile. The Oldsmobile and the Honda had both come to a stop at a four-leg intersection, intending to continue in their southerly travel paths once the traffic signal light changed. Based upon the underride impact configuration, the case vehicle's driver most likely braked just prior to the impact, causing the front of her vehicle to dip downwards. According to the Police Crash Report, the case vehicle's driver indicated that she was not aware of the impending collision. The crash occurred in the inside southbound lane of the roadway. The case vehicle's pre-impact travel speed is unknown, whereas the Oldsmobile and the Honda were stopped in traffic.

Figure 2: Follow-up police photo of case vehicle's frontal damage from impact with Oldsmobile; Note: classic underride damage pattern and scrapes on top of bumper (case photo #03)

The city roadway was straight and level at the area of impact. The pavement was bituminous, but traveled and worn, and the width of the inside southbound lane for all three vehicles was 3.8 meters (12.5 feet). The roadway was bordered by barrier curbs. Pavement markings consisted of a double solid yellow centerline for both north and southbound traffic, and the lanes were divided by a dashed white line (**Figure 1**). In addition, no edge lines were present. The estimated coefficient of friction was 0.60. At least four on-colors, pre-timed, vertically mounted traffic control signals were located near the intersection controlling southbound traffic. 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 clear, and the road pavement was dry. Traffic density is unknown but was most likely moderate to heavy, and the site of the crash was urban commercial.

Figure 3: Follow-up police photo of case vehicle's front underride damage from impact with Oldsmobile viewed from left of front; Note: radiator leakage on pavement (case photo #04)

The front (**Figure 2** above and **Figure 3**) of the case vehicle impacted and underrode the back (**Figure 4**) of the Oldsmobile, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. As a result of the initial crash event, the Oldsmobile was pushed forward causing the front of the Oldsmobile to impact the back of the Honda. According to the Police Crash Report, the police first learned of this crash **two hours** after it occurred. Consequently all vehicles had been moved before it was investigated. All three vehicles most likely came to rest slightly forward (i.e., southward) from their location at which they were initially struck; see **CRASH DIAGRAM** below.

Figure 4: Damage to Oldsmobile's back bumper; Note: override damage pattern and radiator fluid stains on top surface of bumper (case photo #54)

CASE VEHICLE

The 1995 Hyundai Sonata GL was a front wheel drive, five-passenger, four-door sedan (VIN: KMHCF24F5SU------) equipped with a 2.0L, L-4 engine, and a four-speed automatic transmission. Four-wheel, anti-lock brakes are an option for this model, but it is unknown if the case vehicle was so equipped. The case vehicle's wheelbase was 270 centimeters (106.3 inches), and the odometer reading at inspection was 78,694 kilometers (48,898 miles).

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable back bench seat with a folding back and integral head restraints for the back outboard seating positions; continuous loop, three-point, lap-and-shoulder, safety belt systems at the front and back outboard positions; and a two-point, lap belt system at the back center position. The front seat belt systems were not 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 were deformed. 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 underride impact with the Oldsmobile.

Figure 5: Case vehicle's frontal damage viewed from right of front in tow yard; Note: underride damage pattern and scrapes on top of front bumper (case photo #23)

Figure 6: Case vehicle's frontal damage viewed from left of front in tow yard; Note: underride damage pattern and scrapes on top of front bumper (case photo #05)

The case vehicle's contact with the Oldsmobile involved almost the entire front surface (**Figures 5** and **6**). Direct damage began at the front left bumper corner and extended, a measured distance of 148 centimeters (58.3 inches), along the front bumper. Maximum crush was measured along the hood edge as 43 centimeters (16.9 inches) at C_1. However, the maximum residual crush was only 19 centimeters (7.5 inches) between C_3 and C_4. The case vehicle's front bumper fascia, grille, hood, radiator, right and left headlight assemblies, left turn signal assembly, and left fender were directly damaged and crushed rearward. None of the case vehicle's tires were physically restricted or deflated. The right turn signal assembly and both the right and left fenders sustained induced damage as well. The sunroof was buckled upward from the roof.

Figure 7: Case vehicle's driver seating area showing possible contact evidence on driver's knee bolster and steering wheel rim (case photo #26)

Figure 8: Case vehicle's deployed driver air bag and driver's greenhouse area showing contact to driver's sun visor and possible contact evidence on center instrument panel area (case photo #29)

Inspection of the case vehicle's interior revealed what appeared to be a body oil transfer to the steering wheel rim (**Figure 7**). Furthermore, there were transfers, initially suspected to be skin, to the driver's knee bolster (**Figure 8**) and to the front right windshield's glazing (**Figure 9** below). Likewise, it was initially thought that there were four possible contact areas (i.e., body

oil and skin transfers) on the front right air bag module's cover flap (**Figure 10**). However, the available medical evidence does not support direct contact between the front right child passenger and the module's cover flap. Furthermore, there is no deformation to the cover flap that indicates occupant loading. The most solid contact evidence was found on the sun visors. On the driver's sun visor there was a makeup smudge (**Figure 8** above) and on the front right sun visor there appeared to be a blood stain (**Figure 11**). Furthermore, there was a scrape and a hair deposit on the driver's side of the forward-mounted, overhead, interior light controls (**Figure 8** above). In addition, there were suspected body oil transfers on the center instrument panel (**Figure 8** above) and right "A"-pillar (**Figure 9**). The interior inspection found no evidence of intrusion to the occupant compartment and no evidence of loading to the steering column.

Figure 9: Case vehicle's deployed front right passenger air bag and greenhouse area showing contact evidence on front right sun visor, contacts to windshield's glazing, and possible evidence of contact to right "A"-pillar and front right air bag module's cover flap (case photo #34)

Figure 10: Case vehicle's deployed front right air bag and what was initially thought to be contact evidence on air bag module's cover flap and right instrument panel (case photo #40)

Figure 11: Close-up of blood stain evidence on case vehicle's front right sun visor from contact by front right passenger (case photo #35)

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-2 (0)**. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 22.6 km.p.h. (14.0 m.p.h.), -22.6 km.p.h. (-14.0 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). Although the case vehicle was moved from the roadway and parked at the scene, it was towed from its parked location due to damage.

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 front underride impact with the Oldsmobile. 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 19.5 centimeters (7.7 inches) at the horizontal seam and 7 centimeters (2.8 inches) vertically. 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 with two tethers, each approximately 13 centimeters (5.1 inches) wide, and they were attached to the center circular stitching. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed driver's air bag was elliptical with a height of approximately 53 centimeters (20.9 inches) and a width of approximately 64 centimeters (25.2 inches). Inspection of the driver's air bag revealed a facial makeup smear just outside the center circular stitching toward the 6 o'clock position (**Figure 12**).

Figure 12: Case vehicle's deployed driver air bag showing makeup smear (arrow) at bottom of center circular stitching (case photo #46)

The front right passenger's air bag was located in the middle of the instrument panel (i.e., the air bag module was in transition between the top and middle of the instrument panel, with the majority located in the middle). There was a single, essentially rectangular, modular cover flap. The cover flap was made of a thick vinyl over a thick cardboard type frame which acted as the hinge point for the deploying flap. The flap's dimensions were 34.5 centimeters (13.6 inches) at the lower horizontal seam and 20 centimeters (7.9 inches) along both vertical seams. The profile of the case vehicle's instrument panel was flush with the leading edge of the cover flap. An inspection of the front right air bag module's cover flap and air bag revealed that the cover flap opened at the designated tear points, and there was no obvious evidence of damage during the deployment to the air bag module's cover flap. However, there appeared to be some black scuffs on the lower left quadrant [7 x 20 centimeters (2.8 x 7.9 inches)] of the front right air bag's fabric and an area of obliquely oriented scuffs [21 x 20 centimeters (8.3 x 7.9 inches)] on the top surface of the air bag's fabric (**Figure 13**). These scuffs most likely resulted during the deployment from contact with the underneath surface of the module's cover flap. The front right passenger's air bag was designed with two tethers, each 5 centimeters (2.0 inches) wide and running transversely across the width the air bag's fabric near the top and bottom portions of the bag's front surface. The front right air bag had no vent ports. The deployed front right air bag was rectangular with a height of approximately 42 centimeters (16.5 inches) and a width of approximately 52

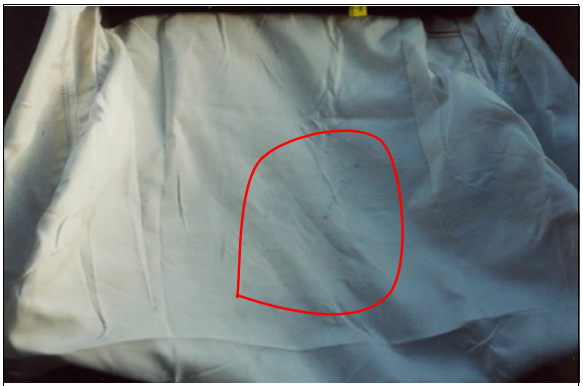

Figure 13: Top surface of case vehicle's deployed front right passenger air bag; Note: friction scuffs most likely from underneath surface of module's cover flap (case photo #52)

centimeters (20.5 inches). An inspection of the front right air bag's fabric revealed that no obvious contact evidence was readily apparent (e.g., oil/skin transfers or blood) on the air bag's front or top surfaces (**Figure 14**).

Figure 14: Front surface of case vehicle's deployed front right passenger air bag showing no obvious evidence of occupant contact and likely friction scuffs in left lower quadrant from module's cover flap (case photo #49)

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash the exact posture of the case vehicle's front right passenger [4-year-old, Black (unknown if Hispanic) female; 108 centimeters and 20 kilograms (42.5 inches, 45 pounds)] is unknown. Presumably she was seated in a reclined posture with her back against the seat back and her feet dangling over the front edge of the seat's cushion, angled downward. This passenger's head may have been turned toward the driver because a conversation was on-going between them. The exact position of her hands is unknown, but available evidence suggests that she was playing with a musical toy just prior to the crash. According to the vehicle inspection, her seat track was located between its middle and rearmost positions, and the seat back was slightly reclined.

The case vehicle's front right passenger (i.e., granddaughter of driver) was not using her available, active, three-point, lap-and-shoulder, safety belt system. Furthermore, there was no evidence of belt pattern bruising and/or abrasions to the front right passenger's body, and the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no detectable evidence of loading. In addition, the safety belt's webbing had been positioned underneath the inboard side of the front right seat's adjustable head restraint so as to keep the webbing "snug" against the seat back (**Figure 15**).

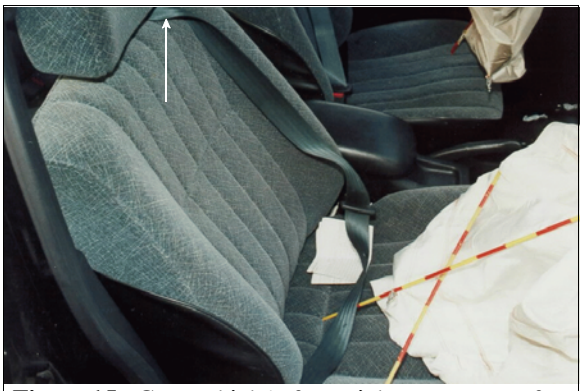

Figure 15: Case vehicle's front right passenger safety belt showing belt's webbing routed underneath seat's adjustable head restraint (case photo #43)

According to the Police Crash Report, the case vehicle's driver had turned her head toward the front right passenger and was conversing with her about tying the child's shoes. As a result, the driver indicated that she was unaware of the impending impact; however, based on the case vehicle's underride damage pattern, the case vehicle's driver most likely braked sharply just prior to the crash. As a result of this attempted avoidance maneuver and the nonuse of the front right passenger's available safety belts, the front right passenger most likely moved forward and upward just prior to impact. The case vehicle's impact with the Oldsmobile enabled the case vehicle's front right passenger to continue forward and upward toward the case vehicle's **0** degree Direction of Principal Force as the case vehicle decelerated. Because the damage on the case vehicle was

primarily above the bumper and produced an underride impact pattern, this 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). This delay also enable the front right passenger to be near the front right air bag module at the moment of deployment. In this contractor's opinion, based on the available evidence, the child passenger, who was most likely moving head-first toward the air bag module, impacted the air bag as it was deploying causing this passenger's fatal cervical lesions. Furthermore, as the child loaded the air bag it caused the top surface of the bag to expand against the underneath surface of the air bag module's cover flap causing the observed striations (**Figure 13** above). In addition, the air bag served as a ramp, redirecting the child upwards into the front right sun visor (**Figure 11** above). The child's musical toy most likely flew out of the child's grip striking the windshield's glazing in a narrow point contact (**Figure 9** above), passing over the module's cover flap before it deployed. The child may or may not have also contacted the right "A"-pillar with an extremity during her upward movement. As the case vehicle decelerated to rest, the front right passenger rebounded backwards into her seat back. After striking her seat back she moved back forwards into the front foot well area where, according to the Police Crash Report, she was reportedly observed at final rest. The front right passenger's exact posture at final rest is unknown. In addition to the child, her shoes and the musical toy also came to rest in the front right wheel well area (**Figure 16**).

Figure 16: Floor pan area of case vehicle's front right seating position showing musical toy that most likely fractured windshield's glazing and child's shoes that were the object of conversation that precipitated the crash (case photo #45)

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right occupant was removed from the vehicle by the case vehicle's driver and/or other family, who were following the case vehicle. She was transported by private vehicle to a nearby hospital. The child was subsequently transferred to a trauma center and hospitalized. She sustained fatal injuries and was pronounced brain dead 7½ hours post-crash. The injuries sustained by the case vehicle's front right passenger included: a laceration of her cervical spinal cord between C_1 and C_2 with atlantoaxial dislocation, diffuse cerebral edema, a right intraventricular hemorrhage, bilateral lacerations to her vertebral arteries, facial abrasions, and a contused anterior neck. This occupant's primary cervical injury was most likely 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	Laceration {transection} of cervical spinal cord at level of C_1-C_2 with 3 cm (1.2 in) atlantoaxial dislocation (i.e., C_1 displaced posteriorly, relative to C_2	640274.6 untreatable	Air bag, front right passenger's	Probable	Autopsy
2	Edema, diffuse, cerebrum with diffuse softening and flattening of gyri[1]	140668.3 serious	Air bag, front right passenger's	Probable	Autopsy
3	Hemorrhage, small, right intraventricular	140678.4 severe	Air bag, front right passenger's	Probable	Autopsy
4 5	Laceration {disruption[2]} bilateral vertebral arteries with large {unquantified} neck fluid accumulation	321006.2 moderate 321006.2 moderate	Air bag, front right passenger's	Certain	Autopsy
6	Abrasion right cheek, just in front of ear	290202.1 minor	Air bag, front right passenger's	Certain	Autopsy
7	Abrasions right corner of mouth and right chin	290202.1 minor	Air bag, front right passenger's	Certain	Autopsy
8	Contusion across anterior neck, just above thyroid cartilage	390402.1 minor	Air bag, front right passenger's	Certain	Autopsy

CASE VEHICLE DRIVER KINEMATICS

The exact posture of the case vehicle's driver [47-year-old, (unknown race and or ethnic origin) female; unknown height and weight] is unknown. Presumably, she was seated in a reclined posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and at least one of her hands on the steering wheel. Her seat track was located in its rearmost position, the seat back was slightly reclined, and the tilt steering wheel was located in its upmost position.

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[1] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
gyrus (jī′ras) pl. ***gyri (jī′rī)***: 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.

[2] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
disruption (dis-rup′shen): [L *diruptio* a bursting apart] a morphologic defect of an organ or larger region of the body, resulting from the extrinsic breakdown of, or interference with, an originally normal developmental process.
disruptive (dis-rup′tiv): bursting apart; rending.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. Inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no detectable evidence of loading; however, there was evidence (i.e., a crease) on the webbing that indicated that this belt has been used in the past (**Figure 17**).

Figure 17: Case vehicle's driver safety belt showing recent (i.e., arrow points to crease in webbing) evidence of usage but not evidence of usage in this crash (case photo #42)

According to the Police Crash Report, the case vehicle's driver had turned her head toward the front right passenger and was conversing with her about tying the child's shoes. As a result, the driver indicated that she was unaware of the impending impact; however, based on the case vehicle's underride damage pattern, the case vehicle's driver most likely braked sharply just prior to the crash. As a result of this attempted avoidance maneuvers and the nonuse of her available safety belts, the driver most likely moved forward and upward just prior to impact. The case vehicle's impact with the Oldsmobile enabled the case vehicle's driver to continue forward and upward toward the case vehicle's **0** degree Direction of Principal Force as the case vehicle decelerated. Because the damage on the case vehicle was primarily above the bumper and produced an underride impact pattern, this 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). This delay also enable the driver to move closer to her air bag module at the moment of deployment. Because the case vehicle was moved by someone (e.g., a relative) from its impact location to a location near the impact where the police inspected it, the location of the driver's seat track during this contractor's inspection could have been misleading. However, without knowing the driver's height, the seat track location at inspection is the most reliable information available. Furthermore, the lack of reported injuries to the driver in conjunction with the delayed nature of the deployment supports the notion that the air bag reach its maximum excursion before being contacted by the forward-moving driver and, thus, her seat track was at least close to where it was observed. In this contractor's opinion, based on the available evidence, the unrestrained driver impacted the deploying air bag with her face and the driver's knee bolster with her knees. She deposited a makeup smear on the front surface of the air bag and a scuff on the knee bolster. Also, the air bag, in conjunction with the driver's forward motion, lifted the driver upwards into the driver's sun visor. In addition, she may have contacted the roof near the forward-mounted, overhead, interior light controls. However, without any reported injuries, no association can be established with these suspected occupant contact areas.

The driver (i.e., grandmother) was transported (i.e., accompanied the front right passenger) by private vehicle to the hospital. The case vehicle's driver did not sustain any injuries as a result of this crash.

The 1994 Oldsmobile Cutlass Ciera S was a front wheel drive, six-passenger, four-door sedan (VIN: 1G3AG55MXR6------) equipped with a 3.1L, V-6 engine, and a four-speed automatic transmission. Four-wheel, anti-lock brakes are standard equipment for this model. The Oldsmobile was equipped with a driver (only) supplemental restraint (air bag) which most likely did not deploy because, based on the available police photograph, the velocity exchange (i.e., Delta V) to the Oldsmobile's front was below the Oldsmobile's deployment threshold (**Figure 18**). The 1st other vehicle's wheelbase was 266 centimeters (104.9 inches), and the odometer reading is unknown because this vehicle was not inspected.

The Oldsmobile was inspected by the police at the driver's residence. Based on the available police photographs (**Figure 4** above and **Figure 18**), the CDCs for the Oldsmobile are estimated as: **06-BDEW-1 (180)** and **12-FDLN-1 (0)**. The Oldsmobile was driven from the scene.

Figure 18: Oldsmobile's frontal damage from subsequent impact with back of Honda (case photo #55)

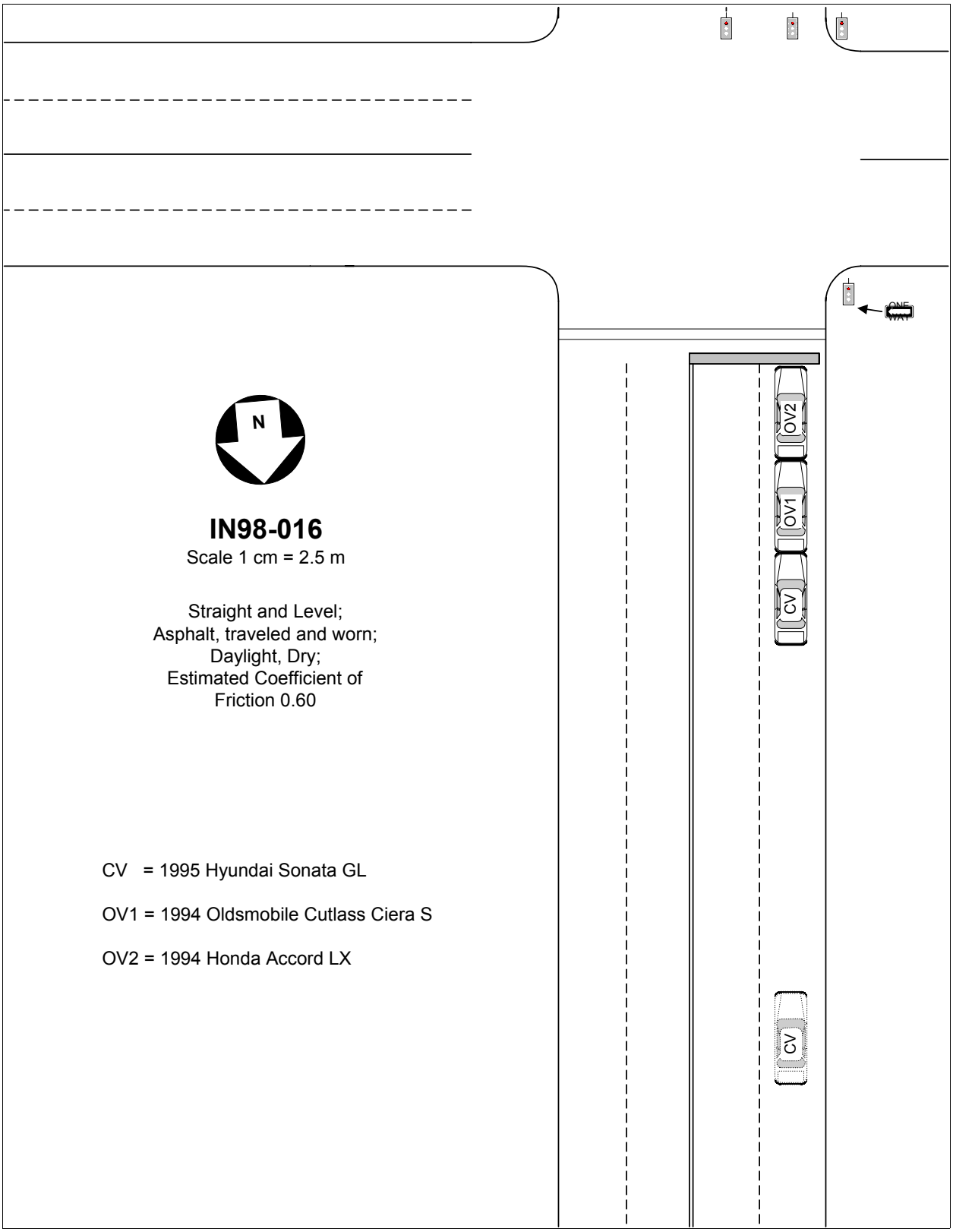
The Oldsmobile's driver [27-year-old (unknown race and/or ethnic origin) male; unknown height and weight] was indicated to have been wearing his available, active, three-point, lap and shoulder belt. He reportedly sustained no injuries and, thus, was not transported to a medical facility.

2ND OTHER VEHICLE

The 1994 Honda Accord LX was a front wheel drive, five-passenger, four-door sedan (VIN: JHMCD5632RC------) equipped with a 2.2L, I-4 engine, and a four-speed automatic transmission. Four-wheel, anti-lock brakes are an option for this model, but it is unknown if the Honda was so equipped. The Honda was equipped driver and front right passenger supplemental restraints (air bags) which most likely did not deploy because of the impact was to this vehicle's back surface. The 2nd other vehicle's wheelbase was 272 centimeters (106.9 inches), and the odometer reading is unknown because this vehicle was not inspected.

The Honda was not inspected by the police. With no available photographs, a CDC for the Honda was not estimable. The Honda was driven from the scene.

The restraint, injury, and transport status of the Honda's driver [20-year-old (unknown race and/or ethnic origin) male; unknown height and weight] was not reported on the Police Crash Report. Based on the available evidence, he sustained no injuries and, thus, did not seek medical attention.


N
IN98-016
Scale 1 cm = 2.5 m
Straight and Level;
Asphalt, traveled and worn;
Daylight, Dry;
Estimated Coefficient of
Friction 0.60
CV = 1995 Hyundai Sonata GL
OV1 = 1994 Oldsmobile Cutlass Ciera S
OV2 = 1994 Honda Accord LX
ONE WAY
OV2
OV1
CV
CV