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# ON-SITE ADAPTIVE EQUIPMENT INVESTIGATION

CASE NUMBER - IN97-038
LOCATION - MINNESOTA
VEHICLE - 1992 TOYOTA CELICA
CRASH DATE - November, 1997

Submitted:

September 21, 1999
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Contract Number: DTNH22-94-D-17058


Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
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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*<br>On-site air bag deployment investigation involving a 1992 Toyota Celica ST, two-door coupe, with manual safety belts and dual front air bags, and a 1993 Plymouth Voyager SE minivan. | | | |
| 16. *Abstract*<br>This report covers an on-site investigation of an air bag deployment crash that involved a 1992 Toyota Celica ST (case vehicle) and a 1993 Plymouth Voyager SE (vehicle #2). This crash is of special interest because the case vehicle was equipped with adaptive controls **and** the case vehicle's, unrestrained, short statured driver (17-year-old female) sustained a fatal neck injury from her deploying driver air bag. The case vehicle was traveling north in the inside, northbound lane of a four-lane, undivided, city roadway. Vehicle #2 was also traveling north, in the inside, northbound lane of the same, four-lane, undivided roadway and had stopped waiting to make a left turn into an intersecting roadway. The crash occurred in the inside northbound lane, within the three-leg intersection of the two roadways. The front of the case vehicle impacted the back of vehicle #2, causing the case vehicle's driver supplemental restraint (air bag) to deploy. The case vehicle's driver was seated with her seat track located in its forward-most position, and the steering wheel was located in its down-most position. The case vehicle was equipped with adaptive controls that extended the brake and accelerator pedals within reach of the driver's feet. She was not wearing her available, active, three-point, lap-and-shoulder, safety belt system, and sustained, according to her medical records, fatal injuries which included: minimal diffuse subdural and subarachnoid hemorrhages, minimal cerebral cortical contusions, fractures of the laryngeal cartilages, a minimal atlanto-occipital dislocation without trauma to the spinal cord, abrasions and superficial lacerations to her neck, and a chest contusion. Based on an interview with the Medical Examiner, the driver died of asphyxiation resulting from the swelling and soft tissue hemorrhage/hematoma in her neck that compressed her larynx. The front right passenger in the case vehicle (16-year-old female) was seated with her seat track located in its middle position and was not wearing her available, active, three-point, lap-and-shoulder, safety belt system. She sustained, according to her interview, minor injuries which included: a contused and lacerated lip and a contusion to the top back of her head. | | | |
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## BACKGROUND

IN97-038

This on-site investigation was brought to NHTSA's attention on November 5, 1997 by a reporter with a Minnesota newspaper. This crash involved a 1992 Toyota Celica ST (case vehicle) and a 1993 Plymouth Voyager SE (vehicle #2). The crash occurred in November, 1997, at 5:56 p.m., in Minnesota and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with adaptive controls **and** the case vehicle's short statured driver [17-year-old, White (non-Hispanic) female] sustained a fatal neck injury from her deploying driver air bag. This contractor inspected the scene and vehicles on November 11, 1997. This contractor interviewed the case vehicle's front right passenger on November 12, 1997. This summary is based on the Police Crash Report; interviews with the driver of vehicle #2, the case vehicle's front right passenger, the investigating police officer, and the Medical Examiner; scene and vehicle inspections; occupant kinematic principles; occupant medical records; and this contractor's evaluation of the evidence.

## SUMMARY

The case vehicle was traveling north in the inside, northbound lane of a four-lane, undivided, city roadway and intended to continue traveling northbound. Vehicle #2 was also traveling north, in the inside, northbound lane of the same, four-lane, undivided roadway and had stopped intending on making a left turn into an intersecting roadway. The case vehicle's driver made no avoidance maneuvers prior to the crash. The crash occurred in the inside northbound lane, within the three-leg intersection of the two roadways (see **CRASH DIAGRAM** below).

The front of the case vehicle impacted the back of vehicle #2, causing the case vehicle's driver supplemental restraint (air bag) to deploy. The case vehicle rotated approximately 20 degrees counterclockwise while moving slightly northward and came to rest in the inside northbound lane heading north-northwest. Vehicle #2 was knocked north-northwestward, approximately 38 meters (124.7 feet), into the inside southbound lane, but vehicle #2's driver drove his vehicle back, approximately 3.0 meters (10 feet), into the inside northbound lane where he brought it to rest to avoid being hit head-on by oncoming traffic.

The case vehicle's driver was short statured [119 centimeters and 40 kilograms (47 inches, 89 pounds)]. As a result the case vehicle was equipped with adaptive extenders on the accelerator and brake pedals. The driver was not wearing her available, active, three-point, lap and shoulder belt. In addition, there was no evidence of belt pattern bruising and/or abrasions to the driver's body, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading.

The case vehicle's driver made no known pre-crash avoidance maneuvers. Based on interview with the case vehicle's front right passenger, there was some question regarding the physical condition of the case vehicle's driver immediately prior to the crash. The front right passenger stated that the driver did not respond to her two verbal warnings of the impending crash, and she also felt and heard the case vehicle accelerate prior to the crash. Two scenarios are: the driver panicked and pressed on the accelerator instead of the brake, or the driver was incapacitated (i.e., blacked out) prior to the crash. According to the Medical Examiner, there was nothing

found during the autopsy that would indicate that the driver was incapacitated, and she had no medical history of any episodes of blacking out. This contractor believes that the case vehicle's driver most likely hit the accelerator instead of the brake pedal. As a result and independent of the nonuse of her available safety belts, her pre-impact body position did not change just prior to impact.

The case vehicle's impact with vehicle #2 enabled the case vehicle's driver to continue forward and slightly upward as the case vehicle decelerated. It should be noted that the distance from the driver's seat back to the steering wheel hub was 43 centimeters (16.9 inches), which includes 5 centimeters (2.0 inches) of steering wheel compression. In addition, the length of the driver's arms was approximately 30 centimeters (11.8 inches) which would have placed the driver extremely close to the driver air bag module. Due to the driver's extreme close proximity, the driver directly contacted the module's cover flaps with her chest, blocking the air bag's normal deployment path. This caused the deploying air bag to find subsequent avenues to deploy which resulted in the top cover flap being completely blown off the air bag module. The top front edge of the deploying air bag caught the case vehicle's driver in her neck and underneath her chin, causing the neck and most likely her brain injuries. As the air bag continued to deploy, it lifted the driver upwards where she contacted the sun visor prior to rebounding back into her seat. At final rest the driver was seated upright in her seat, her back against the seat back, her head tilted forward, and her body tilted slightly to the right.

The driver was transported by ambulance to the hospital. She sustained fatal injuries and was pronounced dead 57 minutes post-crash. According to her medical records, the injuries sustained by the case vehicle's driver included: minimal diffuse subdural and subarachnoid hemorrhages, minimal cerebral cortical contusions, fractures of the laryngeal cartilages, a minimal atlanto-occipital dislocation without trauma to the spinal cord, abrasions and superficial lacerations to her neck, and a chest contusion. Based on an interview with the Medical Examiner, the driver died of asphyxiation resulting from the swelling and soft tissue hemorrhage/hematoma in her neck that compressed her larynx.

The case vehicle was a front wheel drive 1992 Toyota Celica ST, two-door coupe (VIN: JT2AT86F9NO------). The case vehicle was not equipped with anti-lock brakes. Vehicle #2 is a front wheel drive 1993 Plymouth Voyager SE, four-door minivan (VIN: 2P4GH45R8PR------). The case vehicle was towed due to damage; vehicle #2 was driven from the scene. Based on the vehicle inspections the CDCs were determined to be: **12-FYEW-1 (360)** for the case vehicle [maximum crush was 30 centimeters (11.8 inches)] and **06-BZEW-1 (+180)** for vehicle #2 [maximum crush was 10 centimeters (3.9 inches)]. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 22.8 km.p.h. (14.2 m.p.h.), -22.8 km.p.h. (-14.2 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.).

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, but the top cover flap was torn off the air bag module due to the driver blocking the air bag's path during the deployment. Furthermore, there appeared to be blue cloth transfers to

the driver air bag module's top and bottom cover flaps. In addition, the inspection revealed evidence of damage during the deployment to the air bag [i.e., a small tear, 1.5 centimeters (0.6 inches) and small puncture/snag marks to the top center of the air bag]. The driver's air bag was designed without any tethers and had two vent ports, approximately 2.5 centimeters (1.0 inch) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was elliptical with a height of 58 centimeters (22.8 inches) and a width of 63 centimeters (24.8 inches). The inspection of the air bag revealed skin transfers and blood smears to the top seam and backside along with an excessive amount of blue and red cloth transfers from the driver's coat. The case vehicle was not equipped with a front right passenger air bag. Inspection of the remainder of the case vehicle's interior revealed a contact to the driver's sun visor and contacts to the front right instrument panel and windshield.

Immediately prior to the crash the case vehicle's driver was seated in an upright posture (i.e., the driver's seat back was permanently fixed in the up-right position--measured 89 degrees) with her back against the seat back, her left foot sticking out from the seat cushion, her right foot on the accelerator, and both hands on the steering wheel. Her seat track was located in its forward-most position, and her tilt steering wheel was located in its down-most position. The case vehicle was equipped with pedal extenders made by "Drive Master". The adaptive equipment extended the brake pedal rearward 34 centimeters (13.4 inches), within 10 centimeters (3.9 inches) forward of the driver's seat cushion, and the gas pedal rearward 38 centimeters (15.0 inches), within 14 centimeters (5.5 inches) forward of the driver's seat cushion. Cursory inspection of the pedal extenders showed no evidence of failure. The only anomaly was the brake pedal cover pad appeared to have been knocked off the pedal's face. This fact leads this contractor to a third plausible pre-crash scenario (i.e., the driver's foot slipped off the brake, and she hit the accelerator causing the vehicle to speed up) to explain why the front right passenger stated she heard and felt the car accelerate prior to impact.

The case vehicle's front right passenger [friend, 16-year-old, White (Hispanic) female] was seated upright with her back leaning forward toward the center instrument panel (i.e., she had just looked up from changing a CD), both feet on the floor, and both arms out-stretched with her hands on the instrument panel bracing for the impact. Her seat track was located in its middle position, and the seat back was sightly reclined. The case vehicle's front right passenger [160 centimeters and 66 kilograms (63 inches, 146 pounds)] was not wearing her available, active, three-point, lap-and-shoulder, safety belt system. The front right passenger was transported by ambulance to the hospital. She sustained minor soft tissue injuries and was treated and released. The self-reported injuries sustained by the case vehicle's front right passenger included: a contused and lacerated lip (from impacting the instrument panel) and a contusion to the top back of her head from contacting the windshield.

## CRASH CIRCUMSTANCES

The case vehicle was traveling north in the inside, northbound lane of a four-lane, undivided, city roadway and intended to continue traveling northbound. Vehicle #2 was also traveling north, in the inside, northbound lane of the same, four-lane, undivided roadway and had stopped intending on making a left turn into an intersecting roadway (**Figure 1** below). The

bituminous roadway was dry, straight, level, and illuminated by overhead street lamps at the area of the crash. The two northbound lanes were divided by a dashed white line with a 0.5 meter (1.7 feet) wide paved shoulder adjacent to a curb on the east side of the roadway. The inside northbound lane was 3.5 meters wide (11.6 feet). The north and southbound lanes were divided by double solid yellow lines. There was a warning SCHOOL ADVANCE sign (S1-1) and a regulator SPEED LIMIT sign (R2-1) in the immediate area of the crash. The posted speed limit was 64 km.p.h. (40 m.p.h.). The estimated coefficient of friction for the roadway was 0.70% when dry. The surrounding area is primarily residential with the driveway to an elementary school within 20 meters (66 feet) of the crash site. The case vehicle's driver made no avoidance maneuvers prior to the crash. The crash occurred in the inside northbound lane, within the three-leg intersection of the two roadways (see **CRASH DIAGRAM** below).

The front (**Figure 2**) of the case vehicle impacted the back (**Figure 3**) of vehicle #2, causing the case vehicle's driver supplemental restraint (air bag) to deploy. The case vehicle rotated approximately 20 degrees counterclockwise while moving slightly northward and came to rest in the inside northbound lane heading north-northwest. Vehicle #2 was knocked north-northwestward, approximately 38 meters (124.7 feet), into the inside southbound lane, but vehicle #2's driver drove his vehicle back, approximately 3.0 meters (10 feet), into the inside northbound lane where he brought it to rest to avoid being hit head-on by oncoming traffic.

## CASE VEHICLE

The case vehicle was a front wheel drive 1992 Toyota Celica ST, four-passenger, two-door coupe (VIN: JT2AT86F9NO------) equipped with a 1.6L, EFI, I-4 engine and a four-speed automatic transmission and power-assisted rack-

**Figure 1:** Southward view of case vehicle's northward travel path in inside northbound lane, viewed from area of final rest; Note: red paint marks indicate tire positions (case photo #06)

**Figure 2:** Case vehicle's frontal deformation with contour gauge present; Note: yellow tape indicates start of direct damage (case photo #10)

**Figure 3:** On-scene view of vehicle #2's damaged back showing downward rotation of rear bumper (case photo #71)

and-pinion steering. Braking was achieved by a power-assisted four-wheel, front and rear disc system. The case vehicle was not equipped with anti-lock brakes. The case vehicle's wheel base was 253 centimeter (99.4 inch), and the odometer reading at inspection was 121,982 kilometers (75,796 miles).

The interior of the case vehicle was equipped with bucket seats with folding backs and adjustable head restraints. The driver's seat back was permanently fixed in an upright position (measured at 89 degrees) to accommodate the short stature driver (***additional information regarding the case vehicle's adaptive controls are discussed below***). The front seat was equipped with a center console and a floor mounted automatic transmission selector lever along with a manual emergency brake. The case vehicle had available, active, three-point, lap-and-shoulder, safety belt systems for the front and rear outboard seating positions. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver's seat only. The vehicle was not equipped with adjustable "D"-rings. There was a driver side knee bolster made of rigid plastic which showed no evidence of deformation. The back seat was a bench with separate back cushions. Examination of the interior revealed evidence of contact to the driver's sun visor, the rear view mirror, and right instrument panel and windshield. Inspection of the steering wheel's energy absorbing device (shear capsules) showed 5 centimeters (2.0 inches) of compression from the driver's interaction with the steering wheel hub.

## CASE VEHICLE DAMAGE

The crash involved the front bumper of the case vehicle against the back bumper of vehicle #2. The direct contact damage consisted of underride type damage to the case vehicle's bumper and hood. The underride type damage pattern resulted because the sloping front end of the case vehicle happened to be slightly lower than vehicle #2's back bumper. The direct damage to the case vehicle's front end began 28 centimeters (11.0 inches) to the right of center and extended leftward 93 centimeters (36.6 inches) to the left front bumper corner (**Figure 4**). The field L width was 117 centimeters (46.1 inches) and the undeformed end width was 130 centimeters (51.2 inches). The maximum crush was located between $C_2$-$C_3$ and was 30 centimeters (11.8 inches) in depth. The hood, bumper fascia, bumper reinforcement bar, grille, both fenders, left headlight assembly, and windshield were all deformed from the impact (**Figures 2** and **4** above). The hood was folded back accordion style. The windshield on the passenger side was starred from the front right passenger's head. The case vehicle's left front tire was physically restricted but not deflated. The wheelbase was shorten 3 centimeters (1.2 inches) on both sides. There was no visible evidence of intrusion to the case vehicle's interior.

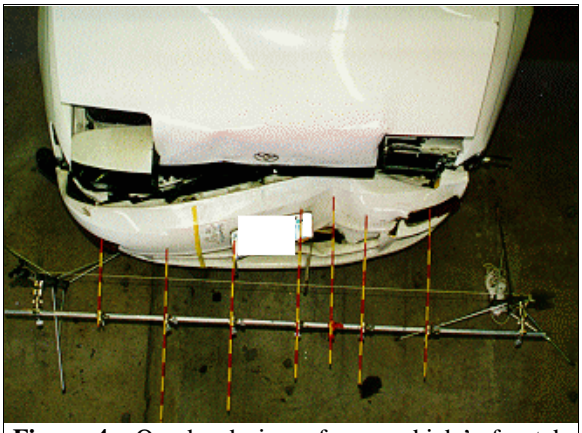


**Figure 4:** Overhead view of case vehicle's frontal damage with contour gauge showing crush values (case photo #09)

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-**

**FYEW-1 (360)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 22.8 km.p.h. (14.2 m.p.h.), -22.8 km.p.h. (-14.2 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was towed due to damage.

**Figure 5:** Case vehicle's driver seating area showing deployed air bag, contacted sun visor and rear view mirror, and noncontacted windshield (i.e., driver's portion); Note: crumpled hood visible through windshield (case photo #27)

## AUTOMATIC RESTRAINT SYSTEM

As previously mentioned, the case vehicle was equipped with a SRS that consisted of a frontal air bag at the driver position. The SRS deployed (**Figure 5**) as a result of the case vehicle's frontal impact with the back of vehicle #2. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical cover flaps with a width dimension of 17 centimeters (6.7 inches) at the horizontal seams and 9 centimeters (3.5 inches) vertically for the top cover flap and 6.5 centimeters (2.6 inches) vertically for the bottom cover flap. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, but the top cover flap was torn off the air bag module due to the driver blocking the air bag's path during the deployment causing the air bag to find subsequent avenues to deploy. Furthermore, there appeared to be blue cloth transfers to the driver air bag module's top and bottom cover flaps. In addition, the inspection revealed evidence of damage during the deployment to the air bag. Two anomalies were found. One was a small tear, 1.5 centimeters (0.6 inches), near the top edge of the air bag near the 11 o'clock position, and the other was a small puncture/snag mark to the top center of the air bag near the 1 o'clock position. The driver's air bag was designed without any tethers and had two vent ports, approximately 2.5 centimeters (1.0 inch) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was elliptical with a height of 58 centimeters (22.8 inches) and a width of 63 centimeters (24.8 inches).

**Figure 6:** Close-up of case vehicle's driver air bag showing faint (i.e., barely visible) blue and red cloth transfers from driver (case photo #39)

The inspection of the driver's air bag revealed an excessive amount of blue and red cloth transfers on the front portion from the driver's coat (**Figure 6**), and there was a 2 x 4

centimeter (0.8 x 1.6 inch) area of what appeared to be skin to the center of the air bag. Further, there was visible evidence of direct contact from the driver's coat to the cover flaps (**Figure 7**). In addition, there were skin transfers and blood smears to the top seam and backside of the air bag in the 12 o'clock area (**Figure 8**). The skin and blood smear started at the top edge (seam) and extended down the backside 14 centimeters (5.5 inches), and the smear was 11 centimeters (4.3 inches) in width at the top seam but narrowed to 7 centimeters (2.8 inches) wide. Also on the top backside of the air bag there were red and blue cloth transfers (more red than blue).

**Figure 7:** Close-up of cloth transfer on case vehicle driver air bag module's bottom cover flap; Note: top flap showed same type of transfers (case photo #47)

**Figure 8:** Close-up of case vehicle's driver air bag showing skin transfer and blood smear from driver's neck on top, backside of air bag (case photo #43)

## CASE VEHICLE ADAPTIVE CONTROLS

**Figure 9:** Close-up of adaptive foot control equipment attached to case vehicle's accelerator and brake pedals (case photo #20)

**Figure 10:** Close-up of floor anchorages for case vehicle's adaptive foot control equipment (case photo #21)

The case vehicle was equipped with special adaptive pedal extenders and a windshield wiper stalk. The pedal extenders were made by "Drive Master" and the fold down pedal extenders made of aluminum and stainless steel. The pedals extenders were attached to both the brake and accelerator pedals (**Figures 9** and **10**). The adaptive equipment extended the brake pedal rearward 34 centimeters (13.4 inches), within 10 centimeters (3.9 inches) forward of the driver's seat cushion, and the gas pedal rearward 38 centimeters (15.0 inches), within 14 centimeters (5.5 inches) forward of the driver's seat cushion. Both pedals were bolted to the floor pan and

extended 30 centimeters (11.8 inches) up from the floor pan to just below the top of the driver's seat cushion. Both pedal extensions were clamped to their respective OEM pedals. Cursory inspection of the pedal extenders showed no evidence of failure. The only anomaly was the rubber, brake pedal cover pad appeared to have been knocked off the stainless steel pedal's face (**Figure 10** above).

The other adaptive equipment on the case vehicle involved the driver's seat back being fixed in a 89 degree, upright position, and the windshield wiper stalk being angled towards the driver in order to accommodate the driver's shorter reach (**Figure 11**).

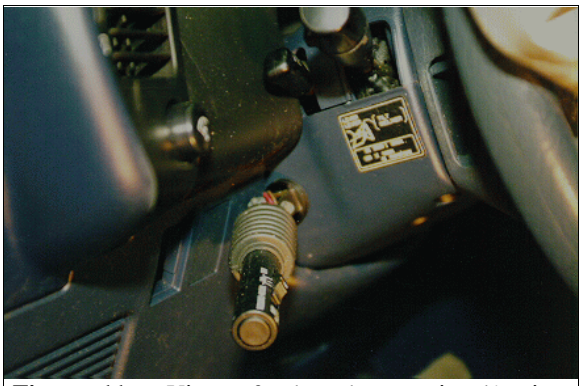


**Figure 11:** View of adapted turn signal/cruise control lever on case vehicle's steering column; Note: compression of steering column into instrument panel (case photo #24)

## CASE VEHICLE DRIVER KINEMATICS

The case vehicle's driver [17-year-old, White (non-Hispanic) female] was short statured [119 centimeters and 40 kilograms (47 inches, 89 pounds)]. As a result the case vehicle was equipped with adaptive extenders on the accelerator and brake pedals. The driver was not wearing her available, active, three-point, lap and shoulder belt. In addition, there was no evidence of belt pattern bruising and/or abrasions to the driver's body, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading.

Immediately prior to the crash the case vehicle's driver was seated in an upright posture with her back against the seat back, her left foot sticking out from the seat cushion, her right foot on the accelerator, and both hands on the steering wheel. Her seat track was located in its forward-most position, and her tilt steering wheel was located in its down-most position. It should be noted that the distance from the center of the driver's seat back to the steering wheel hub was approximately 43 centimeters (16.9 inches), which includes 5 centimeters (2.0 inches) of compression to the shear capsules (energy absorbing device on base of steering column). In addition, the length of the driver's arms was approximately 30 centimeters (11.8 inches) which would have placed the driver extremely close to the driver air bag module (**Figure 12**).

The case vehicle's driver made no known pre-crash avoidance maneuvers. Based on interview with the case vehicle's front right passenger, there was some question regarding the physical condition of the case vehicle's driver immediately prior to the crash. The front right

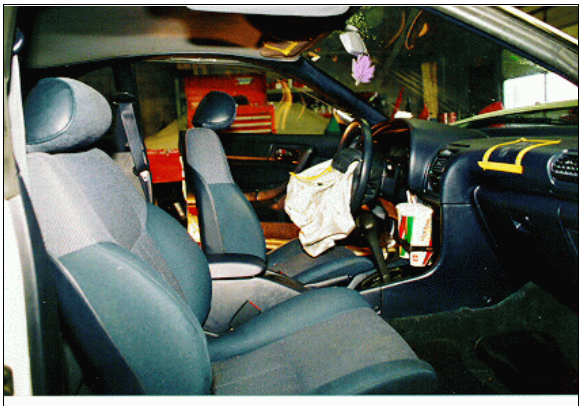


**Figure 12:** Case Vehicle's front seating area showing driver seat's close proximity to steering wheel and highlighted occupant contacts (case photo #31)

passenger stated that the driver did not respond to her two verbal warnings of the impending crash, and she also felt and heard the case vehicle accelerate prior to the crash. Three scenarios are: (1) the driver was incapacitated (i.e., blacked out) prior to the crash, (2) the driver panicked and pressed on the accelerator instead of the brake, or (3) the driver's foot slipped off the brake and hit the accelerator causing the vehicle to speed up. According to the Medical Examiner, there was nothing found during the autopsy that would indicate that the driver was incapacitated, and she had no medical history of any episodes of blacking out. This contractor believes that the case vehicle's driver most likely hit the accelerator, either instead of or after she hit the brake pedal. This would explain why the front right passenger stated she heard and felt the car accelerate prior to impact. As a result and independent of the nonuse of her available safety belts, her pre-impact body position did not change just prior to impact.

The case vehicle's impact with vehicle #2 enabled the case vehicle's driver to continue forward and slightly upward as the case vehicle decelerated. Due to the driver's extreme close proximity, the driver directly contacted the module's cover flaps with her chest, blocking the air bag's normal deployment path. This caused the deploying air bag to find subsequent avenues to deploy which resulted in the top cover flap being completely blown off the air bag module. The top front edge of the deploying air bag caught the case vehicle's driver in her neck and underneath her chin, causing the neck and most likely her brain injuries. As the air bag continued to deploy, it lifted the driver upwards where she contacted the sun visor (**Figure 5** above and **Figure 13**) prior to rebounding back into her seat. At final rest the driver was seated upright in her seat, her back against the seat back, her head tilted forward, and her body tilted slightly to the right.

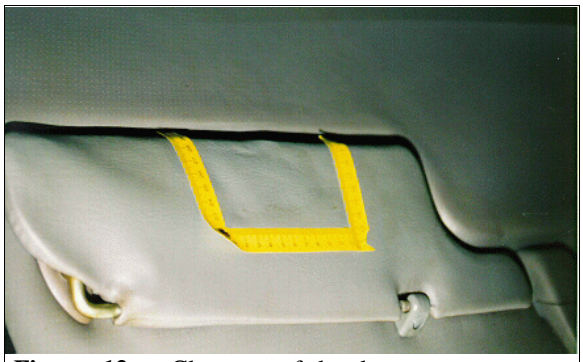


**Figure 13:** Close-up of head contact on case vehicle's driver sun visor; Note: short-statured driver was seated directly underneath sun visor (case photo #28)

**CASE VEHICLE DRIVER'S INJURIES**

The driver was transported by ambulance to the hospital. She sustained fatal injuries and was pronounced dead 57 minutes post-crash. According to her medical records, the injuries sustained by the case vehicle's driver included: minimal diffuse subdural and subarachnoid hemorrhages, minimal cerebral cortical contusions, fractures of the laryngeal cartilages, a minimal atlanto-occipital dislocation without trauma to the spinal cord, abrasions and superficial lacerations to her neck, and a chest contusion. Based on an interview with the Medical Examiner, the driver died of asphyxiation resulting from the swelling and soft tissue hemorrhage/hematoma in her neck that compressed her larynx.

| Injury Number | Injury Description (including Aspect) | NASS Injury Code & AIS 90 | Injury Source (Mechanism) | Source Confidence | Source of Injury Data |
|---|---|---|---|---|---|
| 1 | Hemorrhage, subdural, diffuse, minimal–location not specified [Aspect = Unknown] | 140652.4 severe | Air bag, driver's | Possible | Autopsy |
| 2 | Contusion, cerebral, minimal–a "zone" limited to the cortical gray matter, location not specified [Aspect = Unknown] | 140606.3 serious | Air bag, driver's | Probable | Autopsy |
| 3 | Hemorrhage, subarachnoid, diffuse, minimal, most prominently distributed in interhemispheric midline[1] [Aspect = Unknown] | 140684.3 serious | Air bag, driver's | Probable | Autopsy |
| 4 | Fractures of right superior cornua of thyroid cartilage and posterior (vertically) portion of cricoid cartilage with associated swelling and hemorrhage/hematoma[2] into the strap[3] muscles | 340206.2 moderate | Air bag, driver's | Probable | Autopsy |
| 5 | Dislocation {separation} atlanto-occipital, minimal[4] | 650208.2 moderate | Air bag, driver's | Probable | Autopsy |
| 6 | Abrasion, 2.5 x 16 cm (1.0 x 6.3 in), across central anterior neck, horizontally–with addi-tional linear abrasions under-lying anteriorly | 390202.1 minor | Air bag, driver's | Certain | Autopsy |
| 7 | Lacerations, superficial, neck | 390602.1 minor | Air bag, driver's | Probable | Emergency room records |
| 8 | Contusion {bruising}, 8 x 8 cm (3.1 x 3.1 in), over sternum | 490402.1 minor | Driver module's cover flap | Certain | Autopsy |

[1] The aspect "**UNKNOWN**" is encoded because the NASS CDS injury coding protocol does not allow the use of any aspects other than "**LEFT**," "**RIGHT**," or "**UNKNOWN**".

[2] The autopsy makes no specific mention of trauma to the larynx per se, either positively or negatively. According to our follow-up conversation with the physician who performed the autopsy, he indicated that the supporting laryngeal cartilage are part of the larynx and that the larynx was neither perforated nor were the vocal cords damaged. When pressed about this patient's cause of death, the physician indicated that she died of the neck injury (i.e., the brain lesions and the atlanto-occipital dislocation were survivable). He indicated further that she died of asphyxiation resulting from the swelling and the soft tissue hemorrhage/hematoma in the neck that compressed her larynx. Finally, the physician stated that he was never able to determine the source of the hemorrhage in the soft tissues of her neck.

[3] According to the autopsy the following muscles were hemorrhagic: right sternocleidomastoid, right sternohyoid, both cricothyroid, and both posterior cricoarytenoideus (i.e., left greater than right) muscles.

[4] According to the autopsy, significant displacement of the cervical vertebrae either to each other or to her skull (i.e., occiput) was not found. In addition, there was no injury to the spinal cord.

**Figure 14:** Case vehicle's front seating area viewed from outside right front door showing contacts (taped areas) to driver's air bag and sun visor as well as to dash and windshield on passenger's side (case photo #32)

**Figure 15:** Close-up of starred windshield and make-up smear on top of case vehicle's right instrument panel; Note: both contacts came from front right passenger (case photo #34)

The case vehicle's front right passenger [friend, 16-year-old, White (Hispanic) female] was not wearing her available, active, three-point, lap-and-shoulder, safety belt system. The case vehicle was not equipped with a front right passenger air bag.

The case vehicle's front right passenger [160 centimeters and 66 kilograms (63 inches, 146 pounds)] was seated upright with her back leaning forward toward the center instrument panel (i.e., she had just looked up from changing a CD), both feet on the floor, and both arms out-stretched with her hands on the instrument panel bracing for the impact. Her seat track was located in its middle position, and the seat back was sightly reclined. At impact the front right passenger continued moving forward contacting the top of the instrument panel with her face and cracking the windshield with the top of her head (**Figures 14** and **15**). Following the crash the front right passenger rebounded back into her seat as the vehicle came to final rest.

## CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right passenger was transported by ambulance to the hospital. She sustained minor soft tissue injuries and was treated and released. The self-reported injuries sustained by the case vehicle's front right passenger included: a contused and lacerated lip (from impacting the instrument panel) and a contusion to the top back of her head from contacting the windshield.

| Injury Number | Injury Description (including Aspect) | NASS Injury Code & AIS 90 | Injury Source (Mechanism) | Source Confidence | Source of Injury Data |
|---|---|---|---|---|---|
| 1 | Contusion {bump} posterior to apex of scalp | 190402.1 minor | Windshield, right of center | Certain | Interviewee (same person) |
| 2 | Contusion {fat} lip, location not further specified | 290402.1 minor | Right dash/instrument panel | Certain | Interviewee (same person) |
| 3 | Laceration lip, location not further specified | 290600.1 minor | Right dash/instrument panel | Certain | Interviewee (same person) |

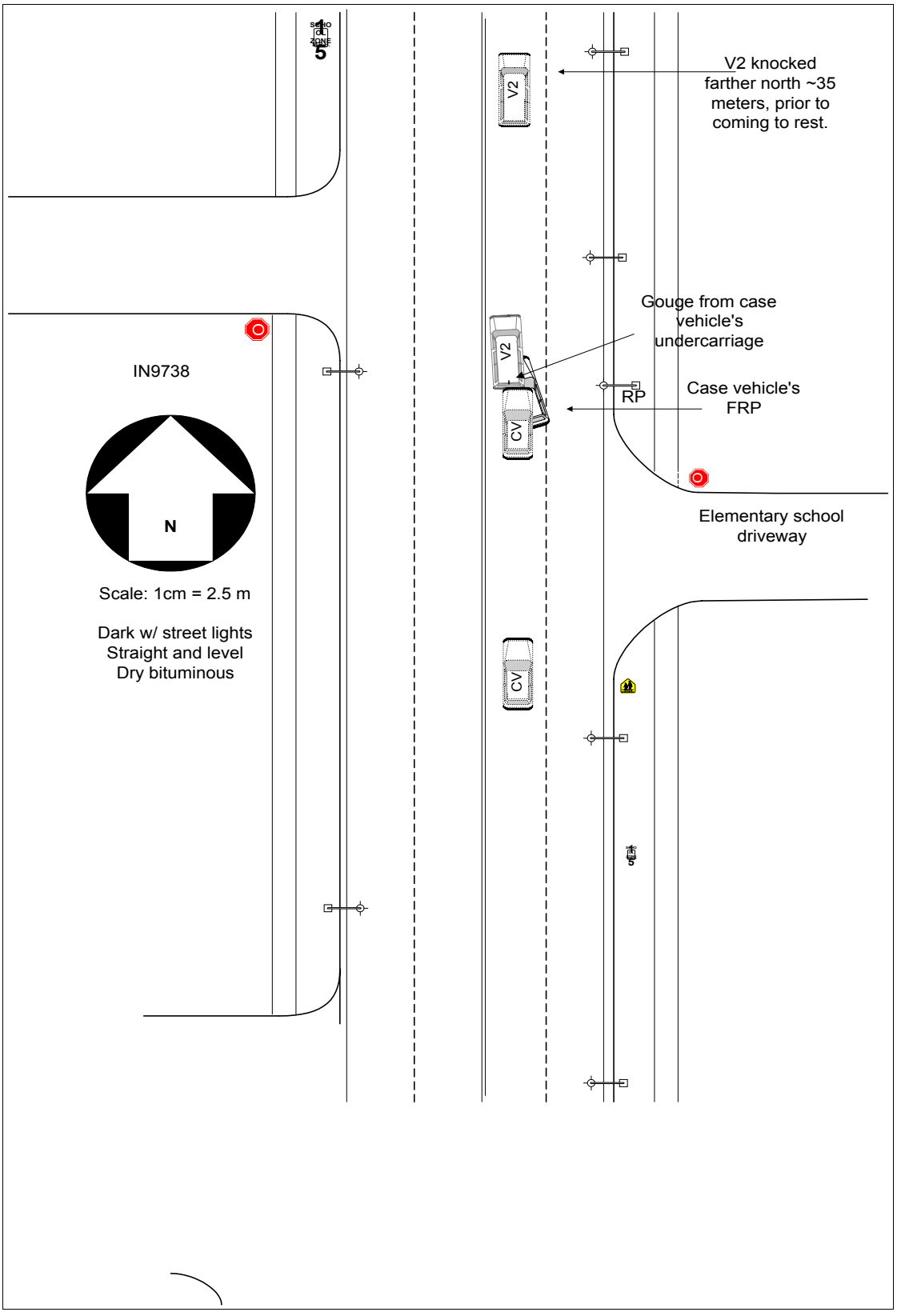
## VEHICLE #2

Vehicle #2 is a front wheel drive 1993 Plymouth Voyager SE, seven-passenger , four-door minivan (VIN: 2P4GH45R8PR------) equipped with a 3.3L, OHV-SMPI, V-6 engine and a five-speed automatic transmission. Braking was achieved using a dual hydraulic, self adjusting front disk and rear drum system. Vehicle #2's wheel base was 285 centimeter (112.3 inches), and the odometer reading at inspection was 128,313 kilometers (79,730 miles). The vehicle was equipped with a supplemental restraint system (air bag) for the driver's position only and three-point lap and shoulder belts for the front, second seat, and rear outboard seating positions. The rear center seat had a lap belt only. The interior was equipped with a bucket seat for the driver and a box-mounted nonadjustable bucket seat for the front right passenger. The second seating row had a two-seat bench, while the rear bench seat accommodated three occupants.

Vehicle #2's back impact from the case vehicle caused the rear bumper to be crushed inward and rotated downward under the vehicle as the case vehicle underrode it (**Figure 3** above and **Figure 16**). Direct damage started at the back right bumper corner and extended to the left 103 centimeters ( 40.6 inches). The maximum crush was measured at 10 centimeters (3.9 inches) at both $C_5$ and $C_6$. The total field L was measured at 163 centimeters (64.2 inches). The rear impact deformed the driver's seat back rearward approximately 15 degrees. Vehicle #2 was driven from the scene.

**Figure 16:** Deformation to vehicle #2's back with contour gauge present (case photo #55)

Based on the vehicle inspection, the CDC for vehicle #2 was determined to be: **06-BZEW-1 (180)**. The WinSMASH reconstruction program, damage only algorithm, was used on vehicle #2's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 19.0 km.p.h. (11.8 m.p.h.), +19.0 km.p.h. (+11.8 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h).


SCHOOL ZONE
5
V2
V2 knocked farther north ~35 meters, prior to coming to rest.
Gouge from case vehicle's undercarriage
V2
RP
Case vehicle's FRP
CV
Elementary school driveway
IN9738
N
Scale: 1cm = 2.5 m
Dark w/ street lights
Straight and level
Dry bituminous
CV
5