

**TRANSPORTATION SCIENCES  
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**VERIDIAN ON-SITE REDESIGNED AIR BAG DEPLOYMENT INVESTIGATION  
VERIDIAN CASE NO. CA98-056  
VEHICLE: 1998 CHEVROLET LUMINA  
LOCATION: NEW YORK  
CRASH DATE: OCTOBER 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 are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. <i>Abstract</i> This on-site investigation focused on the death of a 81 year old female driver of a 1998 Chevrolet Lumina. The Lumina was equipped with redesigned frontal air bags for the driver and right front passenger positions. The air bag system deployed as a result of a head-on crash sequence between the Lumina and a 1997 Ford F150 4x4 pickup truck. The driver of the Lumina was a short stature, slender female. At the time of the crash, she was seated in close proximity to the steering wheel and was restrained by the available 3-point lap and shoulder belt. She sustained multiple bilateral rib fractures, a puncture (laceration) of the heart, bilateral compound fractures of the ankles, and bilateral fractures of the wrists. The driver died at the scene of the crash and was pronounced dead prior to removal from the vehicle.			
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***BACKGROUND***

This on-site investigation focused on the injury mechanisms and cause of death for an 81 year old female driver of a 1998 Chevrolet Lumina. The Lumina was equipped with redesigned frontal air bags for the driver and right front passenger positions. The air bag system deployed as a result of a severe head-on crash sequence between the Lumina and a 1997 Ford F150 4x4 pickup truck (**Figure 1**). The driver of the Lumina was a short stature, slender female. At the time of the crash, she was seated in close proximity to the steering wheel and was restrained by the available 3-point lap and shoulder belt. Due to her forward seated position and the high crash severity, the driver loaded through the deployed air bag and engaged the steering assembly. She sustained multiple bilateral rib fractures and a puncture (laceration) of the heart from loading the belt system and the steering assembly. The driver also sustained bilateral compound fractures of the ankles, and bilateral fractures of the wrists. She expired at the scene of the crash and was pronounced dead prior to removal from the vehicle.



**Figure 1. On-scene view of the frontal damage patterns.**

Veridian's Special Crash Investigation Team was notified of the crash by a representative of the insurance group for General Motors on October 8, 1998. The notification was forwarded to the NHTSA Field Operation's Branch and an on-site investigative task was assigned on that same date. This field investigation was subsequently conducted on October 9th.

***SUMMARY***

***Crash Site***

The crash site was located on a rural two lane roadway in a posted 56 km/h (35 mph) speed zone. At the time of the crash it was daylight, the weather was clear, and the asphalt road surface was dry. The Lumina was traversing a gradual curve to the right with a 2 percent negative grade along its approach direction (south). The north/southbound travel lanes were 2.9 m (9.5') wide and were delineated by double yellow centerlines and solid white edge lines. The estimated coefficient of friction for both travel lanes was 0.65. Both edges of the roadway were bounded by 0.5 m (1.7') paved shoulders with shallow sloped positive dirt and grass embankments located outboard of the shoulders. The Crash Schematic is included as **Figure 18**, Page 12.

## ***Crash Sequence***

### ***Pre-Crash Phase***

The 1998 Chevrolet Lumina was traveling in a southerly direction on the two lane roadway (**Figure 2**), approaching the crash site at an estimated travel speed of 48-56 km/h (30-35 mph). The driver was en route to her residence. It was, therefore, assumed that she was familiar with the roadway. Her travel path and pre-crash driving actions could not be verified since traffic flow was very light and there were no independent witnesses to the crash events.



**Figure 2. Pre-crash southbound trajectory of the Chevrolet Lumina.**



**Figure 3. Pre-crash northbound trajectory of the Ford pickup truck.**

The 1997 Ford F150 pickup truck was being operated by a 26 year old male. This individual had a driving history that included three (3) crashes in the last two year interval. Two of these crashes occurred in January, 1998. This driver was traveling in a northerly direction at a police reported speed of 72 km/h (45 mph). He reported to the investigating officer, immediately following the crash, that he observed the Lumina swerving from lane-to-lane on its approach to the crash site. He further reported that, immediately prior to the crash, he swerved to the left into the opposing southbound travel lane to avoid the Lumina which was in his travel lane.

It should be noted that the driver of the Lumina had no health history (i.e., epilepsy, diabetes, etc.) that could have contributed to crash causation. The investigating officer noted that the driver had recently completed a physical, the results of which indicated that she was in good health. The autopsy also failed to identify a pre-existing condition (e.g., heart, etc.) that could have contributed to crash causation, particularly an erratic driving pattern.

An 11.6 m (38.0') yaw mark from the right front tire of the Ford pickup truck was documented at the crash site (**Figure 3**). This mark began near the center of the northbound travel lane and terminated near the centerline of the roadway. It appeared that prior to the initiation point of the mark, the Ford pickup was traveling in a northerly direction with the left portion of the vehicle in the southbound travel lane. The pickup truck driver may have been inattentive to the driving task and may have been surprised by the presence of the Lumina. His observation that the Lumina was weaving between lanes prior to the crash was questionable and was not supported by the at-impact orientation of the Lumina.

### ***Crash Phase***

The full frontal area of the Ford pickup impacted the full frontal area of the Lumina with the impact occurring in the southbound travel lane. The resultant directions of force were within the 11 o'clock sector for the Lumina and within the 1 o'clock sector for the Ford pickup truck. Direct contact damage was distributed across the frontal structure of the Lumina with a maximum crush value of 88.1 cm (34.7") located 17.1 cm (6.75") to the left of the vehicle's centerline. The Ford pickup also sustained distributed frontal crush with a maximum crush value of 44.5 cm (17.5") located 52.1 cm (20.5") to the right of the vehicle's centerline. Velocity changes were computed by WinSMASH at 50.9 km/h (31.6 mph) for the Lumina and 43.8 km/h (27.2 mph) for the Ford pickup truck. The specific longitudinal and lateral components for the Lumina were -47.8 km/h (-29.7 mph) and 17.4 km/h (10.8 mph) respectively. The impact deployed the Lumina's redesigned frontal air bag system.

Following this engagement, the Lumina was displaced rearward and rotated in a clockwise (CW) direction to its final rest position. The vehicle traveled approximately 4.0 m (13.0') from the point of impact to final rest and rotated slightly less than 90 degrees CW. The Ford pickup truck continued forward approximately 3 m (10'), deflecting in a northwesterly direction to final rest. The Ford pickup truck was also equipped with frontal air bags that deployed during the crash sequence.

### ***Post-Crash Phase***

The Chevrolet Lumina came to rest straddling both travel lanes, facing in a southwesterly direction, approximately perpendicular to the roadway. The Ford pickup came to rest in the southbound lane, facing in a northwesterly direction. The right rear portion of the pickup truck extended back into the northbound travel lane. **Figure 4** is a view of the final rest positions of the vehicles.



**Figure 4. Overall view of the crash site and final rest positions of the vehicles.**

A resident who lived in the immediate vicinity of the crash site heard the impact and responded to the scene within a minute of the crash. He reported that, after the crash, the driver of the Lumina was slumped forward with her face resting in the deployed and deflated driver air bag. He also noted that the driver was properly restrained by the manual belt system. This individual forced open the jammed left front door and gently pushed the driver back into the seat back support. He subsequently checked the left side of her neck for a pulse and noted that there was a faint pulse. This pulse stopped within eight minutes of the crash, prior to the on-scene arrival of rescue personnel and emergency medical technicians (EMTs). After EMTs arrived on-scene, they began evaluating the driver. No vital signs were detected, therefore no resuscitation efforts were attempted.

The local resident also checked on the condition of the driver of the Ford pickup shortly after the crash occurred. As the latter individual was attempting to exit his vehicle he stated that the driver of the Lumina was "all over the road" as she approached the crash site. The pickup driver stated that he was not injured,

however, the resident and the investigating officer both noted that he coughed up blood on several occasions while he was at the scene. He was subsequently transported to a local hospital where he was admitted overnight for observation.

### ***Vehicle Data***

#### ***1998 Chevrolet Lumina***

The subject vehicle in this crash was a 1998 Chevrolet Lumina, 4-door sedan, that was manufactured in 3/98 and identified by the vehicle identification number 2G1WL52M4W9 (production number deleted). The vehicle's odometer reading at the time of the crash was 3,658.6 km (2,290.2 miles). This vehicle was owned and operated exclusively by the 81 year old female driver. In addition to the redesigned frontal air bag system, the Lumina was equipped with a split bench front seat with separate back cushions and a fold-down center armrest, manually adjusted seats, adjustable head restraints, manual windows, power door locks, and front disc/rear drum brakes with anti-lock (ABS).

#### ***1997 Ford Pickup Truck***

The Ford pickup truck was an extended cab version with the short cargo bed on a 353.0 cm (139.0") wheelbase. A fiberglass cap was installed on the cargo bed of the pickup truck. The truck was rated with a Gross Vehicle Weight Rating (GVWR) of 2,721 kg (6,000 lb). The vehicle was equipped with front disc/rear drum brakes with rear wheel ABS. The Ford was identified by vehicle identification number 1FTDX18W3VN (production number deleted) and manufactured in 6/97. At the time of the crash, the Ford's odometer reading was 11,210 km (6,966 miles). The pickup truck was equipped with frontal air bags for the driver and passenger positions which deployed as a result of the head-on crash.

### ***Vehicle Damage***

#### ***Exterior - 1998 Chevrolet Lumina***

Exterior damage to this vehicle was severe with crush damage extending across the full frontal width of the vehicle (**Figure 5**). Damaged components included the front bumper (separated from the frame rails), grille, headlight assemblies, hood, radiator, both front fenders, both front doors, the windshield, and the roof panel. Damage was also noted to basic structural components including both front suspensions and the front chassis frame rails. Both wheelbase dimensions were reduced with the left side dimension reduced by 4.4 cm (1.75") and the right side dimension reduced by 10.2 cm (4.0"). The engine was shifted rearward toward the passenger compartment and the panel separating the engine compartment and passenger compartment was also shifted rearward. The direct contact damage was measured along the vehicle profile and was 143.5 cm (56.5") in width, extending from fender edge-to-fender edge. The impact separated the front bumper cover and the reinforcement beam, therefore the crush was documented at the levels of the upper and lower radiator supports. Maximum frontal crush at the lower radiator support was 71.8 cm (28.25") located 17.1 cm (6.75") left of center. The maximum crush at the upper radiator support was



**Figure 5. Full frontal damage to the Lumina.**

88.1 cm (34.7") located 30.5 cm (12.0") left of center. The crush profiles at both heights of the radiator support were measured as follows:

<u>Lower Radiator Support</u>	<u>Upper Radiator Support</u>
$C_1 = 61.6 \text{ cm (24.25")}$	$C_1 = 80.5 \text{ cm (31.7")}$
$C_2 = 71.8 \text{ cm (28.25")}$	$C_2 = 88.1 \text{ cm (34.7")}$
$C_3 = 65.8 \text{ cm (25.9")}$	$C_3 = 83.6 \text{ cm (32.9")}$
$C_4 = 57.8 \text{ cm (22.75")}$	$C_4 = 81.0 \text{ cm (31.9")}$
$C_5 = 52.7 \text{ cm (20.75")}$	$C_5 = 82.6 \text{ cm (32.5")}$
$C_6 = 34.0 \text{ cm (13.4")}$	$C_6 = 87.6 \text{ cm (34.5")}$

The measured crush dimensions for the upper radiator support were utilized for the WinSMASH program. This profile provided the best representation for the damage algorithm of the reconstruction program. Program results indicated that the total delta V level for this impact was 50.9 km/h (31.6 mph) with a longitudinal component of -47.8 km/h (-29.7 mph). The Collision Deformation Classification (CDC) for this impact was 11-FDEW-4. **Figures 6-8** document the frontal damage to the Lumina.



**Figure 6. Front left view of the Lumina's frontal damage.**



**Figure 7. Front right view of the damage pattern.**



**Figure 8. Left profile view of the crush depth.**

#### ***Interior - 1998 Chevrolet Lumina***

Interior damage to the Lumina was moderate in severity and was associated with a combination of crash induced deformation, occupant contact, and air bag deployment. The passenger compartment was reduced in size by intrusion of the forward structure including the toe pan and instrument panel. The A-dimension (as measured from the steering wheel hub to the backlight header) was reduced 3.1 cm (1.1"). This reduction was inclusive of rearward displacement of the instrument panel and compression of the energy absorbing steering column. Measured at mid-panel height, the left instrument panel intruded 9.7 cm (3.8") rearward, the center aspect intruded 12.4 cm (4.9"), and the right aspect intruded 9.7 cm (3.8"). Impact

induced deformation was noted to the instrument panel, the toe pan, and the forward portion of both roof side rails. Both front doors were jammed closed immediately following the crash and could not be closed again once they were opened by rescue personnel. In addition, the hood buckled during the crash sequence with the right portion contacting and penetrating the right portion of the windshield.

In addition to the rearward intrusion pattern noted above, forward intrusion of the rear seat back support was also noted. The driver had a 4.5 kg (10.0 lb) bag of kitty litter in the trunk. At impact this bag moved forward and struck the back side of the rear seat back support. The center area of the seat back was deformed 25.4 cm (10.0") forward as a result of this loose object.

The Lumina was equipped with manual 3-point lap and shoulder belts for each of the front and rear outboard seated positions. The Lumina driver was using her restraint system when the crash occurred. Evidence of loading abrasions was noted on the lap belt webbing at the lower sill anchorage point. No evidence of D-ring loading, other webbing loading, or fabric transfers were found during the vehicle's examination.

The Lumina was also equipped with redesigned frontal driver and passenger air bags. This system was identified by a sticker on the left front door glazing which specified that the vehicle was equipped with, "Next generation air bags". Both redesigned bags deployed as a result of the crash.

Evidence of driver contact with interior components was noted to the deployed driver's air bag, the knee bolster, the brake pedal, and the left toe pan. Evidence of contact with the knee bolster consisted of two fabric transfers deposited as a result of the drivers knees contacting the bolster (**Figures 9 and 10**). Both transfers were approximately 15.2 cm (6.0") in length with the left knee contact centered 44.5 cm (17.5") to the left of the vehicle's centerline and the right knee contact centered 31.2 cm (12.3") to the left of the vehicle's centerline.



**Figure 9. Knee contacts to the plastic bolster panel.**



**Figure 10. Close-up view of the knee contacts.**

Evidence of contact with the driver's air bag consisted of flesh colored make-up and red lipstick transfers to the air bag surface. The largest of these transfers extended from 26.7 cm (10.5") to the left of the bag's vertical centerline to a point that was 2.5 cm (1.0") to the right of this same reference. Vertically, the transfer extended from 1.21 cm (4.8") above the bag's horizontal centerline down to a point that was 19.7

cm (7.8") below this same reference. A 3.2 cm (1.3") circular red lipstick transfer was located within the make-up transfer noted above. The lipstick transfer was centered 13.3 cm (5.3") to the left of the vertical centerline and 5.3 cm (2.1") below the horizontal centerline. It should be noted that this lipstick transfer was symmetrical in shape, thus indicating the driver contacted a full or near fully deployed air bag. A smaller and less distinct make-up and lipstick transfer was located 5.7 cm (2.3") inboard of the left peripheral seam of the bag and 4.1 cm (1.6") below the horizontal centerline of the bag.

In addition to the make-up and lipstick transfers on the front surface of the bag, the Lumina driver also loaded the steering column through the bag. The steering column shear capsules were completely separated with the separation extent measured at 6.4 cm (2.5"). The upper steering wheel rim was deflected forward as a result of spoke deformation. Driver involvement was also noted with the brake pedal (bone fragments were found in a corrugation of the rubber brake pedal pad) and with the intruded left toe pan [bone fragment on vertical aspect of toe pan 45.7 cm (18.0") left of the center].

#### ***Exterior - 1997 Ford F150 Pickup Truck***

The principal other vehicle in this crash was a 1997 Ford F150, extended cab, 4x4 pickup truck that was manufactured in 6/97 and that was identified by the vehicle identification number 1FTDX181N3VND (production number deleted). The vehicle's odometer reading at the time of the crash was 11,210 km (6,966 miles). The Ford driver had borrowed this vehicle to drive to a physical therapy session. (NOTE: The driver was recovering from an earlier crash which had occurred the preceding January.)

Exterior damage to this vehicle was considered to be moderate with crush damage extending across the full frontal width of the vehicle (**Figure 11**). Damaged components included the front bumper, grille, both headlight assemblies, hood, both front fenders, and both front doors. Direct contact damage initiated at the right corner position and extended 137.2 cm (54.0") to the left. The Field L dimension was 161.3 cm (63.5") that extended the full width of the bumper. Maximum frontal crush was 44.5 cm (17.5") located at the right front ( $C_5$ ) position. Although the front right corner area appears to have greater displacement, the contour of the bumper is greatest at the corner, therefore maximum residual crush was inboard of the corner.



**Figure 11. Frontal damage to the Ford pickup truck.**

The full set of crush dimensions measured at bumper height was as follows:  $C_1 = 8.6$  cm (3.375"),  $C_2 = 17.1$  cm (6.75"),  $C_3 = 29.8$  cm (11.75"),  $C_4 = 41.9$  cm (16.5"),  $C_5 = 44.5$  cm (17.5"),  $C_6 = 40.6$  cm (16.0"). The CDC for this vehicle was 01-FDEW-2.

#### ***Manual Restraint Systems - 1998 Chevrolet Lumina***

The Lumina was equipped with manual 3-point lap and shoulder belts for the front and rear outboard seated positions. The front belt systems consisted of a continuous loop belt webbing that was retracted into an inertia activated locking retractor. The upper anchorages (D-rings) were adjustable with respect to their height positions and the B-pillars. The driver's D-ring was adjusted to a mid-position, adjusted 3.8

cm (1.5") below the full up position and 4.4 cm (1.8") above the full down position. The latch plate of the driver's belt exhibited faint abrasions, indicating routine usage.

The first individual to arrive on-scene (local resident) indicated that the Lumina driver was fully restrained when he arrived. This assessment was verified by on-scene photographs taken by the investigating police agency. During the vehicle examination, evidence of loading abrasions was noted on the lower portion of the drivers belt webbing at the lower sill anchorage point. No evidence of D-ring loading, other webbing loading, or fabric transfers were found during the inspection.

### ***Redesigned Air Bag System - 1998 Chevrolet Lumina***

The 1998 Chevrolet Lumina was equipped with redesigned frontal air bags for the driver and right front passenger seated positions. The driver's air bag module was mounted in the steering wheel and the passenger air bag was mounted in the instrument panel in a top mount configuration (**Figure 12**). This redesigned system was identified by a sticker on the left front door glazing which specified that the vehicle was equipped with, "Next Generation Air Bags". Both air bag modules deployed during the frontal impact sequence with the Ford pickup truck. In addition to the air bag modules, the system utilized a single point sensing system and control module that was mounted to the floor of the Lumina under the front right seat.



**Figure 12. Deployed redesigned frontal air bags.**

The driver's air bag module was mounted in a 4-spoke steering wheel rim. The steering wheel spokes were located at the 9/7 and 3/5 o'clock positions. The air bag was concealed behind an I-configuration module cover assembly with symmetrical left and right cover flaps. Both flaps were 11.1 cm (4.4") in height and 8.9 cm (3.5") wide. The tear seam between these flaps was oriented along the 12/6 axis of the steering wheel. There was no evidence of unintended damage or occupant contact noted to the cover flaps.

The driver air bag deployed as designed with no tears or perforations noted to the woven nylon-type fabric. The bag was constructed of two panels that were sewn with an internal peripheral seam. The overall width of the driver air bag in a deflated state was 58.4 cm (23.0"). This module was a non-tethered design with 2.5 cm (1.0") vent ports located on the rear surface of the bag at the 9 and 3 o'clock positions. The vent ports were centered approximately 10.2 cm (4.0") inboard of the peripheral seam. There was a bar coded ID tag located at the top of the bag (12 o'clock position) which provided the following identification information:

P16756616  
TXM98054669

The driver contacted the redesigned front left air bag during the crash sequence. Evidence of contact consisted of flesh colored make-up and red lipstick transfers to the front surface of the bag. The largest of these transfers extended from a point located 26.7 cm (10.5") to the left of the bag's vertical centerline

to a point that was 2.5 cm (1.0") to the right of this same reference. Vertically, the transfer extended from 12.1 cm (4.8") above the bag's horizontal centerline down to a point that was 19.7 cm (7.8") below this same reference. The lipstick transfer within this make-up transfer was circular in nature with 3.2 cm (1.3") diameter and was centered 13.3 cm (5.3") to the left of the vertical centerline and 5.3 cm (2.1") below the horizontal centerline. A smaller and less distinct make-up and lipstick transfer was located 5.7 cm (2.3") inboard of the left peripheral seam of the bag and 4.1 cm (1.6") below the horizontal centerline of the bag.

The right front passenger bag was mounted in the right instrument panel as a top mount design (**Figure 13**). The module deployment cover was 38.7 cm (15.3") wide and was 25.4 cm (10.0") high at the left edge and 21.6 cm (8.5") high at the right edge. The module cover was hinged at the rear and opened upward. The passenger air bag was 58.4 cm (23.0") wide and 48.3 cm (19.0") deep. This was a tethered bag design with a 25.4 cm (10") wide by 22.3 cm (8.8") deep mesh tether located at the rear of the bag. There was no evidence of driver involvement with this module.



**Figure 13. Front right passenger air bag.**

#### ***SDM Download Data***

Data from the Sensing and Diagnostic Module was downloaded by a GM/EISS representative on October 9<sup>th</sup>, during the Veridian SCI inspection. Preliminary data from the unit indicated that the driver belt system was in use and buckled at the time of the crash. Belt usage was confirmed by observations of the first responders at the crash scene and minor loading evidence on the belt system. The final output report was not provided to the Veridian SCI team, therefore SDM recorded delta V data and the time interval in which the air bag deployed following the SDM's detection of the crash pulse is unknown.

#### ***Driver Demographics - 1998 Chevrolet Lumina***

Age/Sex:	81 year old female
Height:	Unknown, police reported as short stature
Weight:	Unknown
Manual Restraint Usage:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection, observations of the first responders
Eyewear:	Unknown
Vehicle Familiarity:	Owner and sole operator
Route Familiarity:	Familiar with roadway
Medical Treatment	None, expired at scene

***Driver Injuries***

<b>Injury</b>	<b>Injury Severity (AIS 90)</b>	<b>Injury Mechanism</b>
Bilateral rib fractures involving 13 ribs	Severe (450240.4,3)	Combination of loading the manual belt system and steering assembly
Punctured heart	Severe (441008.3,4)	Combination of loading the manual belt system and steering assembly
Bilateral wrist fractures	Moderate (751800.2,1) Moderate (751800.2,2)	Steering wheel
Compound fracture, left ankle	Moderate (852000.2,2)	Toe pan
Compound fracture, right ankle	Moderate (852000.2,1)	Brake pedal

\* Source - Verbal report by the Medical Examiner (Autopsy Report was not available)

***Driver Kinematics***

This 81 year old driver of the Lumina was described by the investigating officer as a short stature female with a slender build. Her specific height and weight were not available. The driver was seated in a normal driving posture prior to the crash. The left front seat track was adjusted to a forward position 5.4 cm (2.1" rearward of the full forward position and 14.2 cm (5.6" forward of the full rearward position] and the seat back was reclined 23 degrees rearward of vertical (**Figure 14**). The post-crash horizontal distance between the center of the driver air bag module and the seat back support was 41.3 cm (16.25"). It should be noted, however, that this measurement was inclusive of the 6.4 cm (2.5") of forward displacement of the energy absorbing steering column.



**Figure 14. Forward seated position of the driver.**

The driver was restrained by the manual 3-point lap and shoulder belt system. Belt usage was determined by the observations of the first respondent to the crash scene, on-scene photographs of the driver within the vehicle, and loading abrasions of the lap belt webbing at the lower sill anchorage. There was no D-ring loading or other webbing loading on the belt system. The driver’s loading force against the manual belt system was relatively low due to the deployment of the redesigned air bag and the driver’s forward position with respect to the steering assembly.

At impact, the redesigned frontal air bag system deployed. The driver initiated a forward trajectory in response to the frontal impact force. The driver's knees contacted the knee bolster (**Figure 15**), depositing fabric transfers and scuff marks on the bolster at the steering column location (beneath the column) and again, to the left of the steering column cutout. These transfers were approximately 15 cm (6.0") in length with the length of the contact pattern reflecting a combination of the driver's forward motion and the rearward displacement of the instrument panel.



**Figure 15. Driver knee contacts to the knee bolster.**

The driver's face and upper torso loaded the deployed front left air bags as she began moving forward with respect to the decelerating vehicle. A large make-up transfer (flesh-tone make-up and red lipstick) was noted to the bag surface (**Figure 16**). The largest portion of this transfer was located on the lower left quadrant of the bag although the transfer did extend into other quadrants. The lipstick transfer was symmetrical in shape and not streaked which indicated the driver loaded a deployed, or near fully deployed air bag. The driver's loading force was transmitted through the bag, due to the relatively large crash pulse, which resulted in forward deflection of the upper steering wheel rim (spoke deflection) and compression of the energy absorbing steering column (**Figure 17**). The column shear capsules were completely separated with 6.4 cm (2.5") of separation movement documented.



**Figure 16. Make-up transfers on the front left air bag.**



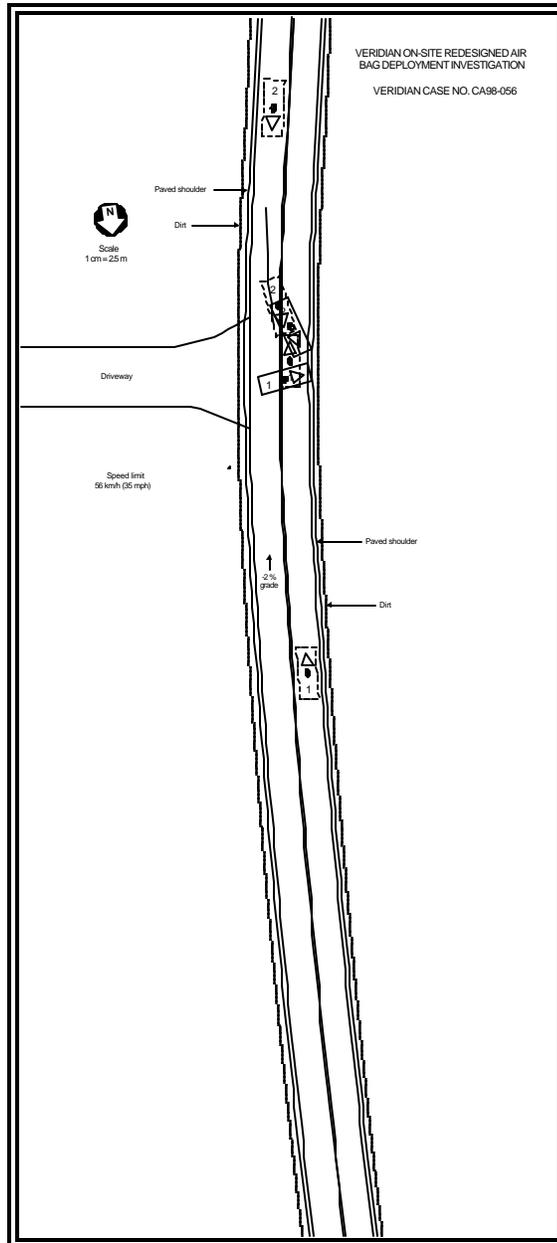
**Figure 17. Forward deflection of the steering wheel and steering column.**

The Lumina driver sustained bilateral rib fractures involving 13 ribs and a puncture wound of the heart. It is believed that these injuries were sustained as a combination of loading the manual restraint system belt webbing and loading of the steering assembly through the air bag.

The Lumina driver also sustained fractures of both wrists and compound fractures of both ankles. The wrist fractures were probably sustained as a result of bracing against the steering wheel rim. There was no evidence of contact to the windshield, left A-pillar, instrument panel, or rear view mirror as a result of upper

extremity displacement from the steering rim (commonly associated with air bag expansion). The compound right ankle fracture was associated with involvement with the brake pedal. Bone fragments were present in the corrugations of the rubber brake pedal pad. Similarly, the compound left ankle fracture was associated with the left toe pan where bone fragments were found in the carpeting to the left of the brake pedal. The brake pedal and toe pan intruded rearward as a result of the frontal impact sequence.

The driver expired at the scene of the crash and was pronounced dead in the vehicle. There were no attempts to revive the driver.



**Figure 18. Crash Schematic**