

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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CALSPAN ON-SITE DRIVER AIR BAG DEPLOYMENT FATALITY INVESTIGATION

CALSPAN CASE NO. CA98-048

VEHICLE - 1996 OLDSMOBILE NINETY EIGHT

LOCATION - NORTH CAROLINA

CRASH DATE - AUGUST, 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 of the involved vehicle(s) or their safety systems.

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BACKGROUND

This on-site investigation focused on the fatal injury mechanisms of the 61 year old female driver of a 1996 Oldsmobile Ninety Eight. The Oldsmobile was involved in an intersection collision with a 1991 GMC medium-duty straight truck. The Oldsmobile was equipped with a front Supplemental Inflatable Restraint (SIR) that consisted of driver and right front passenger air bags that deployed as a result of the crash. The Oldsmobile's driver was restrained by the vehicle's 3-point manual restraint and was seated in a probable mid-track position at the time of the crash. The driver loaded the manual restraint and was contacted by the deploying air bag which resulted in multiple thoracic and neck injuries. The autopsy records indicated the driver's major injuries included: a brainstem contusion, an atlanto-occipital dislocation, bilateral rib fractures, and sternal and clavicle fractures. The driver was found pulseless and slumped over the steering wheel by the first responders. She was pronounced dead approximately one hour post-crash at the emergency room of a local hospital.

The driver's daughter notified the Field Branch Office of the National Highway Traffic Safety Administration (NHTSA) of the crash on September 10, 1998. NHTSA in-turn assigned an on-site investigative effort to the Special Crash Investigation team at Calspan on the same day. The on-site investigation began on September 13, 1998. Technical representatives from General Motors Corporation inspected the Oldsmobile and downloaded data from the vehicle's Sensing Diagnostic Module on October 29, 1998.

SUMMARY

This two-vehicle crash occurred in a suburban 4-leg intersection during the morning hours of August, 1998. At the time of the crash, it was daylight and the weather was not a factor. **Figure 1** is a southward view into the intersection. The roadways comprising the intersection were configured north/south and east/west in direction and intersected at an acute angle. The north/south road was asphalt paved and consisted of three lanes, two travel lanes through the intersection and a center left turn lane. The total width of the road was 11 m (36 ft). The east/west roadway was asphalt paved and consisted of 2 lanes. The intersection was controlled by standard (overhead) red/amber/green traffic signals. A left turn arrow controlled the northbound center turn lane. The speed limit in the area of the crash was 89 km/h (55 mph).



Figure 1: Southward view into the intersection.

The 1996 Oldsmobile Ninety Eight was southbound on the approach to the intersection, driven by a 61 year old female en route to a morning appointment. The 1991 GMC straight truck was northbound in the center turn lane driven by a 21 year old male. The truck was reportedly loaded and was in the process of making a delivery at a local manufacturing facility. As the Oldsmobile entered the intersection on the green signal phase, the driver of the GMC initiated a left turn directly across the Oldsmobile's path of travel.

The crash occurred with the front of the Oldsmobile impacting the front of the GMC. The low frontal profile and compliant suspension of the Oldsmobile, as compared to the truck, caused the vehicle to under-ride the GMC's front bumper. **Figure 2** is an on-scene police photograph of the vehicles engaged at final rest. The vehicle's came to rest near the point of impact and in contact with one another, in the southbound lane of the intersection. There was no evidence identified at the crash scene that located the specific point of impact. The 12 o'clock direction of the impact force deployed the Supplemental Inflatable Restraint of the Oldsmobile.



Figure 2: Southwestward view of the vehicle's at final rest.

Figures 3 and 4 are the front and left lateral views of the Oldsmobile respectively. The front bumper structure of the Oldsmobile sustained 100.3 cm (39.5 in) of direct contact damage that began 21.6 cm (8.5 in) right of centerline and extended to the left corner of the bumper. Due to the under-ride nature of the crash, the bumper damage to the Oldsmobile consisted primarily of scuffs and scratches. There was approximately 2.5 cm (1.0 in) of residual crush across the width of the bumper. A tire scuff was located on the vertical surface of the bumper cover as a result of contact with the left front tire of the truck. The tire scuff began 21.6 cm (8.5 in) right of center and extended 13 cm (5 in) to the left. The front bumper was mounted to the vehicle's forward uni-body structure by two Energy Absorbing Devices (EAD's). The left and right EAD's compressed 3.2 cm (1.3 in) and 6.4 cm (2.5 in), respectively, during the impact with the truck tire. Both EAD's had returned to their original 8.9 cm (3.5 in) length through full restitution. The



Figure 3: Front view of the Oldsmobile.

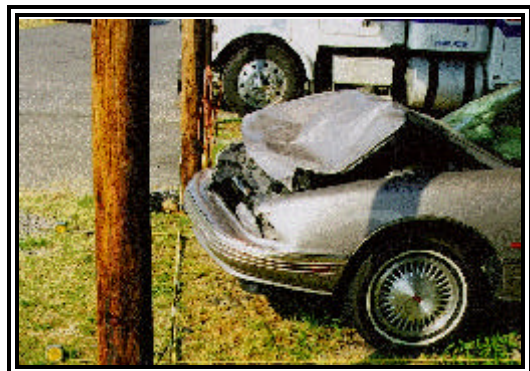


Figure 4: Left lateral view of the Oldsmobile.

under-ride damage extended rearward over the area surrounding the left headlamp structures and onto the left aspect of the hood and the left front fender. The hood buckled and shifted rearward fracturing the left lower aspect of the windshield. The scratches along the top edge of the left fender extended rearward 86 cm (34 in) from the front of the vehicle. The vehicle was mechanically operational (driveable) after the crash. There was no measurable change in the wheelbase dimensions. All the doors were operational and the side glass and backlight were intact. The windshield was fractured from the aforementioned hood contact and from the deployment of the right front passenger air bag. The Collision Deformation Classification (CDC) of the Oldsmobile was 12-FYEW-1. An analysis of the damage sustained by the Oldsmobile for the purposes of crash reconstruction was beyond the scope of the WINSMASH model. Forensic analysis of the damage based on SCI experience indicated the delta V experienced by the Oldsmobile was approximately 23 to 29 km/h (14 to 18 mph). Additionally, the crash pulse was of a long duration due to the nature of the under-ride impact.

Crash event data recorded by the SIR's Sensing Diagnostic Module (SDM) was downloaded by GM technical representatives on October 29, 1998. A summary of the on-board data follows:

- , Ignition cycle at download: 3,191
- , Code 51 "deployment commanded" set and crash file created on ignition cycle 3,188
- , No other active codes
- , SIR warning lamp was off at the time of deployment
- , Lamp was off for at least 125 ignition cycles before deployment (125 is max. count)
- , Deployment commanded at 147 msec
- , Velocity boundary curve exceeded
- , Delta V =26.6 km/h (16.5 mph)
- , Driver seat belt buckled

GM further indicated the deployment thresholds for the 1996 Oldsmobile Ninety Eight was a speed change of 14.5 - 25.3 km/h (9 - 15 mph) into a barrier.

Analysis of the data indicated the vehicle's SIR was operating as designed and without errors at the time of the crash. The crash severity was above the threshold for required for SIR deployment. The vehicle's SDM calculated the delta V for this crash to be 26.6 km/h (16.5 mph). SIR deployment was initiated late in the crash sequence - 147 milliseconds after the crash was detected. The initiation of the deployment sequence is variable and is dependant on crash severity and crash dynamics. Typical firing times can range from approximately 40 to 100 milliseconds after crash detection.

The GMC truck was unavailable for inspection. The vehicle was operational and driven from scene upon completion of the police investigation. **Figure 5** is a front view of the GMC truck obtained from the investigating officer. The vehicle's damage was confined to the front bumper structure. The truck's front bumper was frame-



Figure 5: Front view of the GMC truck.

mounted and constructed from a steel rectangular section. A series of scratches and paint transfers were located on the bumper's lower center aspect. The center section of the bumper was deformed approximately 10 cm (4 in) rearward and slightly upward. The bumper damage was indicative of the Oldsmobile's under-ride and engagement with the vehicle's hood face and radiator support.

The Oldsmobile Ninety Eight's 61 year old female driver had a reported height and weight of 152 cm (60 in) and 64 kg (140 lb). She was restrained with her seat adjusted in a probable mid-track position due to her stature. A witness trailing the Oldsmobile indicated that as the Oldsmobile entered the intersection, the traffic signal was on the green signal phase. He further indicated that he did not recall any brake lights illuminate on the Oldsmobile prior to impact.

Upon impact, the Oldsmobile driver initiated a forward trajectory in response to the 12 o'clock direction of the impact force and loaded the 3-point restraint. A 10 cm (4 in) section of the shoulder belt, identified during the inspection, displayed stretched webbing from interaction with the driver. The Supplemental Inflatable Restraint deployed late in the collision sequence at a time when the driver became positioned within the deployment path of the driver air bag. The driver air bag deployed impacting the driver in the chest. The sudden deceleration of the driver's upper torso due to the contact with the 3-point restraint and air bag caused the head/neck complex to flex forward and down. A red lip stick transfer was identified on the back side of the bag in the 10 o'clock sector. The air bag expanded across the driver's chest and neck and hyper-extended the driver's head. The autopsy records indicated the driver sustained a brainstem contusion, an atlanto-occipital dislocation, multiple bilateral rib fractures, sternal and right clavicle fractures, and associated minor injuries in the crash. The inertial loading of the manual restraint loading contributed to the thoracic skeletal injuries. She was found pulseless and slumped over the steering wheel by the first responders. She was transported to the emergency room of a local hospital located approximately 1.6 km (1 mile) from the crash scene. Her Glasgow Coma Score was 3 upon arrival. The driver was pronounced dead approximately 66 minutes post-crash.

The driver's daughter indicated that she and her mother had accessed the data available through NHTSA's web site pertaining to short stature drivers. They both had investigated the installation of a cut-off switch and/or the disconnection of the air bag system's in their respective vehicles due to safety concerns. In the course of their research, they obtained DOT publication HS 808 629, which outlines NHTSA's 25 cm (10 in) measure of safety. The daughter indicated that they both used the 25 cm (10 in) measure from the "module to breastbone", as described, and adjusted the seat if necessary. She further indicated that it was a subjective measure depending on whether the top center or bottom of the module was used as a baseline. She also noted that her abdomen was much closer than the breastbone to the module. The daughter did indicate that both she and her mother felt safe, seated this distance from the air bag module, in part, after reading the NHTSA publication.

AIR BAG VEHICLE

The 1996 Oldsmobile Ninety Eight was identified by a Vehicle Identification Number (VIN): 1G3CX52K8T4 (production sequence deleted). The vehicle was equipped with a 3.6 liter, V-6 engine linked to a 4-speed automatic transmission. Safety equipment installed on the vehicle, in addition to the

Supplemental Inflatable Restraint, consisted of an anti-lock braking system. The vehicle's date of manufacture was 4/96. The odometer read 55,928 km (34,753 miles) at the time of inspection.

INTERIOR CONFIGURATION AND DAMAGE

The only damage to the vehicle's interior were those directly associated to occupant contact and the deployment of the Supplemental Inflatable Restraint. There was no interior damage associated to the external forces of the crash.

The steering assembly was configured with a four spoke, tilt steering wheel. The tilt steering wheel had five adjustments and was positioned in the second adjustment down from the top. There was no deformation of the steering wheel rim. Inspection of the steering column's shear plate indicated there was no displacement of the column.

The vehicle's interior was leather and gray in color. The front seat was a 60/40 split bench with a 6-way electrically powered adjustment. At inspection, the left front seat was found to be in the full rear track position. The seat back was adjusted to the most upright position, measured at 20 degrees aft of vertical. It is believed the seat track had been altered from the at-crash position. The seat was probably moved rearward by rescue personnel at the crash scene during extrication of the driver. The seat may also have been moved by the tow truck operator. Reportedly he drove the vehicle during its removal from the crash scene.

The driver's daughter described her mother's nominal seat position during an interview. Reportedly, the driver typically adjusted the seat to a mid-track position with the seat back slightly reclined and the seat cushion somewhat elevated. At inspection, the right front seat was found to be in a mid track position. Assuming the split bench seat was adjusted consistently right to left, the left front seat would have been in a mid-track position at the time of the crash. The front seat track had a 20 cm (8 in) adjustment range. The horizontal distance from the driver air bag module to the seat back measured 31.1 cm (12.2 in) with the seat in the full forward position and measured 51 cm (20 in) with the seat track adjusted to the full rear position.

The only possible interior occupant contact identified was a faint 5 cm (2 in) scuff on the driver's knee bolster. The center of the scuff was located 10 cm (4 in) left of the steering column centerline. This minor contact would have been non-injury producing. It was also possible this scuff could have developed from contact during the driver's ingress/egress.

MANUAL RESTRAINT SYSTEM

The manual front outboard restraint in the 1996 Oldsmobile Ninety Eight consisted of a 3-point lap and shoulder belt system. The lap and shoulder belt webbings were fixed to the integral latch plate and spooled from two separate dual purpose (webbing and inertial sensitive) locking retractors located in the base of the B-pillar. The D-rings were adjustable. There was a lap belt in the center front position.

All evidence identified in the course of the investigation indicated the Oldsmobile's driver was restrained. The first responders to the crash scene indicated they removed the seat belt from the driver during the extrication process. **Figure 6** is a view of the left front restraint. Inspection of the restraint identified a region on the shoulder belt webbing that exhibited evidence of occupant contact. The contact evidence was approximately 10 cm (4 in) in length and was located 33.6-43.8 cm (13.25-17.25 in) from the latch plate. Webbing fibers located within this area were stretched and pulled. This region of the shoulder belt would have been located approximately over the driver's mid-chest and probably contributed to the driver's skeletal injuries. The left front D-ring was in the full up position. This D-ring adjustment would have introduced slack in the belt system, given the driver's short stature. The D-ring probably should have been adjusted to the full down position to provide a better fit of the shoulder belt to the driver's stature.



Figure 6: View of the left front restraint.

SUPPLEMENTAL INFLATABLE RESTRAINT

The 1996 Oldsmobile Ninety Eight was equipped with a Supplemental Inflatable Restraint (SIR) that consisted of driver and right front passenger air bags that deployed as a result of the crash. The Sensing and Diagnostic Module (SDM) of the SIR was located within the occupant compartment. There was an additional forward crash sensor mounted to the upper radiator support. The sensor was located approximately 15 cm (6 in) left of center and was within the area of direct vehicular contact (refer to **Figure 3**).

The driver air bag module was designed in the typical configuration within the center hub of the steering wheel. The I-configuration cover flaps measured 8.3 cm by 12.7 cm (3.3 in by 5.0 in) width by height. There was no contact evidence on the exterior surfaces of the cover flaps. A 2.5 cm by 1.2 cm (1.0 in by 0.5 in) red lip stick transfer from occupant contact was identified on the back side of the air bag. The transfer was located in the 10 o'clock sector approximately 5.7 cm (2.2 in) from the module (**Figure 7**).

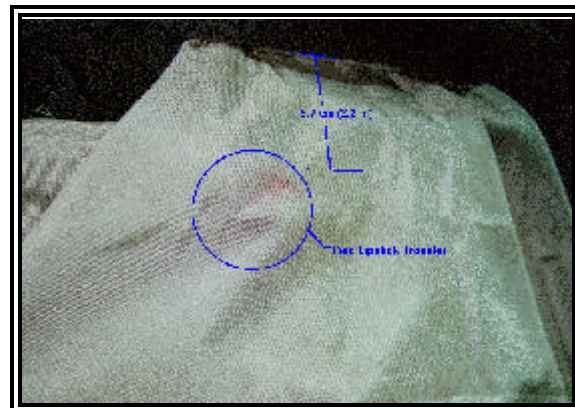


Figure 7: Lip stick transfer to the back side of the driver air bag.

Figure 8 is a view of the face of the driver air bag. The air bag was oval shaped and measured 51 cm by 61 cm (20 in by 24 in) width by height. The bag was not tethered. There were two 2.5 cm (1.0 in) vent ports located in the 3/9 o'clock sectors on the back side of the bag. One 3 mm (1/8 in) diameter blood

spatter and two 3 mm (1/8 in) diameter blood spatters were located on the face of the air bag in the upper left and lower right quadrants, respectively. A 3.8 cm (1.5 in) diameter blood transfer was located on the face of the bag 4.5 cm (1.8 in) right of center. A red lip stick transfer, 1.2 cm (0.5 in) in length, was located 12.1 cm (4.8 in) left of the center of bag. The transfers on the face of the air bag resulted from the driver's rebound contact.



Figure 8: View of the driver air bag.

The right front passenger air bag deployed from a top mount module designed in the right aspect of the instrument panel. The module cover measured 39.4 cm by 19.1 cm (15.5 in by 7.5 in), width by height. The module cover fractured the right side of the windshield during the deployment sequence. The face of the passenger air bag measured 71 cm by 66 cm (28 in by 26 in) width by height and extended 28 cm (11 in) from the aft edge of the module, in its deflated state.. The bag was tethered by two 62.2 cm (24.5 in) straps sewn to the face of the bag. The air bag was vented by two 5 cm (2 in) diameter ports located on the side panels of the bag. There was no contact evidence on the air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	61 year old/Female
Height:	152 cm (60 in)
Weight:	64 kg (140 lb)
Manual Restraint Usage:	3-point lap and shoulder
Usage Source:	Vehicle inspection/Observations of the first responders to the crash scene
Eyewear:	Sunglasses

DRIVER INJURIES

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
Pontine contusions (anterior region)	Severe (140204.5,8)	Deploying driver air bag
Subarachnoid hemorrhage - cerebellum	Serious (140466.3,6)	Deploying driver air bag
Fracture of the right 1 st , 3 rd , 4 th , 5 th Left 2 nd , 3 rd ribs w/ left hemothorax (50 ml)	Serious (450232.4,3)	Inertial loading of 3-point restraint Deploying driver air bag

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
Atlanto occipital dislocation	Moderate (650208.2,6)	Deploying driver air bag
Sternal fracture	Moderate (450804.2,4)	Inertial loading of 3-point restraint/deploying driver air bag
Right clavicular fracture	Moderate (752200.2,1)	Deploying driver air bag
Multiple facial abrasions	Minor (290202.1,9)	Deploying driver air bag
Multiple facial contusions	Minor (290402.1,9)	Deploying driver air bag
1.5 cm (0.6 in) laceration of the lower lip	Minor (290600.1,8)	Deploying driver air bag
5x7 cm (2x3 in) contusion of the chest muscle (left side)	Minor (490402.1,2)	Inertial loading of 3-point restraint
Contusion right upper chest	Minor (490402.1,1)	Deploying driver air bag
Unspecified chest abrasions	Minor (490202.1,9)	Deploying driver air bag
Bilateral contusions of the upper arms	Minor (790402.1,3)	Deploying driver air bag

Note: the injuries listed above were identified in the driver's autopsy records

DRIVER KINEMATICS AND INJURY

At impact, the driver of the Oldsmobile was properly restrained with her seat adjusted to a presumed mid-track position. The restraint's adjustable D-ring was in the full up position. This adjustment probably introduced some additional slack into the belt system, given the driver's short stature. Due to the configuration of the interior, the mid-track seat adjustment probably positioned the driver at the outer limits of the driver air bag deployment zone. She may have raised her right arm up and/or across her chest guarding/protecting herself from the crash.

The driver initiated a forward trajectory in response to the 12 o'clock direction of the impact force and loaded the 3-point restraint. Inspection of the left front restraint identified a 10 cm (4 in) section of the webbing with fibers that were stretched/pulled, **Figure 6**. This deformed section of the belt would have been positioned approximately over the driver's mid-chest. In the crash, the Oldsmobile under-rode the GMC truck's front bumper and contacted the truck's left front tire. The "soft" (under-ride) nature of the impact delayed the deployment of the Oldsmobile's SIR until a point late in the collision sequence. The SDM commanded deployment of the air bag system 147 milliseconds (0.147 seconds) after detection of the crash. The late air bag deployment resulted in increased manual restraint loading and greater occupant

translation. The driver's forward trajectory caused her to become positioned within the deployment path of the air bag.

The SIR deployed and the driver air bag contacted the driver's upper chest and right arm evidenced by the minor abrasions and contusions to these body regions. Her arm probably rebounded with the right hand impacting and causing the localized left chest contusion. Her right clavicle was probably fractured in this sequence. The sudden deceleration of the chest due to the combined restraint and air bag loading caused the driver's head/neck complex to flex forward and down. The driver's face contacted the 10 o'clock sector of the back side of the bag evidenced by the red lip stick transfer, **Figure 7**. The impact of the bag caused multiple bilateral rib fractures and the sternal fracture. The driver's inertial contact with the 3-point restraint probably contributed to the left rib fractures.

The air bag expanded across the driver's chest, neck and face. The continued expansion of the bag hyper-extended the driver's head causing an atlanto-occipital dislocation and a brainstem contusion. Expansion of the bag caused the multiple abrasions/contusions to the face and the laceration of the lower lip. The driver rebounded to the seat back and then forward again into contact with the face of the air bag evidenced by the lip stick and blood transfers on the face of the bag, **Figure 8**. Post-crash, the driver was found slumped over the steering wheel and unresponsive.