

**TRANSPORTATION SCIENCES  
CRASH RESEARCH SECTION**

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**CALSPAN REMOTE AIR BAG DEPLOYMENT/CHILD  
FATALITY INVESTIGATION  
CALSPAN CASE NO. 1997-41-049A  
CRASH LOCATION: STATE OF FLORIDA  
CRASH DATE: APRIL, 1997**

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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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<p>16. <i>Abstract</i> This remote investigation focused on the deployment of the front left and front right air bags of a 1995 Saturn SL-2, 4-door sedan, and the subsequent fatality of a two year old male that was seated on the lap of the right front passenger. The front of the Saturn impacted the rear of a 1984 Oldsmobile 98 Regency, 4-door sedan, in a front-to-rear type impact configuration which initiated the deployment of the Saturn's air bag system. The two year old male child sustained injuries which included a fracture/dislocation of C1 and C2 with transection of the spinal cord and a 10 cm (4 in) separation between C1 and C2 (AIS-6) resulting from the expanding front right air bag. The child also sustained a retroperitoneal hematoma (AIS-3). Post-crash, the male occupant was removed from the Saturn by passers by who placed him on the south shoulder of the roadway where CPR was initiated. EMS arrived on scene and transported the child to a local trauma center. Elapsed time from scene departure to arrival at the medical facility was 30 minutes. The male child was pronounced deceased two and one half hours post-crash due to an unrecoverable cervical cord injury. The male driver and primary right front female passenger of the Saturn reportedly sustained minor injuries (AIS-1) as a result of the crash.</p>			
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***Background***

This remote investigation focused on the deployment of the front left and front right air bags of a 1995 Saturn SL-2, 4-door sedan, and the subsequent fatality of a two year old male that was seated on the lap of the right front passenger. The front of the Saturn impacted the rear of a 1984 Oldsmobile 98 Regency, 4-door sedan, in a front-to-rear type impact configuration which initiated the deployment of the Saturn's air bag system. The two year old male child sustained injuries which included a fracture/dislocation of C1 and C2 with transection of the spinal cord and a 10 cm (4 in) separation between C1 and C2 (AIS-6) resulting from the expanding front right air bag. The child also sustained a retroperitoneal hematoma (AIS-3). Post-crash, the male occupant was removed from the Saturn by passing motorists who placed him on the south shoulder of the roadway where CPR was initiated. EMS arrived on scene and transported the child to a local trauma center. Elapsed time from scene departure to arrival at the medical facility was 30 minutes. The male child was pronounced deceased two and one half hours post-crash due to an unrecoverable cervical cord injury. The male driver and primary right front female passenger of the Saturn reportedly sustained minor injuries (AIS-1) as a result of the crash.



Figure 1. View of the damaged frontal plane  
of the Saturn.

This remote investigation was assigned to Calspan's Special Crash Investigation team on October 24, 1997, following data acquisition from NASS Primary Sampling Unit 41 and the regional trauma center who initially researched this crash. NHTSA subsequently requested a narrative report from Calspan's Special Crash Investigation team based on the data obtained.

## ***Summary***

This crash occurred during the evening hours on a five lane undivided straight roadway with a posted speed limit of 56 km/h (35 mph). The roadway was bordered by a sidewalk for the east and west bound travel lanes and intersected with a north/south bound roadway. All roadways were artificially illuminated. The four-leg intersection was controlled by overhead signals that were in the red phase for east/westbound travel at the time of the crash. Rainy conditions resulted in a wet asphalt road surface.

The 1995 Saturn SL-2, 4-door sedan (1.9 L, L-4), was identified by vehicle identification number (V.I.N.) 1G8ZK5278SZ (production number omitted) and had 99,232 kilometers (61,660 miles) at the time it was inspected by the trauma center researcher. The Saturn was equipped with a Supplemental Inflatable Restraint (SIR) system that included front left and front right air bags which initiated deployment as a result of the front-to-rear type impact configuration. Three-point manual lap and shoulder belt systems were available for the four outboard seated positions and a lap belt was available for the rear center seated position. The Saturn was equipped with a four-speed automatic transmission and it was unknown if an this vehicle was equipped with an anti-lock braking system.

The 1984 Oldsmobile 98 Regency, 4-door sedan (5.0 L, V-8), was identified by V.I.N. 1G3AG69Y0EM (production number omitted). The vehicle was equipped with 3-point manual lap and shoulder belt systems for the front outboard seated positions and lap belts for the center front and all rear seated positions. The Oldsmobile was equipped with a 40/60 split bench seat.

## ***Crash Events***

The Saturn was traveling eastbound in the second lane of the five lane undivided roadway approaching the four-leg intersection. The Oldsmobile was traveling ahead of the Saturn also in the second lane. The driver of the Oldsmobile began braking actions to slow for the overhead control signal in the red phase. The driver of the Saturn failed to detect the overhead light or the yielding Oldsmobile in sufficient time to successfully avoid the collision. He initiated avoidance actions by applying the brakes of the Saturn, however, he subsequently impacted the back plane of the Oldsmobile with the front plane of the Saturn. The PAR and scene photographs did not identify the presence of pre-crash braking skid marks. The front bumper fascia of the Saturn contacted and overrode the back bumper of the Oldsmobile which resulted in the deployment sequence of the front left and front right air bag system of the Saturn. The rear springs of the Oldsmobile had been modified and the rear of the vehicle subsequently rode low to the ground. The alteration of the rear springs resulted in the override-type damage to the rear of the Oldsmobile. The Saturn came to final rest in its respective travel lane. The Oldsmobile came to final rest in the left turn lane of the eastbound roadway.



Figure 2. View of the Saturn's approach to point of impact.

**Vehicle Damage**

The Saturn SL-2 sustained minor frontal damage which extended across the entire width of the front bumper fascia. Direct contact damage began at the left front bumper corner and extended 114 cm (45 in) to the right corner. Crush was minimal and was reported at a maximum of 6.0 cm (2.4 in) located at the right front bumper corner. Table 1 identifies the crush sustained by the frontal plane of the Saturn. The damage resulted in a 12 o'clock direction of force with a resulting Collision Deformation Classification (CDC) of 12-FDEW-1. The SMASH program generated a total delta V of 22.9 km/h (14.2 mph). Calculated longitudinal and lateral delta V's were -22.9 km/h (-14.2 mph) and 0 km/h, respectively. A General Motors representative present at the vehicle inspection with the trauma center researcher ascertained a total delta V of 24.9 km/h (15.5 mph) from information retained in the Saturn's Systems Diagnostic Module (SDM). The Saturn's measured crush was probably under represented due to rebound of the front bumper's energy absorption system and the pliable material of the bumper cover which resulted in a lower calculated SMASH delta V then reported by the SDM. The interior of the Saturn lacked intrusion damage. Interior vehicle damage consisted of a fracture of the rear view mirror's glazing and its subsequent forward displacement which resulted in a fracture of the windshield.



Figure 3. View of the damaged frontal plane of the Saturn.

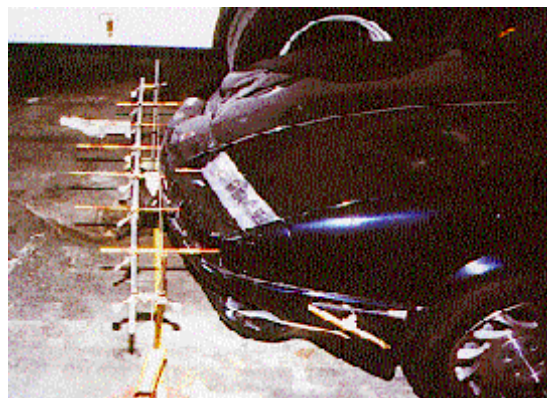


Figure 4. Left lateral view of the Saturn's damaged frontal plane.

Table 1. Saturn SL2 Frontal Plane Crush Measurements

	<b>C1</b>	<b>C2</b>	<b>C3</b>	<b>C4</b>	<b>C5</b>	<b>C6</b>
<b>Front Bumper Crush</b>	3.0 cm (1.3 in)	3.0 cm (1.3 in)	3.0 cm (1.3 in)	3.0 cm (1.3 in)	4.0 cm (1.6 in)	6.0 cm (2.4 in)

The Oldsmobile 98 Regency sustained induced and direct damage which extended across the width of the back plane. Direct contact damage began at the right rear bumper corner and extended 119 cm (47 in) left. Crush measurements were calculated at the bumper level and at the at the lower aspect of the tail lamps due to the overriding damage pattern sustained by the Oldsmobile. Maximum bumper crush was

reported at 23.0 cm (9.1 in) at the right rear bumper corner. Maximum crush at the tail lights was calculated at 42.0 cm ( 16.5 in). Maximum crush was 42.0 cm (16.5 in) located at the right rear bumper corner. Table 2 identifies the crush damage profile sustained by the Oldsmobile. The damage resulted in a 6 o'clock direction of force with a resulting CDC of 06-BDEW-2. The extent zone was revised following SCI reviewing the CDS case file. The SMASH program generated a total delta V of 14.0 km/h (8.7 mph). Calculated longitudinal and lateral delta V were 14.0 km/h (8.7 mph) and 0 km/h, respectively.



Figure 5. View of the damaged back plane of the Oldsmobile.

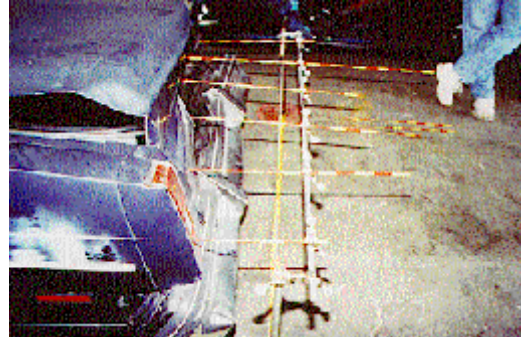


Figure 6. Left lateral view of the Oldsmobile's damaged back plane.

**Table 2. Oldsmobile 98 Regency Back Plane Crush Measurements**

	<b>C1</b>	<b>C2</b>	<b>C3</b>	<b>C4</b>	<b>C5</b>	<b>C6</b>
<b>Back Bumper Crush</b>	10 cm (3.9 in)	16.0 cm (6.3 in)	21 cm (8.3 in)	24.0 cm (9.4 in)	23.0 cm (9.1 in)	18.0 cm (7.1 in)
<b>Above Bumper Crush</b>	0 cm (0 in)	5 cm (2.0 in)	16.0 cm (6.3 in)	40.0 cm (15.7 in)	42.0 cm (16.5 in)	34.0 cm (13.4 in)
<b>Resultant Crush</b>	10 cm (3.9 in)	16 cm (6.3 in)	21 cm (8.3 in)	32 cm (12.6 in)	33 cm (13.0 in)	26 cm (10.2 in)

### *Automatic Restraint System*

The Supplemental Inflatable Restraint system of the Saturn consisted of a SDM and front left and front right air bags which deployed as a result of this vehicle's frontal impact with the back plane of the Oldsmobile. Information retained by the vehicle's SDM indicated that the SIR Warning Lamp, located on the instrument panel display, was off at the time of deployment and that the air bag system deployed 82.5 milliseconds after the crash was first detected by the SDM. Another event was also recorded during the same ignition cycle as the crash event. The maximum delta V for this secondary event was recorded at 0.35 km/h (0.22 mph).



The front left air bag was concealed within the hub of the steering wheel and deployed from the I-configuration module cover flap. The air bag was equipped with two vent ports located at the 1 and 11 o'clock positions. The air bag's rearward excursion was restricted by four tethers. Several black vinyl transfers were located in the upper left, upper right, and lower right quadrants on the face of the air bag. Steering rim and spoke deformation was not present and the trauma center researcher reported no movement of the steering column shear capsules.



Figure 7. Right lateral view of the Saturn's passenger compartment area.

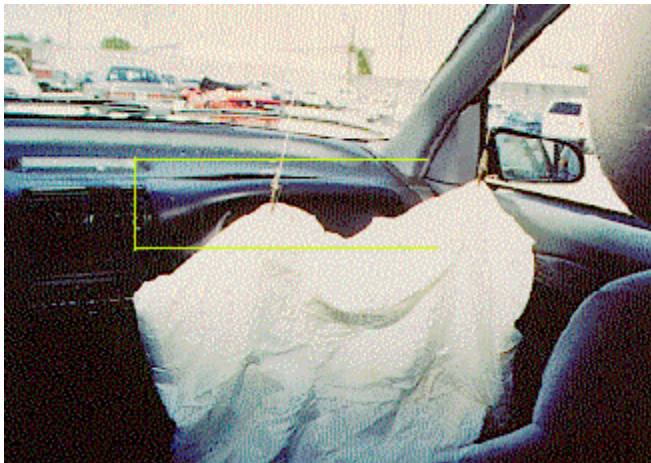


Figure 8. View of the deployed front right air bag and highlighted instrument panel brow.

The front right air bag deployed from a mid-mounted position in the right side instrument panel which was equipped with a brow (protruding curved upper panel) above the module cover flap designed to direct the deployment path of the air bag. The module cover flap had a measured maximum width of 30 cm (12 in) and a maximum height of 12.0 cm (4.7 in). Possible occupant contact was located inferior and adjacent to the top seam of the air bag which consisted of a brown transfer. The air bag was not equipped with tethers or vent ports and measured 69 cm (27 in) in width and 43 cm (17 in) in height. Contact damage to the air bag consisted of a "scuff", not further defined, at the top seam of the face of the air bag, centered.

### ***Driver Information and Kinematics***

The driver of the Saturn was a 22 year old male with a reported height of 175 cm (69 in) and weight of 136 kgs (300 lbs). He was not restrained by the 3-point manual lap and shoulder belt system as indicated by SDM stored data, the PAR, and witness accounts of the crash events. Location of the seat track was reported at the rear most position by the trauma center researcher. The seat back was reportedly reclined and the tilt steering wheel was in the full upright position. At impact, the unrestrained driver responded to the 12 o'clock direction of force and was displaced in a forward direction as the air bag deployed. The driver presumably contacted his right forearm or hand with the displaced and fractured rearview mirror and windshield as his hand was displaced from the steering wheel when the air bag deployed. The mirror

was displaced down and to the left with respect to the vehicle and the windshield fracture was located to the left of the rearview mirror. The PAR indicated that the driver of the vehicle did not sustain injury as a result of the crash, however, medical reports for the child positioned on the lap of the right front seated occupant indicated that the driver sustained minor (not further specified) injuries. The driver did not receive treatment.



Figure 9. Displaced and damaged rear view mirror and fractured windshield.

### ***Right Front Passengers Information***

The primary right front seated passenger of the Saturn was a 21 year old female with an unknown height and weight. A two year old male child was positioned on her lap in a forward facing position. He had a reported height of 81.3 cm (32.0 in) and weight of 9.5 kgs (21 lbs). The right front seat track was reported by the trauma center researcher at the rear track position and the seat back slightly reclined. Restraint usage for these occupants was questionable. Witnesses to the crash events report that the available 3-point manual belt was not utilized by either the right front seated female passenger or the male child positioned on her lap. The PAR does not indicate restraint usage for the female occupant, however, it does indicate that the male child was not restrained. NASS and trauma center researchers as well as medical reports also indicated that the female and child occupants were not restrained. The SDM does not record belt usage for the right front position. Abdominal and groin injuries sustained by the child occupant were typical in nature of a lap belted occupant. These included a laterally oriented left thigh abrasion (AIS-1), a right groin laceration (AIS-1), left groin contusion (AIS-1), and retroperitoneal hematoma (AIS-3). All injuries are identified in Table 3.

### ***Right Front Passengers Kinematics***

There are several scenarios capable of explaining the occupant kinematic pattern and resulting injury for the male child occupant seated on the lap of the right front female occupant. The first focused on the theorized unrestrained right front occupants. If the occupants were unrestrained, forward displacement

would initially have resulted from pre-impact braking maneuvers on the part of the Saturn's driver. The female passenger probably recognized an impending crash and held the male child tightly around the waist in an effort to restrain the child. At impact, the passengers were displaced further forward in response to the 12 o'clock direction of force as the air bag began its deployment sequence. The air bag's initial deployment was directed to the approximate height of the male child's neck due to the child's position on the lap of the female occupant and the instrument panel brow that was designed to direct the deployment path of the air bag toward the occupant, rather than upward. Contact with the deploying air bag resulted in soft tissue injuries which included a neck abrasion extending across the entire anterior neck just below the jaw line (AIS-1), small central chin abrasion with an inner lower lip laceration (AIS-1), left lower cheek abrasion along the jaw line (AIS-1), abrasion behind the right earlobe (AIS-1), and a large left neck hematoma (AIS-1). The force of the deploying air bag against the child's neck initiated the rapid movement of the child's head and torso as the lower half of his body was presumably still restricted by the female passenger's tight grasp. This upward and rearward movement, resultant of air bag expansion, resulted in 10 cm (4 in) of separation between C1 and C2 with a fracture/dislocation and cervical cord transection (AIS-6). A retroperitoneal hematoma (AIS-3), left thigh abrasion (AIS-1), right groin laceration (AIS-1), and left groin contusion (AIS-1) were a result of the passenger's tight grasp and the child's primary upward movement from the force of the expanding air bag. Secondary rearward displacement of the child resulted in contact to the right front female passenger's mouth and teeth with the posterior of the child's head. A posterior scalp laceration (AIS-1) was reported to the child and unspecified mouth and/or dental injuries to the female right front passenger.

The second scenario focused on the use of the lap portion of the belt system as the source of lower bodily injury sustained by the male child passenger. Pre-impact braking and the 12 o'clock direction of force sustained by the Saturn would have resulted in a jackknife movement of the male child occupant due to use of the lap portion of the belt system as the air bag initiated its deployment sequence. Exemplar to the first scenario, the air bag's initial deployment was directed to the approximate height of the male child's neck due to the child's position on the lap of the female occupant and the instrument panel brow. The force of the deploying air bag against the child's neck resulted in previously noted soft tissue injuries and the upward and rearward movement of the child's head and torso as he was still restrained by the manual lap belt. A 10 cm (4 in) separation between C1 and C2 with a fracture/dislocation and cervical cord transection (AIS-6) resulted. Previously noted abdominal and groin injuries were a result of restriction by the lap belt. This scenario is the most plausible for this crash.

### ***Male Child Right Front Passenger Treatment***

Post-crash, passers by, which included a nurse, stopped at the crash scene and assisted in removing the male child from the Saturn to the south shoulder of the road. After determining that the child was not breathing, the nurse initiated CPR and reported that the child did "blow air back into her mouth". EMS responded to the scene and reported that the male child was found to be asystole (in cardiac arrest) with a Glasgow Coma Scale (GCS) of 3. The child was subsequently transported via ambulance to a trauma center. Elapsed time from on-scene departure to arrival at the medical facility was 30 minutes. Trauma

center physicians diagnosed the child’s injuries as fatal and pronounced death two and one half hours post-crash. Presumably, the right front female passenger was treated for sustained mouth injury, however, it is not reported on available documentation.

**Table 3. Right Front Male Child Passenger Injuries**

<b>Injury</b>	<b>Injury Severity (AIS-90)</b>	<b>Injury Mechanism</b>
C1/C2 fracture/dislocation with transection of the cervical spinal cord and 10 cm (4 in) separation between C1 and C2	Maximum (640276.6,6)	Expansion of the front right air bag
Retroperitoneal hematoma	Serious (543800.3,8)	Primary right front passenger or lap belt
*Left thigh abrasion	Minor (890202.1,2)	Primary right front passenger or lap belt
*Right groin laceration	Minor (590602.1,8)	Primary right front passenger or lap belt
*Left groin contusion	Minor (590402.1,8)	Primary right front passenger or lap belt
Neck abrasion extending across the entire anterior neck, just below the jaw line	Minor (390202.1,5)	Expansion of the front right air bag
Small central chin abrasion with inner lower lip laceration	Minor (290202.1,8)	Expansion of the front right air bag
Left lower cheek abrasion (along the jaw line)	Minor (290202.1,2)	Expansion of the front right air bag
Abrasion behind the right earlobe	Minor (190202.1,1)	Expansion of the front right air bag
Right inner lower lip laceration	Minor (290602.1,8)	Front right air bag
Large left neck hematoma	Minor (390402.1,0)	Front right air bag
Irregular posterior scalp laceration with small amount of hemorrhage	Minor (190602.1,6)	Primary right front passenger

*\* Injury was not medically diagnosed, but identified in autopsy photographs.*

### *Other Involved Occupants*

The left rear seated occupant of the Saturn was an unrestrained male of unknown height and weight and did not sustain injury as a result of the crash. The rear center seated occupant was an unrestrained two year old male and did not sustain injury as a result of the crash. The right rear seated occupant of the Saturn was an 18 year old female who was reportedly unrestrained and uninjured as a result of the crash.

The driver of the Oldsmobile was a 22 year old male with a police reported height of 173 cm (68 in) and weight of 62 kgs (137 lbs). The PAR indicated that he was restrained by the 3-point manual lap and belt system and was not injured as a result of the crash.