

**TRANSPORTATION SCIENCES  
CRASH RESEARCH SECTION**

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**CALSPAN ON-SITE AIR BAG CHILD FATALITY INVESTIGATION**

**CALSPAN CASE NO. CA97-42**

**VEHICLE - 1995 TOYOTA AVALON**

**LOCATION - NEW YORK**

**CRASH DATE - OCTOBER, 1997**

**Contract No. DTNH22-94-07058**

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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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## CALSPAN ON-SITE AIR BAG CHILD FATALITY INVESTIGATION

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LOCATION: NEW YORK

VEHICLE: 1995 TOYOTA AVALON

CRASH DATE: OCTOBER, 1997

### **BACKGROUND**

This on-site investigation focused on a child fatality resultant to a single vehicle road side departure crash which occurred in the late afternoon hours of October, 1997. The crash involved an air bag equipped 1995 Toyota Avalon XLS 4-door. sedan. The Toyota was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags. The Toyota's SRS deployed as a result of the vehicle's impact into a tree. The fatally injured child was a seven year old male, seated unrestrained in the right front position. It was the medical examiner's impression that the child sustained a high cervical injury with probable cord transection, as a result of contact with the deploying front passenger air bag. No autopsy was performed.

The local medical examiner's office contacted the National Transportation Safety Board (NTSB) about the crash. NTSB relayed the information to the Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA). The Special Crash Investigation (SCI) Team at Calspan was assigned an on-site investigation of this crash by NHTSA on October 29, 1997. The Calspan SCI Team began the on-site investigation October 30, 1997. The vehicle was held at the police impound pending SCI investigation.

### **SUMMARY**

Inspection of the crash scene revealed the crash occurred in a residential neighborhood, in front of the child's home. The east/west road measured 10.2 m (33.5 ft) in width and was constructed of asphalt (re-paved within the last six months). The subject residence was on the north side of the road and the private driveway to the home was circular. The driveway entrances were situated on a right curve and were 32 m (105 ft) apart. Concrete curbs, 15 cm (6 in) in height, bordered the road edges. A negative grade westbound began at the east drive and the grade increased to -8% at the west drive. Further downstream from the crash scene the grade increased to -11%. The roads were damp/wet and leaf covered at the time of the crash. It had recently stopped raining. The road was marked with an advisory speed limit of 24 km/h (15 mph) preceding the curve.

**Figure 1** is a westerly view of the crash scene.

The Toyota Avalon was traveling westbound and was intending to turn right into the west drive of the residence. The vehicle was occupied by the 66 year old driver and



**Figure 1:** Trajectory view of the crash scene.

the seven year old right front passenger (the driver's grandson). In addition, the vehicle's trunk was loaded with an estimated 181 kg (400 lb) for a driving vacation. The crash occurred when the driver lost directional control, while the vehicle was in the process of executing a right turn into the driveway. The vehicle entered the northwest intersection quadrant, formed by the driveway and roadway, and struck a 35 cm (14 in) diameter tree located 2.1 m (6.9 ft) west of the driveway and 1.0 m (3.2 ft) north of the curb. A scratch 81 cm (32 in) in length was located on the road just prior to the vehicle's departure and defined the vehicle's trajectory. The center frontal plane of the Toyota impacted the tree (**Figure 2**). The vehicle came to rest in contact with the tree, partially in the northwest intersection quadrant, at a thirty degree angle relative to the road.



**Figure 2:** View of final rest position of the Toyota Avalon.

Upon impact, the inboard sidewall of the left front tire (**Figure 3**) came in contact with the curb sidewall. A distinct scuff 25 cm (10 in) in width was noted on the sidewall of the curb. Reportedly, the vehicle's engine continued to run and the front tires continued to rotate after the impact. One of the investigating officers reported that as the tire rotated, the tire rapidly heated and began to separate. The disintegrating tire damaged the inner fender of the left front wheel house and a wiring harness above the wheel area. The officer indicated that only the beads and portions of the tire's sidewalls remained attached to the wheel rim. The balance of the tire was shredded. This tire was removed and a spare tire was in place at the time of the vehicle inspection. A safety check of the vehicle was conducted. No mechanical defects were found in the brake or steering systems. However, low air pressure was measured in the remaining tires. The rear tires each measured 152 kPa (22 psi) and the right front tire measured 138 kPa (20 psi). The left front tire was probably under-inflated in a similar manner. It was the investigating officer's opinion that the low tire pressure may have been a contributing factor in the crash.

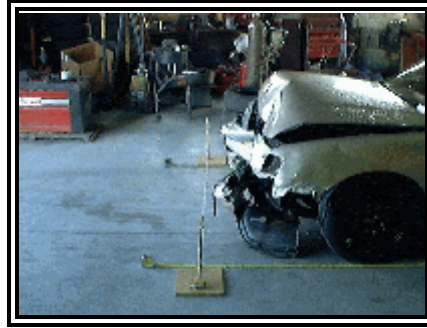


**Figure 3:** Post-crash condition of the Toyota's left front tire.

**Figures 4 and 5** are the left front and left lateral view of the Toyota Avalon taken during the inspection, respectively. The Collision Deformation Classification (CDC) of the Toyota Avalon was 12-FCEN-2. The impact deformed the entire front bumper structure of the Toyota into a V pattern when viewed from overhead. The width of the direct contact damage was 35 cm (14 in). There was a maximum deformation of 42.7 cm (16.8 in) measured at C<sub>3</sub>, located 6.4 cm (2.5 in) left of the vehicle's centerline. The deformation extended rearward buckling the hood and the center of the upper radiator support. The delta V of the Toyota was determined to be approximately 32 km/h (20 mph) by a barrier calculation using the WINSMASH algorithm.



**Figure 4:** Left front three-quarter view of the Toyota.



**Figure 5:** Left lateral view of the Toyota.

The driver of the Toyota was a 66 year old male of unknown height and weight. He was restrained by the available 3-point lap and shoulder belt. At impact, the driver exhibited a forward trajectory in response to the 12 o'clock direction of force and loaded the belt system. The driver then contacted the deployed air bag evidenced by the blood spatters and then loaded and fractured the steering wheel mechanism. A blood stained eyeglass lens was found between the driver seat and door. The lens had been popped out of its frame, indicating the driver was wearing prescription eyewear during the crash. The fractured eyewear probably lacerated the driver's face causing the blood spatters.

The right front unrestrained passenger of the Toyota was a seven year old male with a reported height/weight of 122 cm (48 in) and 22 kg (48 lb). He was seated in a presumed normal posture with the seat adjusted 5 cm (2 in) forward of the most rearward position. The seat back was reclined 25 degrees from vertical. The child occupant responded to the pre-impact braking of the Toyota by initiating a forward trajectory. This kinematic pattern positioned the child in a forward position at the time of impact. Upon impact, the child moved further forward in response to the 12 o'clock direction of force and in to the path of the deploying air bag. The air bag contacted and abraded the anterior aspect of the child's neck and its continued expansion hyper-extended the head/neck complex resulting in a high cervical injury.

The police and ambulance responded to the crash scene. The occupants of the Toyota were immediately transported to a University hospital, reportedly arriving 40 minutes post-crash. The ambulance records indicated the child occupant had no vital signs at the scene and he had a Glasgow Coma score of 3. He was pronounced deceased approximately 55 minutes post-crash. An autopsy was refused by the family for religious reasons.

### ***AIR BAG VEHICLE***

The 1995 Toyota Avalon XLS 4-door sedan was identified by the Vehicle Identification Number (VIN) of: 4T1GB11E3SU (production sequence deleted). The vehicle was equipped with a 3.0 liter, V-6 engine linked to a 4 -speed automatic transmission. Additional safety equipment included an anti-lock braking system. The odometer read 43,639 km (27,117 miles) at the time of the inspection.

### ***AIR BAG VEHICLE (CONT'D)***

The front seats in the Toyota were bucket seats constructed of a high grade vinyl/leather. The head restraints were adjustable. There were no seat performance failures. The seats were adjusted electronically by control switches located on the outboard side of the seat cushion. The driver seat cushion was adjusted to the most rearward position. The seat back was reclined 35 degrees rearward of vertical. The position of the seat back appeared to be reclined, relative to a “normal” driving position. The position of the seat (both position and seat back angle) probably were adjusted by the responding medical personnel during rescue activities. The right front seat was positioned 5 cm (2 in) forward of the most rearward position and the seat back was reclined 25 degrees from vertical. In this location, the upper/mid portion of the seat back was located 81 cm (32 in) rearward of the lower edge of the front passenger air bag module cover flap, 94 cm (37 in) rearward of the front passenger air bag inflator. This seat position probably was its at crash position.

### ***INTERIOR DAMAGE***

The right side of the windshield exhibited two specific fractures that joined together due to the weakened condition of the laminate (**Figure 6**). The fractures were located 24.1 cm (9.5 in) and 62.2 cm (24.5 in) right of center, approximately 14.0 cm (5.5 in) above the instrument panel. A 35.6 cm (14.0 in) long vinyl transfer was located between the fractures. The transfer was 5 cm (2 in) in width and tapered to 11.3 cm (0.5 in). This fracture pattern and transfer matched to the front passenger air bag module cover flap. Immediately below the fractures was a crack in the top of the instrument panel. The crack was 17.8 cm (7.0 in) long, 6.4 cm (2.5 in) forward of the edge of the instrument panel and centered laterally within the dimension of the front passenger air bag module cover flap. On the edge of the instrument panel were two sets of small fabric abrasions 17.8 cm (7.0 in) apart that matched to the cover flap tethers.



**Figure 6:** View of the right windshield fractures.

### ***MANUAL RESTRAINT SYSTEM***

The Toyota was equipped with manual 3-point lap and shoulder belt systems in all five (5) seating positions (2 front/3 rear). The restraint systems consisted of a continuous loop webbing with a sliding latch plate and dual mode (inertial locking and webbing sensitive) retractors. The retractors for the forward restraints were located in the base of the B-pillars. The retractors for the rear restraints were located under the rear seat cushion. The front restraints had adjustable D-rings and the rear D-rings were fixed. The left front latch plate showed a wear pattern indicating routine usage. Also, the edges of the webbing appeared to be slightly frayed from repeated use. Detailed inspection of the left front restraint indicated it was in use at the time of the crash. The D-ring was adjusted to the full up position. The belt was stowed at the time of inspection, however the plastic covering of the latch plate was spattered with blood. In addition, there were two blood stained areas 1.9 cm (0.75 in) diameter, located approximately 12 cm (5 in) and 30 cm (12 in)



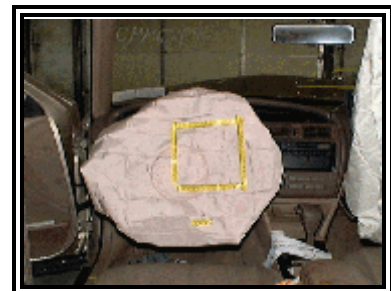
### ***MANUAL RESTRAINTS (CONT'D)***

above the latched position of the restraint, in a position covering the driver's torso. A small transfer mark was also noted on the left D-ring. The lower trim panel covering the left B-pillar was partially displaced in the crash. The right front restraint was stowed upon inspection and showed no signs of usage in this crash. The latch plate did not have a distinct wear pattern similar to the driver's belt and the edges of the webbing were not frayed. The belt system appeared to have had minimal use during the vehicle's life. The surface of the belt webbing was clean. The right D-ring was adjusted 6.3 mm (0.25 in) below the full up position. There was no webbing transfer on the right front D-ring.

### ***SUPPLEMENTAL RESTRAINT SYSTEM***

The vehicle's steering assembly was in-tact and operational. The steering wheel was adjustable and had four tilt positions. The wheel was adjusted one position up from the lowest adjustment. The steering wheel angle measured 20 degrees from vertical. The steering wheel was a two spoke wheel with the spokes located at the 4/8 o'clock positions. There appeared to be slight/minor separations between the spokes and the inflator module. The steering wheel/column had been loaded by the driver during the impact sequence. This was evidenced by a fractured mechanism between the steering wheel and tilt mechanisms of the upper column, located above the instrument panel. The steering wheel rim was not deformed.

The driver air bag deployed as designed from the center hub of the steering wheel (**Figure 7**). The cover flaps of the driver air bag module were configured in the H-pattern. The upper and lower flaps were symmetrical measuring 17.1 cm (6.8 in) at the center seam by 7.6 cm (3.0 in) vertically. The driver air bag diameter measured 63.5 cm (25.0 in) in its deflated state and was tethered by four internal straps 6.4 cm (2.5 in) wide. The center tether stitching measured 16.5 cm (6.5 in) diameter. Two 2.9 cm (1.12 in) diameter vent ports were located on the back side of the air bag at the 11/1 o'clock positions. The face of the driver bag was lightly blood spattered in the upper left quadrant of the bag and with a single spatter in the lower left quadrant. There were no other interior contacts on the driver side of the vehicle.



**Figure 7:** Driver air bag.

The front passenger air bag deployed from a mid-mount configuration. The rectangular module cover flap measured 38.1 cm (15 in) lateral by 15.2 cm (6.0 in) vertical. The cover flap was constructed of vinyl covered PVC and was tethered by two straps 6.4 cm (2.5 in) long. The lower edge of the flap was abraded and the corners of the flap were impacted. This evidence correlated to contact with the windshield. There was no evidence that the occupant was in contact with the front passenger air bag module cover flap.

The front passenger air bag was wedge shaped and extended 76 cm (30 in) from the inflator, in its deflated state (**Figure 8**). The top of the bag measured 28 cm (11 in) laterally at the inflator and

***SUPPLEMENTAL RESTRAINT SYSTEM (CONT'D)***

increased to 64 cm (25 in) laterally at the extended bag face. The bag face measured 61 cm (24 in) vertically. The air bag was vented by two 3.5 cm (1.38 in) diameter vent ports located in the center of the bag's side panels. The center of the bag was tethered by a 61 cm (24 in) long strap. The center tethering allowed the perimeter of the bag to "billow" beyond the 61 cm (24 in) tethered dimension. The only evidence of occupant contact on the front passenger air bag was a 5 cm (2 in) long blood transfer on the left (inboard) side of the bag. The transfer was located 10 cm (4 in) down from the top of the bag and 10 cm (4 in) forward of the face.



**Figure 8:** Front passenger air bag.

***CHILD PASSENGER INJURIES***

<b>Injury</b>	<b>Severity (AIS 90)</b>	<b>Injury Mechanism</b>
Gingiva laceration	Minor (243204.1,8)	Deploying front passenger air bag
Gingiva contusion	Minor (243202.1,8)	Deploying front passenger air bag
8.9 cm x 8.9 cm (3.5 in x 3.5 in) anterior neck abrasion	Minor (390202.1,5)	Deploying front passenger air bag
Abrasion anterior left shoulder	Minor (790202.1,2)	Deploying front passenger air bag
Punctate abrasions anterior chest	Minor (490202.1,4)	Deploying front passenger air bag
Punctate abrasions right lateral abdomen	Minor (590202.1,1)	Deploying front passenger air bag
Linear abrasion posterior left upper arm	Minor (790202.1,2)	Rebound contact seat/seat back
Punctate abrasions anterior right deltoid and upper arm	Minor (790202.1,1)	Deploying front passenger air bag
Linear abrasion antero-lateral right upper arm	Minor (790202.1,1)	Rebound contact seat/seat back
Abrasion lateral aspect of right elbow	Minor (790202.1,1)	Deploying front passenger air bag

*Note: the above documented injuries are from an external examination only - no invasive autopsy was performed.*

### ***CHILD PASSENGER KINEMATICS***

The front passenger was reportedly 122 cm (48 in) and 22 kg (48 lb), height and weight respectively. He was seated unrestrained in the right front seat, presumable in a normal posture. The right front seat was adjusted 5 cm (2 in) forward of the most rearward position and the seat back was reclined 25 degrees from vertical. In this position, the upper/mid portion of the seat back was located 81 cm (32 in) rearward of the edge of the instrument panel, 94 cm (37 in) rearward of the front passenger air bag inflator. The Toyota was traveling westward approaching the west entrance to the circular drive at approximately 32 km/h (20 mph). The driver began braking to reduce speed and initiated a right turn into the driveway. The child occupant responded to the braking and turning maneuver by moving forward and slightly to the left. Upon impact, the child moved further forward in response to the 12 o'clock direction of the impact forces and into the deployment path of the front passenger air bag. The deploying air bag struck the child in the upper chest and neck evidenced by the anterior abrasions. The air bag continued to expand under and around the child's neck causing the head/neck to be hyper-extended. The child then rebounded back into the seat where he was found.

### ***MEDICAL TREATMENT***

The ambulance records indicated the child had no vital signs at the scene. Upon initial assessment, he had a Glasgow Coma score of 3. He arrived at a University hospital 40 minutes post-crash and was pronounced deceased approximately 15 minutes after admission. An autopsy was refused by the family on religious grounds, therefore a detailed examination was unavailable. The medical examiner reported that X-rays were taken during the post-mortem examination. However, the X-rays were inconclusive as to the type of cervical injury sustained by the child. It was the medical examiner's impression that the child sustained a high cervical injury with probable cord transection considering the immediate demise of the child. The examiner stated the air bag "apparently killed the boy". However, lacking the definitive findings from the autopsy, the cause of the death was certified as blunt force trauma of a passenger in motor vehicle accident. He identified the manner of death as accidental.