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**ON-SITE AIR BAG/CHILD PASSENGER FATALITY
INVESTIGATION**

VERIDIAN ENGINEERING CASE NO. CA 98-047

VEHICLE #1 - 1995 TOYOTA COROLLA

LOCATION - STATE OF GEORGIA

CRASH DATE - AUGUST, 1998

Contract No. DTNH22-94-D-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 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>15. <i>Supplementary Notes</i> On-site investigation of a dual frontal air bag system deployment that resulted in fatal injuries to a three year old child front right occupant.</p>			
<p>16. <i>Abstract</i></p> <p>This crash involved a 1995 Toyota Corolla which was traveling on a suburban two lane roadway in a posted 56 km/h (35 mph) speed zone when it departed the right side of the roadway and struck a fire hydrant with the right frontal area and a tree root with the right front wheel. The collision deformation classification (CDC) code for the impact with the fire hydrant was 12-FZEN-2 and 12-FRWN-3 for the tree root. The velocity change associated with the frontal impact was computed at 20 km/h (12 mph) using the SMASH program. The collision sequence resulted in the deployment of the front dual air bag system.</p> <p>The unrestrained 3 year old child front occupant was sitting on the edge of the front right seat cushion and moved forward during pre-impact braking. At impact with the fire hydrant, his upper body and head were in very close proximity to the right portion of the instrument panel. He began loading the glove box door and glove box latch mechanism with his chest which resulted in a lateral abrasion of the center chest area. He was then struck by the deploying air bag module cover flap as the front right air bag deployed resulting in heavy abrasions of the anterior neck and chin areas. As the cover flap continued upward, it effectively wrapped around his face with the left and right ends of the flap contacting his left maxillary (cheek) and right maxillary (cheek) areas, respectively. As the air bag expanded, it also contacted his neck and chest areas. Module flap lifted the child vertically which resulted in a fracture of his neck with complete separation of the skull from the C1 spinal vertebra (AIS-6). The child subsequently struck the upper portion of the windshield glass with his left hand and the forward portion of the right sunvisor with his facial area. The passenger then rebounded into the front right seat, contacting the seat back support. He came to rest with his buttocks on the seat cushion and his upper body leaning over the center console area. The child was transported to a local hospital via ambulance where he was pronounced dead approximately 54 minutes after the occurrence of the crash.</p> <p>The 20 year old female driver suffered minor soft tissue injuries as the result of contact with the expanding front left air bag module cover and air bag. She was not transported to a medical facility from the scene.</p>			
<p>17. <i>Key Words</i> Deployment of the dual frontal air bag system 20 km/h (12 mph) 3 year old male front right occupant Contact by the deploying front right passenger air bag components Fatal injuries AIS-6 (Maximum), front right occupant</p>		<p>18. <i>Distribution Statement</i> General Public</p>	
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Final Case Report
On-site Air Bag/Child Passenger Fatality Investigation
Veridian Engineering Case No. CA 98-047
Location: State of Georgia
Crash Date: August, 1998

Background

This on-site air bag deployment investigation focused on the death of a three (3) year old male who was a front right passenger in a 1995 Toyota Corolla. The Toyota was equipped with air bags for the driver and front right passenger positions. After initially exiting the roadway, the Toyota was subsequently involved in a right frontal plane impact with a fire hydrant and a right front wheel impact with a tree root (**Figure 1**). These impacts were nearly simultaneous with the frontal impact occurring a few milliseconds prior to the wheel impact.



Figure 1. Frontal damage to the Toyota.

The driver of the Toyota reported to the investigating police officer that the fatally injured child passenger was restrained by the manual 3-point lap and shoulder belt system during the crash sequence. Physical evidence within the vehicle and the child's injury pattern, however, indicated that the passenger was not using the restraint system at the time of the crash (**Figure 2**). At impact, the passenger was out of position and located in very close proximity to the right portion of the instrument panel. As he began loading the glove box, the mid-mounted air bag module cover flap opened and swung upward. The flap contacted his upper chest, anterior neck, and lower facial areas. The passenger was also contacted by the expanding air bag as he was lifted upward by the module cover flap. He subsequently struck the right sunvisor with his head, rebounded into the front right seat back, and then slumped to his left over the center console area. He sustained abrasions of the upper chest, neck, chin, and both maxillary areas as a result of contact with the air bag module cover flap. His major injury from this contact was complete separation of the skull from the C1 spinal vertebra. The passenger also sustained abrasions of the chest, both upper arms, the posterior neck, and the right ear as a result of being contacted by the expanding air bag. Most of the passenger's injuries were sustained as a result of deployment of the front right passenger air bag.



Figure 2. Profile view of front right seated position and the deployed air bag.

This crash occurred in a suburban area in August, 1998. NHTSA was notified of the crash by a representative of the Governor's Office of Highway Safety.

Summary

This crash involved a 1995 Toyota Corolla which exited the roadway and was subsequently involved in a right frontal impact with a fire hydrant and a right front wheel impact with a tree root. The impact resulted in the deployment of the front dual air bag system and fatal injuries to the 3 year old male front right occupant.

Crash Site

This crash sequence occurred on a suburban two lane roadway in a posted 56 km/h (35 mph) speed zone. The asphalt road surface was dry and straight along the approach to the crash site with a 1.7 percent (1 degree) grade that was positive to the north (travel direction of subject vehicle). The north/southbound travel lanes were delineated by yellow full barrier centerlines and solid white fog lines located at each edge of the roadway. The overall width of the roadway was 7 m (23'). Narrow asphalt shoulders that were approximately 0.5 m (1.6') in width were located outboard of the fog lines. The west shoulder was bounded by a 12.7 cm (5.0") high barrier curb. The east shoulder was bounded by a grassy berm with a 23 percent (13 degree) negative slope to the east that terminated in a shallow drainage area 4.1 m (13.4') east of the east edge of the roadway. A 55.9 cm (22.0") high embankment with a 70 percent (35 degree) positive slope was located outboard of the drainage area (i.e., this positive embankment was the rear wall of a shallow drainage ditch). The northbound travel lane began curving to the left a short distance beyond the point where the right front wheel of the Toyota exited the east edge of the roadway (**Figure 3**). The crash sequence occurred during daylight hours with clear atmospheric conditions.



Figure 3. View of the Toyota's approach to the crash site.

Crash Sequence

The Toyota approached the crash site traveling in a northerly direction in the northbound travel lane at an estimated travel speed of 56-64 km/h (35-40 mph). The driver and front right passenger were returning home after completing a number of errands. Physical evidence in the vehicle indicated that the driver of the Toyota was restrained by the lap belt portion of the manual 3-point lap and shoulder belt system. Although the female driver reported that the front right passenger was also restrained, contact marks within the vehicle and the lack of supportive evidence on the front right restraint system indicated that the passenger was unrestrained at the time the crash occurred.



Figure 4. Point where the Toyota exited the roadway.



Figure 5. On-site police view showing the Toyota's trajectory and final rest position.

The Toyota driver reported to the investigating officer that as she was traversing a straight roadway segment, approaching the crash site, the child passenger leaned to the left and grabbed the steering wheel imparting pronounced steering input to the right. This description was not consistent with the front right passenger's position when the air bag deployment occurred as the child's injury pattern and interior physical evidence placed the boy directly in-line with the air bag module cover. At this point, the driver allegedly lost steering control. The Toyota exited the right edge of the roadway at a departure angle of approximately 15 degrees, traveling in a northeasterly direction. The driver initiated a moderate level of braking as the vehicle traversed the east shoulder. She maintained this level of braking as the Toyota traversed a shallow arc (convex to the north) and traveled approximately 15 m (49') from the edge of the east shoulder to the point of impact with a fire hydrant located 4.3 m (14.1') east of the east edge of the roadway (**Figures 4 & 5**). The fire hydrant was located on the positive sloped embankment rising from the low point of the drainage area. While traversing the off-road trajectory, the Toyota maintained a near tracking altitude and narrowly missed striking a sign post located on the east berm outboard of the east shoulder.

The right frontal area of the Toyota engaged the fire hydrant (12 o'clock direction of force). This impact resulted in a maximum crush to the frontal plane of 32.4 cm (12.8") located 38.7 cm (15.3") to the right of the vehicle's centerline. The top of the fire hydrant was displaced approximately 15.2 cm (6") to the northeast as a result of this impact (**Figure 6**). Shortly after the frontal engagement was initiated, the right front wheel of the Toyota struck a tree root. During this impact, the right front tire sustained an air out, the right front wheel rim was deformed, and the right wheelbase dimension was reduced 10.8 cm (4.3"). The velocity change associated with the frontal impact was estimated at 20 km/h (12 mph) using the SMASH program. This value, however, should be regarded as a minimal level estimate since the right front wheel impact could not be incorporated in the SMASH run.



Figure 6. Close-up view of the fire hydrant and tree root.

Following the impact sequence noted above, the Toyota rotated approximately 70 degrees in a clockwise direction and came to rest facing in an east southeasterly direction. At final rest the left side of the Toyota was in line with the fire hydrant that was struck, the vehicle was nearly perpendicular to the roadway, and the rear portion of the vehicle was straddling the east shoulder of the roadway (**Figure 7**).

A southbound witness to the crash sequence stopped at the scene, driving off the west side of the roadway onto the sidewalk across from the final rest position of the Toyota. The witness walked over to the Toyota carrying a portable cellular telephone. By the time he reached the vehicle, the Toyota driver had exited the vehicle through the left door (without assistance). The witness asked her if she was okay and she responded that her child had been hurt. At this point both individuals walked around the rear of the vehicle to the right passenger door. The driver opened the door and began attempting to arouse the passenger. The witness noted that the passenger was slumped to the left, over the center console area, and appeared to be in, "bad shape". He then used the cellular telephone to request police and medical assistance. While he was completing this call, the driver lifted the passenger from the vehicle and laid him on the ground near the right rear wheel of the Toyota.

The first police unit arrived on scene approximately eight minutes after the crash occurred. An EMS unit staffed with emergency medical technicians (EMTs) arrived several minutes later. The EMTs began providing first aid treatment to the passenger. Recognizing the apparent severity of his injuries, the EMTs first placed the passenger on a back board, immobilized him, and then initiated transport procedures in an expeditious manner. The passenger was transported to a local hospital where he was pronounced dead approximately 54 minutes after the crash occurred. The Toyota driver accompanied the passenger to the hospital in the EMS unit.

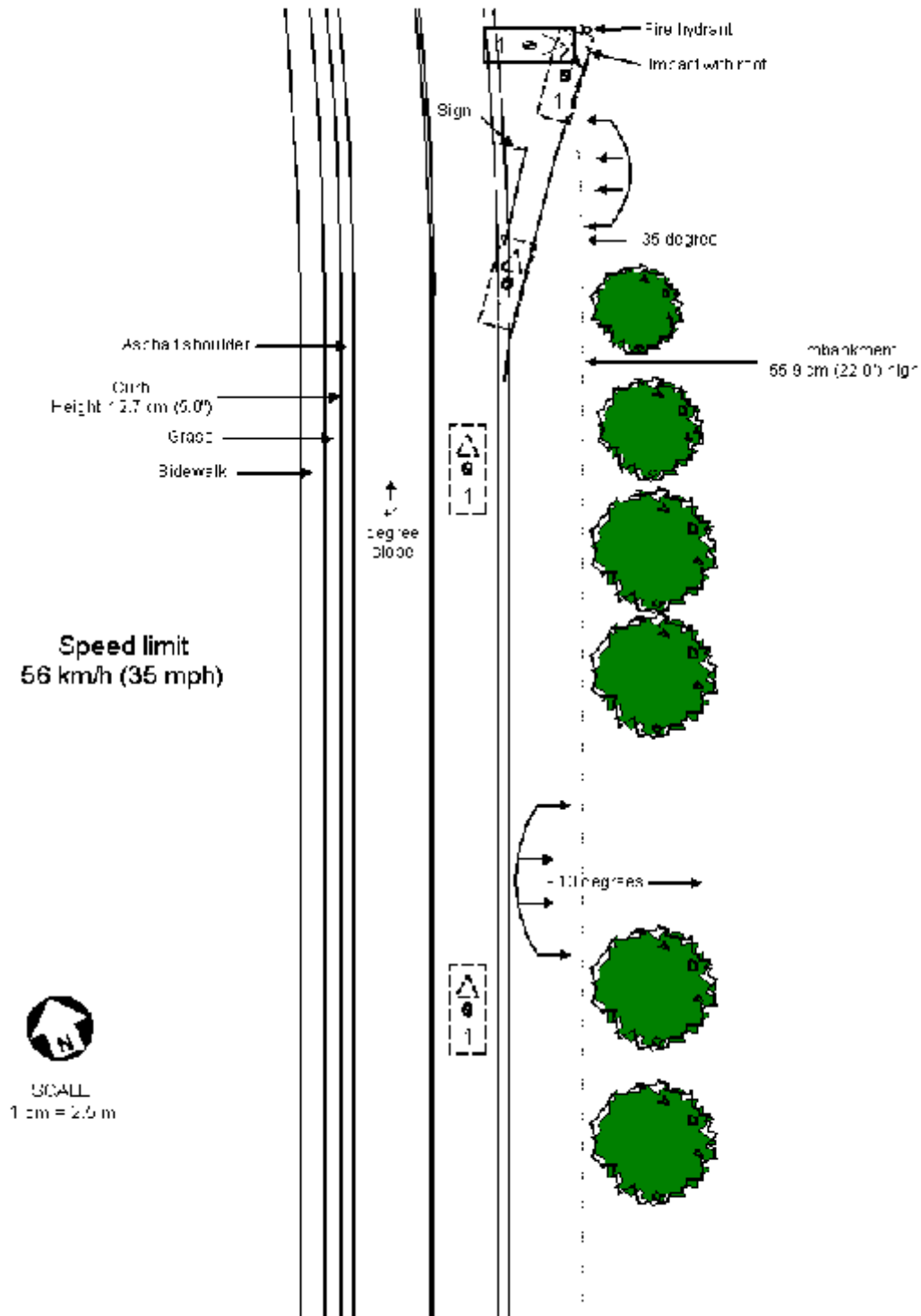


Figure 7. Scene diagram

Vehicle Data

The subject vehicle was a 1995 Toyota Corolla, four door sedan. The manufacture data of the vehicle was 2/95 and the vehicle identification number (VIN) was 2T1AE09B3SC (production number deleted). The vehicle was equipped with a front disc/rear drum braking system, a 4 cylinder transverse mounted engine, and a automatic transmission with a console mounted transmission selector lever. The Toyota was also equipped with a tilt steering column which was adjusted to the mid position. At the time of vehicle inspection, the odometer reading was 133,629.8 km (83,036 miles).

Damage sustained during this crash sequence was limited to the right portion of the front bumper, grille, hood, right headlight assembly, right front fender, and the right front wheel. During the vehicle inspection, additional damage was noted to the left corner of the front bumper, the left front fender, both left doors, and the left corner area of the rear bumper. This damage to the left side of the vehicle appeared to be pre-existing (i.e., relatively heavy oxidation patterns) and could not be associated with the current crash sequence.

Vehicle Damage

The Toyota Corolla was towed from the scene of the crash and stored in a secure indoor facility. The vehicle was subsequently inspected by the SCI investigator five days following the crash sequence.

Exterior:

As indicated previously, components sustaining damage during this crash sequence were limited to the front bumper, grille, hood, right headlight and parking light assemblies, the right front fender, and the right front wheel and suspension components. The width of direct contact damage as a result of striking the fire hydrant was 36.5 cm (14.4"). Maximum crush within this contact pattern was 32.4 cm (12.8") located 38.7 cm (15.3") to the right of the vehicle's centerline (**Figure 8**). The width of the direct and induced damage envelope was 108 cm (42.5") as measure from the right front corner to the left. The corresponding set of crush dimensions associated with this envelope was as follows:



Figure 8. Close-up of damage from impacting fire hydrant.

Toyota Corolla Crush			
Crash Impact with fire hydrant	$C_1 = 3.3 \text{ cm (1.3")}$	$C_2 = 7.6 \text{ cm (3.0")}$	$C_3 = 14.7 \text{ cm (5.8")}$
	$C_4 = 22.4 \text{ cm (8.8")}$	$C_5 = 27.9 \text{ cm (11.0")}$	$C_6 = 16.0 \text{ cm (6.3")}$

The frontal structure of the Toyota had crushed approximately 5.1 cm (2.0") when the right front wheel struck the exposed tree root (**Figure 9**). As a result of this second impact, the right front suspension strut was deformed inward and rearward, the right front tire experienced an air out, the right front wheel rim was deformed, and the right wheel base dimension was reduced 10.8 cm (4.3"). This impact added to the total delta V level experienced by the vehicle.

CDC:

The collision deformation classification (CDC) code for the impact with the fire hydrant was 12-FZEN-2 and 12-FRWN-3 for the tree root.

Interior:

The integrity of the Toyota's passenger compartment was maintained in that there was no interior intrusion or damage resulting from exterior deformation. All window glazing was also intact. The overall level of interior damage was considered minor and was associated with deployment of the driver and right front passenger air bag modules and occupant contact with interior surfaces.

The driver's left knee and lower leg contacted the knee bolster to the left of the steering column (**Figure 10**). This contact resulted in two white colored cloth transfers to the knee bolster. The highest transfer (left knee) was 1.3 cm (0.5") by 5.1 cm (2") and located 48.3 cm (19") to the left of the vehicle centerline and 5.1 cm (2") below the top of the holster. The lower transfer (left leg) was vertically oriented transfer that was 1.9 cm (0.75") wide and 3.8 cm (1.5") high. This second transfer was located 47 cm (18.5") to the left of the vehicle centerline and 10.2 cm (4") below the top of the bolster. There was no deformation of the bolster as a result of these contacts.

At the time the driver's air bag deployed, the driver was positioned very close to the steering wheel. As a result she was struck by both the upper and lower air bag module flaps. These contacts resulted in white colored transfers being deposited on both the upper and lower flaps (contacts are described more fully in the Supplemental Restraint System section) of the module cover. In addition, the left portion of the upper flap was separated from the remainder of the flap (i.e., the left portion of the flap was torn off in two separate pieces/the lower left corner of the flap was not found in the vehicle). The driver also loaded the expanding air bag although no transfers were noted to the air bag surfaces. Due to the driver's close proximity to the deploying air bag module cover, the expanding air bag back loaded the upper steering wheel rim, deforming the upper rim 1.3 cm (0.5") forward.



Figure 9. Damage to right front wheel and suspension.



Figure 10. Driver contact with knee bolster.

The driver also contacted the radio/tape player located in the center of the instrument panel with her right hand during the crash sequence. The grille panel surrounding this unit was dislodged and warped (deformed) as a result of the contact.

The right front male passenger moved forward during the pre-crash braking phase. At impact, he was in very close proximity to the right portion of the instrument panel. He loaded the glove box door (chest), depositing a 3.8 cm (1.5") by 6.4 cm (2.5") white colored transfer immediately below the glove box latch mechanism (**Figure 11**). This transfer was located 30.5 cm (12.0") to the right of the vehicle centerline and 12.7 cm (5.0") below the bottom edge of the air bag module cover flap. He also loaded the glove box latch mechanism which broke and separated from the glove box door.



Figure 11. Passenger contact with the glove compartment door.

As the right front air bag deployed, the module cover flap contacted the upper chest, anterior neck, and chin of the right front passenger (**Figure 12**). This contact resulted in a tissue/body fluid transfer to the flap which was 12.7 cm (5.0") wide and extended across the full height of the flap. The left edge of the transfer was located 5.7 cm (2.3") inboard of the left edge of the flap. The contact resulted in a permanent 7.6 cm (3.0") deformation of the flap (e.g., ends of flap were curved upward 7.6 cm (3.0") from the contact area).



Figure 12. Passenger contact with air bag module cover flap.

Contact with the air bag module cover flap and subsequent contact with the expanding air bag lifted the right front occupant upward. He subsequently struck the upper portion of the windshield (probable left hand contact) and the forward portion of the right sunvisor (probable head contact). A tissue transfer that measured 3.8 cm (1.5") wide and 8.3 cm (3.3") long was located 29.2 cm (11.5") to the right of the vehicle centerline. The transfer initiated 8.3 cm (3.3") below the windshield header and extended upward to the header. The contact to the sunvisor was located immediately to the right of the tissue transfer and involved a flattening and slight denting of the forward edge of the sunvisor. The contact area was 8.3 cm (3.3") wide and the left edge of the contact was located 34.3 cm (13.5") to the right of the vehicle centerline.

Following these contacts, the right front passenger rebounded into the right front seat. He subsequently slumped to the left and came to rest leaning over the center console area.

Manual Restraint Systems

The Toyota was equipped with manual 3-point lap and shoulder belts for the four outboard seated positions. The front belt systems utilized a continuous loop belt webbing with retractors that incorporated both belt sensitive and inertia activated operational aspects. The upper anchorages (D-rings) of both front belts was adjustable with the left anchorage adjusted to the full down position and the right anchorage adjusted to the full up position. Both front belts were also equipped with energy management loops which were intact following the crash sequence.

Examination of the left front belt system indicated that the lower portion of this belt was worn during the crash sequence. A brown colored transfer was noted on the inboard surface of the lower belt. The transfer was located 66 cm (26.0") from the floor anchorage point and measured 25.4 cm (10.0") in length. When the lower belt was extended, the transfer appeared to be approximately centered in the left front seated position. There was no evidence of use of the shoulder belt portion of the system in terms of transfers or loading patterns.

Examination of the right front belt system indicated that it was unlikely that this system was used by the right front passenger. The belt was clean and did not exhibit evidence of transfers or loading stresses. Given the amount of blood on the center console and left portion of the right front seat, it is unlikely that the belt system would have remained clean if it had been worn. In addition, the upper anchorage (D-ring) for this position was in the full up position, indicating that the belt had been adjusted for adult usage.

Supplemental Restraint System (SRS)

The 1995 Toyota Corolla involved in this crash sequence was equipped with a Supplemental Restraint System (SRS) that consisted of dual front air bags. The system deployed as a result of the right frontal impact with a fire hydrant and a right wheel impact with a tree root.

The front left driver air bag module was mounted within a 4-spoke steering wheel. The spokes were located at the 9/3 and 4:30/7:30 clock positions. The air bag was concealed within an H-configuration module cover assembly. The upper flap was 14.6 cm (5.8") wide with a height of 7.6 cm (3.0"). The lower flap was also 14.6 cm (5.8") wide with a height of 6.4 cm (2.5"). The driver was located very close to the steering wheel at the time of impact. She was struck by both the upper and lower flaps of the module cover during the deployment. A white colored cloth transfer was noted to the lower deployment flap (**Figure 13**). At the right edge of the lower flap, the transfer extended the full height of the flap. Moving laterally across the flap, the transfer pattern narrowed until it ended at the upper tear seam approximately 2.5 cm (1.0") from the left edge of the flap. The upper flap separated into three pieces during the deployment sequence (**Figure 14**). Moving from right to left along the lower tear seam of the upper flap, the first separation line initiated 6.4 cm (2.5") inboard of the right edge of the flap.



Figure 13. View of the module flaps for the front left driver air bag.



Figure 14. Lower flap of driver's air bag module.

The tear then extended up and to the left, intersecting the left edge of the upper flap approximately 3.8 cm (1.5") below the top of the flap. As shown in **Figure 13**, a piece of the flap which abutted against this tear line was found in the vehicle. The lower portion of this piece had the same white colored cloth transfer as was noted on the lower deployment flap. The lower left corner of the upper flap was not found during the vehicle

examination. Based on the pattern of the cloth transfer on the piece shown in **Figure 13**, however, it was assumed that the cloth transfer extended onto the piece of the flap (lower left corner) that was missing.

The front left driver air bag deployed as designed with no tears or perforations noted to the woven nylon-type fabric surface. The overall diameter of the bag in a deflated state was 66 cm (26.0"). The identification number of the bag was: 94B3020G0321. This installation was a non tethered design with two vent ports located on the rear surface of the bag. These ports were located in the 11 and 1 clock sectors and were 3.2 cm (1.3") in diameter. Each port was centered approximately 7 cm (2.8") inboard of the peripheral seam. Two dark blue colored transfers were noted to the front surface of the bag and three dark blue colored transfers were noted to rear surface of the bag. These transfers were associated with contacting the air bag module cover. There was no other damage or evidence of driver contact noted to either surface of the front left driver air bag.

The right front air bag module was a mid mount design which incorporated a single flap that opened upward toward the windshield. The module cover flap measured 34.9 cm (13.8") laterally and 14 cm (5.5") longitudinally. The left side of the module flap was located 15.2 cm (6.0") to the right of the vehicle centerline. The polyethylene flap design incorporated a 15 gauge (0.063") sheet metal plate which functioned as a stiffener to ensure that the module flap maintained its shape in an undeployed state.

The front right air bag was non-tethered and contained a 5.1 cm (2.0") diameter vent port on the inboard and outboard side surfaces. These vent ports were located 47.0 cm (18.5") below the inflator unit. The air bag material was a course woven, white colored nylon. The longitudinal excursion of this bag measured 55.9 cm (22.0") from the air bag module cover opening to the seat back support. The air bag identification number was stamped on the bag and read as follows:

1390702010-B
171U179
C27
1/19/95
S
L02500009478

The front right passenger was located in very close proximity to the front right air bag module cover flap when deployment occurred. He loaded the right glove box area with his chest and was then struck by the deploying module cover flap in his upper chest, anterior neck, and chin areas. The center area of the cover flap was held by the chin contact as the ends of the flap continued upward, in effect, molding around the passenger's face. The left end of the flap struck his left maxillary (cheek) area and the right end of the flap struck his right maxillary (cheek) area. As a result of this contact, the cover flap sustained a permanent bow which was approximately 7.6 cm (3.0") deep. A tissue/body fluid transfer was noted to the center area of the flap. This contact was 12.7 cm (5.0") wide and extended across the full height of the flap. The left edge of the transfer was located 5.7 cm (2.3") inboard of the left edge of the flap (**Figure 15**).



Figure 15. Shirt worn by passenger (back view).

A protective, orange colored, cloth cover was installed over the air bag as part of the manufacturer's assembly process. As the air bag expanded, the protective cover was pinched between the back of the module cover flap, the front surface of the air bag, and the passenger's chest and neck areas. A 25.4 cm (10.0") wide by 16.5 cm (6.5") high section of the protective cover was torn away from the left portion of the installation. Examination of the material revealed heavy tissue transfers that were associated with contacting the passenger's upper chest and anterior neck areas.

Blood and body fluid transfers were also noted to the front surface of the air bag. The principal contact evidence was a blood streak that was 30.5 cm (12.0") in length. The top of this streak was located 25.4 cm (10.0") down from the inflator location. At this point, the streak was 16.5 cm (6.5") inboard of the right side of the bag. The bottom of the streak was located 25.4 cm (10.0") inboard of the right side of the bag (i.e., streak was angled from the upper right to the lower left across the bag frontal area). A 12.7 cm (5.0") by 6.35 cm (2.5") body fluid transfer was located to the left of the lower portion of the blood streak and a 2.5 cm (1.0") diameter body fluid transfer was located to the left of the upper portion of the blood streak. Other transfers located on the front and right side surfaces of the bag appeared to be associated with deployment.

Driver Injuries

Injury	Injury Severity (AIS 90)	Injury Mechanism
Abrasion, left lateral neck	Minor (390202.1,2)	Front left driver air bag
Contusion, left inner forearm	Minor (790402.1,2)	Air bag module flaps
Sprain, left arm	Minor (740402.1,2)	Air bag module flaps
Contusion, left chest	Minor (490402.1,2)	Air bag module flaps

Driver Kinematics

The 20 year old female driver was seated in a normal posture with her head turned to the right and both hands on the steering wheel rim at the time the impact occurred. The seat track of the left front seat was adjusted to a mid track position. Specifically, the seat track was adjusted to a location that was 10.2 cm (4.0") rearward of the full forward position and 11.4 cm (4.5") forward of the full rear position. The left seat back support was adjusted to an angle of 23 degrees. Based on vehicle inspection findings, it appeared that the driver was using the lower lap belt portion of the 3-point lap and shoulder belt restraint. The upper shoulder belt portion of the system was either not worn or was worn very loosely.

Interview information indicated that the Toyota driver was looking to her right, at the front right passenger, immediately prior to the crash. Following the frontal impact crash event, she began moving forward. She loaded the knee bolster to the left of the steering column with her left knee and leg without sustaining injury. She was struck by the air bag module cover flaps as the driver's air bag deployed. These contacts involved her left forearm (contusion/sprain) and left chest (contusion) areas. The left chest contact involved the area immediately below the left breast. The left side of her neck (contusion) was subsequently contacted by the

expanding air bag. She also loaded the lower portion of the manual restraint system during the crash sequence without sustaining injury and her right hand struck the center mounted radio/tape player without sustaining injury.

Front Right Passenger Demographics/Data

Age/Sex: 3 year old male
 Height: 109.2 cm (43")
 Weight: 18.2 kg (40 lbs.)
 Manual Restraint Usage: Did not use available restraint system
 Usage Source: Vehicle Inspection
 Transport Mode
 From Scene: Ambulance
 Medical Treatment: First aid treatment at scene, pronounced DOA at local hospital 54 minutes after the crash occurred.

Front Right Passenger Injuries

The child was transported to a medical facility where he was pronounced deceased. The body was then transferred to the medical examiner’s office where an external examination was performed.

Injury	Injury Severity (AIS 90)	Injury Mechanism
Abrasion, left side of nose	Minor (290202.1,4)	Right sunvisor
Abrasion, lower lip	Minor (290202.1,8)	Right sunvisor
Abrasion, right cheek	Minor (290220.1,1)	Air bag module cover flap
Abrasion, left cheek	Minor (290202.1,2)	Air bag module cover flap
Abrasion, posterior aspect of rear ear	Minor (290202.1,1)	Expanding air bag
Abrasion, right posterior neck and lower anterior neck	Minor (390202.1,0)	Expanding air bag
Heavy abrasion of chin	Minor (290202.1,8)	Air bag module cover flap
Heavy abrasion, right anterior neck	Minor (390202.1,5)	Air bag module cover flap

Injury	Injury Severity (AIS 90)	Injury Mechanism
Fracture of neck with marked hypermobility of head upon cervical spine and complete separation between the cranium and C1.	Moderate (640232.6,6)	Air bag module cover flap
Light abrasion, right upper and right lateral chest	Minor (490202.1,1)	Expanding air bag
Lateral abrasion, center chest, slightly above nipple height	Minor (490202.1,4)	Glove box latch
Abrasion, anterior aspect of left and right upper arms	Minor (790202.1,3)	Expanding air bag

Front Right Passenger Kinematics

The 3 year old child passenger was seated in the front right position of the Toyota Corolla. Although his exact pre-crash position was unknown at the time of report preparation, it appeared that he may have been seated forward on the seat cushion. At the time of vehicle inspection, the manually operated front right bucket seat was adjusted to a mid-track position with the seat located 8.9 cm (3.5") forward of the full rear position and 13.3 cm (5.3") rearward of the full forward position. The lack of blood and other transfers on the restraint system tended to indicate that the child passenger was unrestrained at the time of crash occurrence. His clothing consisted of a white oversized muscle shirt (sleeveless) with a blue logo on the front, light blue shorts, and black sandals.

Inspection of the interior surfaces of the Toyota Corolla, the deployed front right passenger air bag, and evaluation of the medical data provided by the Medical Examiner, resulted in the following reconstruction of the passenger's kinematic pattern and injury mechanisms.

Based on contact evidence within the vehicle, it appeared that the passenger was unrestrained and was seated on the forward portion of the front right seat. Braking action initiated by the Toyota driver as the vehicle departed the roadway caused the passenger to move forward with respect to the vehicle's interior. At impact with the fire hydrant, his upper body and head were in very close proximity to the right portion of the instrument panel. He began loading the glove box door and glove box latch mechanism with his chest which resulted in a lateral abrasion of the center chest area. He was then struck by the deploying air bag module cover flap as the front right air bag deployed. Initial contact involved his upper right chest, anterior neck, and chin areas. This contact sequence resulted in heavy abrasions of the anterior neck and chin areas. As the cover flap continued upward, it effectively wrapped around his face with the left and right ends of the flap contacting his left maxillary (cheek) and right maxillary (cheek) areas, respectively. As the air bag expanded, it also contacted his neck and chest areas. Module flap involvement with the passenger began lifting the passenger vertically and altered the normal deployment path of the air bag. The right side of the air bag expanded around the

passenger's head, contacting his right ear and the right posterior surface of his neck. These contacts also resulted in abrasions of the posterior surfaces of the right ear and neck.

The passenger continued to be lifted vertically during the remainder of the deployment sequence. Contact with the air bag module cover flap rotated his head rearward as he rose. This contact also resulted in a fracture of his neck with complete separation of the skull from the C1 spinal vertebra. The passenger subsequently struck the upper portion of the windshield glass with his left hand (no reported injury) and the forward portion of the right sunvisor with his facial area. The latter contact resulted in an abrasion of the nose and lower lip. The passenger then rebounded into the front right seat, contacting the seat back support (no reported injury). As the vehicle came to rest, the passenger slumped to his left. He came to rest with his buttocks on the seat cushion and his upper body leaning over the center console area.

Medical Treatment

The Toyota driver removed the passenger from the vehicle shortly after the vehicle came to rest. The driver laid him on the ground near the right rear wheel of the Toyota. An EMS unit arrived on scene approximately 10-12 minutes after impact. Two emergency medical technicians (EMTs) from this unit provided first aid treatment at the scene. The passenger was placed on a backboard, immobilized, and an air way was established to administer oxygen. Apparently recognizing the severity of the passenger's injuries, transport procedures were initiated relatively rapidly. The passenger was transported to a local hospital (accompanied by the driver). He was pronounced dead at that facility approximately 54 minutes after impact.