

**TRANSPORTATION SCIENCES
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**VERIDIAN REMOTE AIR BAG RELATED CHILD SAFETY SEAT FATALITY
INVESTIGATION
SCI TECHNICAL SUMMARY REPORT**

VERIDIAN CASE NO. CA01-014

VEHICLE - 1996 TOYOTA COROLLA

LOCATION - STATE OF OHIO

CRASH DATE - OCTOBER 1998

Contract No. DTNH22-94-D-07058

Prepared for:

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

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

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16. <i>Abstract</i> This remote investigation focused on a 1996 Toyota Corolla that was equipped with frontal air bags for the driver and front right positions that deployed as a result of a frontal impact with a 1995 Oldsmobile Delta 88. The Corolla was occupied by a 36-year-old female driver, two adult passengers, and three child passengers. A 2-month-old male infant passenger was positioned in a rear-facing child safety seat that was held on the lap of the front right adult passenger. The Corolla was parked in the outboard lane of an arterial roadway preparing to discharge passengers. The driver of the Delta 88 was operating the vehicle in the opposite direction. The Delta 88 crossed the centerline and impacted the parked Corolla in a head-on configuration. The impact induced deceleration was sufficient to deploy the frontal air bag systems in both vehicles. The occupants of the Corolla initiated forward trajectories in response to the frontal impact. The top aspect of the child safety seat was struck by the front right passenger's air bag cover flap and the child safety seat was accelerated rearward by the expansion of the air bag. The 2-month-old sustained right side facial contusions, lacerations, and abrasions, subgaleal, subdural, and subarachnoid hemorrhage, multiple skull fractures (linear, diastatic, and comminuted), a brain laceration, cortical contusions, and a fracture of the right radius. The head injuries were associated with the deployment of the front right passenger air bag system. He was transported by ambulance to a regional children's hospital and pronounced dead 1.5 hours after the crash. The front right passenger sustained police-reported minor visible injuries and was transported by ambulance to a local hospital. She was admitted overnight for observation.			
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TABLE OF CONTENTS

BACKGROUND	1
SUMMARY	2
Crash Site	2
Pre-Crash	2
Crash	2
Post-Crash	3
VEHICLE DATA - <i>1996 Toyota Corolla</i>	3
CHILD SAFETY SEAT DATA	3
CHILD SAFETY SEAT DAMAGE	4
VEHICLE DAMAGE	4
Exterior Damage - <i>1996 Toyota Corolla</i>	4
Interior Damage - <i>1996 Toyota Corolla</i>	5
Exterior Damage - <i>1995 Oldsmobile Delta 88</i>	5
AIR BAG SYSTEM - <i>1996 Toyota Corolla</i>	5
OCCUPANT DEMOGRAPHICS - <i>1996 Toyota Corolla</i>	6
Driver	6
Driver Kinematics	6
Front Right Passenger	6
Front Right Passenger Kinematics	7
Front Right Infant Passenger (on lap)	7
Front Right Infant Passenger (on lap) Injuries	8
Front Right Infant Passenger (on lap) Kinematics	10
Rear Seat Passenger Kinematics	10

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LOCATION - STATE OF OHIO
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BACKGROUND

This remote investigation focused on a 1996 Toyota Corolla (**Figure 1**) that was equipped with frontal air bags for the driver and front right positions that deployed as a result of a frontal impact with a 1995 Oldsmobile Delta 88. The Corolla was occupied by a 36-year-old female driver, two adult passengers, and three child passengers. A 2-month-old male infant passenger was positioned in a rear-facing child safety seat that was held on the lap of the front right adult passenger. The Corolla was parked in the outboard lane of an arterial roadway preparing to discharge passengers. The driver of the Delta 88 was operating the vehicle in the opposite direction. The Delta 88 crossed the centerline and impacted the parked Corolla in a head-on configuration. The impact induced rearward acceleration was sufficient to deploy the frontal air bag systems in both vehicles. The occupants of the Corolla initiated forward trajectories in response to the frontal impact. The top aspect of the child safety seat was struck by the front right passenger's air bag cover flap and the child safety seat was accelerated rearward by the expansion of the air bag. The 2-month-old sustained right side facial contusions, lacerations, and abrasions, subgaleal, subdural, and subarachnoid hemorrhage, multiple skull fractures (linear, diastatic, and comminuted), a brain laceration, cortical contusions, and a fracture of the right radius. The head injuries were associated with the deployment of the front right passenger air bag system. He was transported by ambulance to a regional children's hospital and pronounced dead 1.5 hours after the crash. The front right passenger sustained police-reported minor visible injuries and was transported by ambulance to a local hospital. She was admitted overnight for observation.



Figure 1. Frontal damage to the 1996 Toyota Corolla

This crash was identified through a search of the Fatality Analysis Reporting System (FARS) for child fatalities that occurred in vehicles equipped with air bags. The crash occurred in October 1998 and was assigned to the Veridian Special Crash Investigations Team on January 29, 2001 as a remote investigation effort. Police photographs, a police crash report, and an autopsy report were obtained which provide the basis for this narrative report.

SUMMARY

Crash Site

This two-vehicle crash occurred during the nighttime hours of October 1998 on a six-lane arterial roadway. At the time of the crash, it was dark with overhead roadway illumination. The police reported clear weather conditions and a temperature of 19 degrees Celsius (66 degrees Fahrenheit) at the time of the crash. The roadway surface was dry. The crash occurred on the outboard northbound lane adjacent to a curb cutout that was used to facilitate parallel parking. The north/south roadway was constructed of asphalt, was straight with a level grade, and measured a police-reported 19 m (61') in width. The six-lane roadway was configured with three travel lanes in each direction, separated by a double-yellow centerline and broken white lane lines. The roadway was bordered by concrete curbs and sidewalks. There was no traffic control present at the crash site. The posted speed limit for the roadway was 40 km/h (25 mph).

Pre-Crash

The 36-year-old female driver of the 1996 Toyota Corolla had stopped the vehicle in the outboard northbound lane to discharge passengers. The driver of the Corolla stated to police that she was unable to legally park the vehicle in the curb cutout due to the presence of a car and truck which were occupying the curb cutout. The Corolla was parked at the time of the crash with the engine running. Police reported that the 45-year-old male driver of the 1995 Oldsmobile Delta 88 was intoxicated. The driver was operating the vehicle southbound on the inboard lane when he relinquished control and the vehicle crossed the centerline. The Delta 88 continued across the northbound lanes in a tracking mode toward the parked Toyota Corolla. There was no evidence that suggested any avoidance maneuvers were attempted by the driver of the Delta 88.

Crash

The front of the Delta 88 impacted the front of the Toyota Corolla in a head-on configuration. Impact resulted in moderate damage to both vehicles. The front of the Delta 88 displaced the bumper system on the Corolla rearward, and allowed the Delta 88 to engage the grille area and leading edge of the Corolla's hood. The resultant directions of force were in the 12 o'clock sectors for both vehicles. The damage algorithm of the WinSMASH program computed total velocity changes of 27.0 km/h (16.8 mph) for the Corolla and 21.0 km/h (13.0 mph) for the Delta 88. The outputs were based on estimated crush profiles generated from the on-scene police photographs. The longitudinal and latitudinal components for the Corolla were -26.6 km/h (-16.5 mph) and 4.7 km/h (2.9 mph), respectively. The longitudinal and latitudinal components for the Delta 88 were -20.7 km/h (-12.9 mph) and -3.6 km/h (-2.3 mph), respectively. The forward momentum of the Delta 88 accelerated the Toyota Corolla rearward, and sustained contact was likely as the Delta 88 displaced the Corolla rearward.

The Delta 88 came to rest adjacent to the curb facing south on the outboard northbound lane (**Figure 2**). The Corolla came to rest facing north on the outboard northbound lane (**Figure 3**).

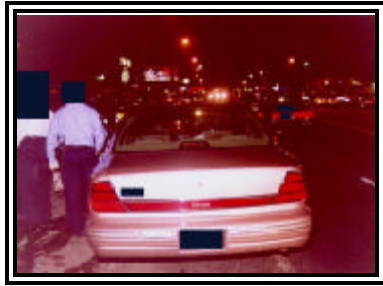


Figure 2. Final rest position for the Delta 88



Figure 3. Final rest position for the Corolla

Post-Crash

It was not known how the occupants exited the vehicles. The driver of the Corolla did not sustain any visible injury. The 2-month-old infant in the child safety seat that was on the lap of the front right passenger sustained fatal injuries. The front right and rear right adult passengers and the two rear seat child passengers all sustained police-reported minor visible injuries. The adult passengers were transported by ambulance to a local hospital. The front right and rear right adult passengers were admitted overnight. The child passengers were transported by ambulance to a regional children's hospital. The rear seated children were admitted overnight and the 2-month-old died 1.5 hours following the crash.

VEHICLE DATA - 1996 Toyota Corolla

The 1996 Toyota Corolla was identified by the police photographs. The Corolla's Vehicle Identification Number (VIN) was not reported. The Toyota Corolla was a four-door sedan equipped with a 1.6 liter, 4 cylinder engine, front-wheel drive, and an automatic transmission. The seating was configured with front bucket seats and a rear bench seat with a split folding back. The front and rear outboard positions were equipped with manual 3-point lap and shoulder belts with sliding latch plates and the center rear position was equipped with a lap belt with a locking latch plate.

CHILD SAFETY SEAT DATA

The child safety seat that was used in this crash was a rear-facing infant seat. The seat was designed so that it could be used with a detachable base, and it appeared that the base was attached to the bottom aspect of the seat in the police photographs. The manufacturer and model of the seat could not be determined from the available photographs. These color photographs were over-exposed, therefore the shell of the restraint was not identifiable. This type of child safety seat was the correct type for the 2-month old infant, however, it was not known if he was properly restrained by the seat's harness system.

The child safety seat was not properly installed in the vehicle and was positioned on the lap of the front right passenger. A warning label was affixed to the side plane of the right instrument panel that illustrated the potential hazard associated with placing a rear-facing child safety seat in the front right position.

CHILD SAFETY SEAT DAMAGE

Damage to the child safety seat was based on the on-scene police photographs. Due to the overexposed nature of the photographs, the exact extent of the damage could not be identified. The child safety seat was found in the front right floor pan area and was upside down in the photographs (**Figure 4**). The top aspect was on the floor pan and the bottom aspect was resting against the front right seat cushion. The rigid plastic on the outboard areas of the child safety seat was fractured, and plastic fragments were noted on the floor pan and interior sill area (**Figure 5**). It appeared that the plastic carrying handle had fractured on the top aspect, and the left arm was displaced upward. There also appeared to be a fracture line on the lower right aspect of the base.



Figure 4. Damaged child safety seat in the Corolla



Figure 5. Closer view of the damaged child safety seat

VEHICLE DAMAGE

Exterior Damage - 1996 Toyota Corolla

The 1996 Toyota Corolla sustained moderate frontal damage as a result of the impact with the Oldsmobile Delta 88. The direct contact damage began at the front left bumper corner and extended approximately 115 cm (45") laterally across the frontal plane. The combined direct and induced damage involved the entire frontal width of the vehicle (**Figure 6**). The bumper fascia was displaced downward and was partially separated from the vehicle. It was also abraded on the top aspect. The bumper beam was crushed rearward and fractured approximately 15 cm (6") to the left of the centerline at C4. The maximum crush was also located 15 cm (6") to the left of the centerline at C4 and was estimated to be 30 cm (12"). The radiator core was crushed as well as the upper and lower radiator supports. Both headlamp assemblies were displaced and the grille fascia was separated from the vehicle. The hood was buckled rearward at the designated fold points and the leading edge was abraded from contact with the Delta 88. The left fender was crushed rearward and buckled. The left front wheel appeared to be restricted from the rearward displacement of the frontal components. The Collision Deformation Classification (CDC) for the impact with the Delta 88 was 12-FDEW-2. Six crush measurements were estimated along the bumper beam



Figure 6. Frontal damage to the Toyota Corolla

(Figure 7) and were as follows: C1 = 15 cm (6"), C2 = 20 cm (8"), C3 = 25 cm (10"), C4 = 30 cm (12"), C5 = 15 cm (6"), C6 = 5 cm (2").

Interior Damage - 1996 Toyota Corolla

The interior damage for the 1996 Toyota Corolla was based on the on-scene police photographs. There did not appear to be significant compartment intrusion. Occupant contact was noted on the top right aspect of the glove box door, possibly a result of a knee strike by the front right occupant. The driver's seat back and head restraint were displaced rearward and slightly counterclockwise (CCW), probably from the driver rebounding into the seat back. White abrasions were also noted on the top right aspect of the glove box door from contact with the rigid plastic of the child safety seat.



Figure 7. Frontal damage along the bumper beam

Exterior Damage - 1995 Oldsmobile Delta 88

The 1995 Oldsmobile Delta 88 sustained moderate frontal damage as a result of the impact with the Toyota Corolla. The direct damage began at the front left bumper corner and extended laterally approximately 115 cm (45") across the frontal plane. The combined direct and induced damage involved the entire frontal width of the vehicle (Figure 8). The maximum crush was located at C4, approximately 17 cm (7") to the right of the centerline and was estimated to be 15 cm (6"). The bumper fascia was crushed and displaced upward on the left and center aspects. Abrasions were noted on the front aspect of the bumper fascia on the left and center aspects, as well. The bumper fascia was fractured approximately 50 cm (20") to the left of the centerline on the bottom aspect. The left side aspect of the bumper fascia was crushed against the left front wheel, which appeared to be restricted. The grille was separated from the vehicle. There was no direct contact evidence on the leading edge of the hood, but the hood was buckled rearward at the designated fold points. Both headlamps were displaced. The CDC for this impact with the Corolla was 12-FDEW-1. Six crush measurements were estimated along the bumper and were as follows: C1 = 13 cm (5"), C2 = 13 cm (5"), C3 = 13 cm (5"), C4 = 15 cm (6"), C5 = 8 cm (3"), C6 = 3 cm (1").



Figure 8. Frontal damage to the Delta 88

AIR BAG SYSTEM - 1996 Toyota Corolla

The 1996 Toyota Corolla was equipped with frontal air bags for the driver and front right passenger positions (**Figure 9**) that deployed as a result of the impact with the Delta 88. The driver's air bag was housed in the center of the steering wheel with symmetrical H-configuration module cover flaps.



Figure 9. Deployed frontal air bag system in the Toyota Corolla

The front right passenger's air bag deployed from a mid-instrument panel mounted module with a single cover flap design hinged at the top aspect. Contact evidence on the air bag and cover flap could not be identified in the police photographs.

OCCUPANT DEMOGRAPHICS - 1996 Toyota Corolla

Driver

Age/Sex:	36-year-old female
Height:	Not reported
Weight:	Not reported
Seat Track Position:	Appeared to be mid-track in police photographs
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Police report
Eyewear:	Unknown
Type of Medical Treatment:	Not visibly injured and transported by ambulance to a local hospital and admitted overnight

Driver Kinematics

The 36-year-old female driver was presumed to have been seated in an upright posture with the seat track adjusted to the mid-track position. The seat back was slightly reclined in the on-scene photographs. The police report indicated that the driver was restrained by the available manual 3-point lap and shoulder belt. At impact, the frontal air bag system deployed and she initiated a forward trajectory. She loaded the manual restraint and struck the deployed driver's air bag which mitigated contact with the steering wheel assembly. She probably rebounded against the seat back which appeared to be deformed in a slight clockwise direction in the police photographs. She did not sustain any visible injuries but was transported by ambulance to a local hospital for observation.

Front Right Passenger

Age/Sex: 35-year-old female
Height: Not reported
Weight: Not reported
Seat Track Position: Appeared to be mid-track in police photographs
Manual Restraint Use: Unknown
Usage Source: Police report
Eyewear: Unknown
Type of Medical Treatment: Transported by ambulance to a local hospital and admitted overnight

Front Right Passenger Kinematics

The 35-year-old female front right passenger was presumed to be seated in an upright posture with the seat track adjusted to the mid-track position. She was probably not restrained by the available manual 3-point lap and shoulder belt, although restraint usage was coded on the police report as unknown. She was holding the rear-facing child safety seat on her lap with the 2-month-old infant positioned in the safety seat. At impact, the frontal air bag system deployed and displaced the child safety seat rearward. The front right passenger initiated a forward trajectory and was struck by the infant and the child safety seat as they were accelerated rearward. She may have struck her right knee on the glove box door. The child safety seat probably prevented front right passenger from contacting the front right passenger's air bag. The combination of the front right passenger's forward momentum and rearward displacement of the child safety seat caused her to compress the child safety seat between herself and the expanding front right passenger's air bag. The front right passenger sustained police-reported minor visible injuries and was transported by ambulance to a local hospital. She was admitted overnight for observation.

Front Right Infant Passenger (on lap)

Age/Sex: 2-month-old male
Height: 61 cm (24")
Weight: 8 kg (17 lb)
Seat Track Position: N/A
Manual Restraint Use: Improperly positioned rear-facing infant child safety seat
Usage Source: Injury data, police report
Eyewear: None
Type of Medical Treatment: Transported by ambulance to a regional children's hospital and pronounced dead 1.5 hours following the crash

Front Right Infant Passenger (on lap) Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Laceration of the left basal ganglia	Maximum (140212.6,8)	Front right passenger's air bag cover flap and expansion of the air bag
Epidural hemorrhage	Severe (140630.4,9)	Front right passenger's air bag cover flap and expansion of the air bag
Subdural hemorrhage	Severe (140650.4,9)	Rearward acceleration due to the expansion of the front right passenger's air bag
Minimal intraventricular hemorrhage	Severe (140678.4,9)	Front right passenger's air bag cover flap and expansion of the air bag
Laceration of the septum pellucidum	Severe (140688.4,9)	Front right passenger's air bag cover flap and expansion of the air bag
Linear fractures of the base of the skull and comminuted fracture of the right anterior fossa with right intraorbital hemorrhage	Severe (150206.4,8)	Front right passenger's air bag cover flap and expansion of the air bag
Multiple cortical contusions	Serious (140620.3,3)	Front right passenger's air bag cover flap and expansion of the air bag
Subarachnoid hemorrhage over both convexities of the cerebral hemispheres and confluent subarachnoid hemorrhage at the base	Serious (140684.3,1) (140684.3,2)	Front right passenger's air bag cover flap and expansion of the air bag

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Multiple skull fractures of the calvarium (linear and diastatic) with overlying of the fragments	Moderate (150402.2,9)	Front right passenger's air bag cover flap and expansion of the air bag
Right radius fracture	Moderate (752800.2,1)	Rigid plastic shell of the child safety seat
Subgaleal hemorrhage of the entire scalp except the mid-posterior occipital region	Minor (190402.1,0)	Front right passenger's air bag cover flap and expansion of the air bag
1.3 cm (0.5") contusion of the upper gingiva to the left of the midline	Minor (243202.1,8)	Probable occupant-to-occupant contact with the front right adult passenger
1.3 cm (0.5") laceration of the upper gingiva to the left of the midline	Minor (243204.1,8)	Probable occupant-to-occupant contact with the front right adult passenger
Two 0.6 cm (0.3") linear contusions on the bridge of the nose	Minor (290402.1,4)	Probable occupant-to-occupant contact with the front right adult passenger
6.4 x 2.5 cm (2.5 x 1") forehead contusions above the right eyebrow extending to the right temple	Minor (290402.1,7)	Probable occupant-to-occupant contact with the front right adult passenger
1.9 cm (0.8") oblique linear laceration below the right eye	Minor (290602.1,1)	Probable occupant-to-occupant contact with the front right adult passenger
1.9 cm (0.8") right upper eyelid contusion	Minor (297402.1,1)	Probable occupant-to-occupant contact with the front right adult passenger

Injury source: Autopsy report

Front Right Infant Passenger (on lap) Kinematics

The 2-month-old male infant was positioned in the rear-facing infant child safety seat. Based on the damage to the child safety seat and injury patterns to the infant, the seat was placed in a rear-facing orientation on the front right adult passenger's lap and was probably positioned against the front right passenger's air bag cover flap. It was not known if the infant was properly restrained by the child safety seat's harness system. At impact, the frontal air bag system deployed. The cover flap struck the middle rear aspect of the child safety seat shell which caused a fracture in the rigid plastic and the forward edge of the seat to pivot upward and rearward. The front right passenger's air bag expanded against the rear aspect of the seat and accelerated it rearward. The rigid plastic shell struck the rear aspect of the infant's head which resulted in a subgaleal hemorrhage of the entire scalp except the mid-posterior occipital region, epidural hemorrhage, multiple skull fractures of the calvarium (linear and diastatic) with overlying of the fragments, linear fractures of the base of the skull and comminuted fracture of the right anterior fossa with right intraorbital hemorrhage, a laceration of the left basal ganglia, a laceration of the septum pellucidum, multiple cortical contusions, minimal intraventricular hemorrhage, and subarachnoid hemorrhage over both convexities of the cerebral hemispheres and confluent subarachnoid hemorrhage at the base. The rearward acceleration of the infant resulted in a subdural hemorrhage. The infant was displaced upward in the seat which exposed his head. As the child safety seat was redirected rearward, the front right passenger initiated a forward trajectory in response to the frontal impact. The child safety seat struck the front right passenger and the infant's head continued rearward. The rearward movement of the child safety seat combined with the forward momentum of the front right passenger compressed the infant against the child safety seat. The infant's right arm contacted the outer edge of the rigid plastic shell of the child safety seat which resulted in a right radius fracture. The vertical and rearward displacement of the infant in the seat probably resulted in occupant-to-occupant contact with the front right adult passenger which caused 6.4 x 2.5 cm (2.5 x 1") forehead contusions above the right eyebrow extending to the right temple, a 1.9 cm (0.8") right upper eyelid contusion, a 1.9 cm (0.8") oblique linear laceration below the right eye, two 0.6 cm (0.3") linear contusions on the bridge of the nose, and a 1.3 cm (0.5") contusion and laceration of the upper gingiva to the left of the midline. The infant rebounded into the child safety seat. It was not known how the child safety seat came to rest in the vehicle or how the infant was removed from the vehicle. He was transported by ambulance to a regional children's hospital and was in full cardiopulmonary arrest secondary to head trauma, on arrival. Treatment was continued in the emergency room, but the infant failed to respond and was pronounced dead 1.5 hours after the crash. The autopsy report listed the cause of death to be: Blunt impact to head with skull fractures and brain injuries.

Rear Seat Passenger Kinematics

The rear seat occupants of the Toyota Corolla consisted of a 3-year-old male rear left passenger, a 6-year-old female rear center passenger, and a 42-year-old female rear right passenger. Restraint usage for the rear seat occupants was unknown. At impact, the rear seat occupants initiated forward trajectories and probably loaded the rear aspects of the front seat backs. The adult passenger sustained police-reported minor visible injuries and was transported by ambulance to a local hospital and admitted overnight for observation. Both child passengers sustained police-reported minor visible injuries and was transported by ambulance to a regional children's hospital and admitted.