TRANSPORTATION SCIENCES
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REMOTE REDESIGNED AIR BAG DEPLOYMENT INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

VERIDIAN CASE NO. CA99-063

RABSS VEHICLE - 1998 TOYOTA AVALON

LOCATION - NEW YORK STATE

CRASH DATE - AUGUST 1998

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
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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. *Abstract* This remote investigation focused on a single vehicle crash that involved a 1998 Toyota Avalon. The Toyota Avalon was equipped with redesigned frontal air bags that deployed as a result of a frontal collision with a concrete drainage culvert. The Avalon was occupied by a 26-year-old female driver and 61-year-old male seated in the front right position. Both occupants were restrained by the manual 3-point lap and shoulder belt systems. The driver of the Avalon lost control of the vehicle during a rainstorm. The Avalon departed the roadway and struck a concrete culvert in a drainage ditch. Both occupants initiated forward trajectories in response to the 1 o'clock impact force. The driver loaded the manual restraint and deployed redesigned driver air bag. She sustained an unspecified hip/upper leg contusion and refused medical treatment. The front right passenger loaded the manual restraint resulting in multiple bilateral rib fractures, sternum fracture, laceration of pericardium, laceration of right pleura, and lacerations of right atrium including the tricuspid valve. He also sustained a transectional fracture of the vertebral column at T2/T3 from probable forward excursion over the shoulder belt. He subsequently loaded the deployed redesigned front right passenger air bag and lower instrument panel. His contact with the lower instrument panel and glove compartment door resulted in bilateral pelvic fractures and lower leg abrasions and lacerations. The front right passenger expired at the scene.			
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BACKGROUND

This remote investigation focused on a single vehicle crash that involved a 1998 Toyota Avalon. The Toyota Avalon was equipped with redesigned frontal air bags that deployed as a result of a frontal collision with a concrete drainage culvert. The Avalon was occupied by a 26-year-old female driver and 61-year-old male seated in the front right position. Both occupants were restrained by the manual 3-point lap and shoulder belt systems. The driver of the Avalon lost control of the vehicle during a rainstorm. The Avalon departed the roadway and struck a concrete culvert in a drainage ditch. Both occupants initiated forward trajectories in response to the 1 o'clock impact force. The driver loaded the manual restraint and deployed redesigned driver air bag. She sustained an unspecified hip/upper leg contusion and refused medical treatment. The front right passenger loaded the manual restraint resulting in multiple bilateral rib fractures, sternum fracture, laceration of pericardium, laceration of right pleura, and lacerations of right atrium including the tricuspid valve. He also sustained a transectional fracture of the vertebral column at T2/T3 from probable forward excursion over the shoulder belt. He subsequently loaded the deployed redesigned front right passenger air bag and lower instrument panel. His contact with the lower instrument panel and glove compartment door resulted in bilateral pelvic fractures and lower leg abrasions and lacerations. The front right passenger expired at the scene.

This crash was identified through a search of the Fatality Analysis Reporting System (FARS) for fatalities that occurred in vehicles equipped with redesigned air bags. The crash occurred in August 1998 and was assigned to the Veridian Special Crash Investigation Team on September 2, 1999 as a remote investigation effort. Insurance photographs and an autopsy report were obtained, which provided the basis for this narrative report.

SUMMARY

Crash Site

This single vehicle crash occurred during the nighttime hours of August, 1998. At the time of the crash, it was dark with no roadway illumination. The roadway consisted of two travel lanes, one northbound and one southbound. The asphalt roadway was straight and had a police-reported level grade. The road surface was wet as a result of a rainstorm at the time of the crash, which produced puddled water on the asphalt surface, and caused slippery conditions. The posted speed limit for the roadway was 89 km/h (55 mph). The roadside environment consisted of asphalt

Figure 1. East roadside with drainage ditch

shoulders and a grassy drainage ditch on the east side of the roadway **(Figure 1)**. The investigating officer reported the drainage ditch to be 1.5 m (5') below the grade of the roadway. The roadway was bordered by trees and vegetation on both sides.

Pre-Crash

The 26-year-old female driver of the 1998 Toyota Avalon was operating the vehicle southbound on a 2-lane state roadway during a rainstorm **(Figure 2)**. A non-contact vehicle traveling northbound splashed water onto the windshield of the Toyota, causing the driver's view to become obstructed. According to police, the driver reacted by steering right which caused the vehicle to travel onto the west shoulder. In an attempt to correct this maneuver, the driver steered left and lost control of the vehicle. The vehicle began to yaw in a counterclockwise (CCW) direction due to the slippery road conditions, crossed the centerline, and departed the roadway on the east side. The vehicle continued to yaw a police reported 27 m (89') along the east shoulder and into the grassy drainage ditch that bordered the east shoulder before impact.

Figure 2. Southbound approach for the Toyota Avalon

Crash

As the 1998 Toyota Avalon traveled down the slope into the bottom of the drainage ditch, it impacted a 0.5 x 3.4 m (1.6' x 11.0') concrete culvert **(Figure 3)** with the front right area. The principal direction of force was in the 1 o'clock sector. The damage algorithm of the WinSMASH program computed a velocity change of 35.6 km/h (22.3 mph) based on an estimated crush profile. The longitudinal and lateral components were -30.8 km/h (-19.3 mph) and -17.8 km/h (-11.1 mph) respectively. The impact induced deceleration was sufficient to deploy the redesigned frontal air bag system. The vehicle continued to travel in a forward direction over the culvert. It impacted the ground with the front left corner and struck the culvert with the lower right rear area before coming to rest in the ditch facing southeast.

Figure 3. Concrete culvert

Post-Crash

Reports did not indicate how the occupants exited the vehicle, however vehicle damage noted in insurance photos indicated probable removal by rescue personnel. The driver was reportedly conscious and sustained a contusion on her upper leg. The police report indicated that she refused medical treatment. The front right passenger expired at the scene of the crash due to crash related injuries.

RABSS VEHICLE

The 1998 Toyota Avalon was identified by the Vehicle Identification Number (VIN): 4T1BF18B2WU (production sequence omitted). The vehicle was a 4-door sedan equipped with a 3.0 liter, 6 cylinder engine, 4-speed automatic transmission, and four-wheel disc brakes with anti-lock (ABS). The seating was configured with front bucket seats with adjustable head restraints and a rear bench seat with a folding integral center armrest. The police report listed the front right passenger as the owner of the vehicle.

VEHICLE DAMAGE - 1998 Toyota Avalon

Exterior Damage

The 1998 Toyota Avalon sustained moderate frontal damage as a result of the impact with the concrete culvert. Insurance photos provided the basis Aan analysis of the exterior damage of the vehicle **(Figure 4)**. The roof and all glazing were removed by rescue personnel to extricate the occupants. The Collision Deformation Classification (CDC) for the frontal impact with the culvert was 01-FREE-4. Direct contact damage began at the front right bumper corner and extended laterally approximately 25 cm (10") toward the center of the vehicle. Direct contact damage was also noted longitudinally along the right front area forward of the A-pillar. The right front fender was displaced rearward and upward, and the hood was buckled at the designed fold points. The right front wheel was displaced rearward to the right A-pillar and was rotated clockwise (CW) at an approximate 50 degree angle relative to the vehicle. The bumper reinforcement bar was displaced rearward and the bumper fascia was separated from the vehicle. The combined direct and induced damage involved the entire frontal width of the vehicle. Six crush measurements were estimated at the level of the bumper reinforcement bar and were as follows: C1 = 5 cm (2"), C2 = 15 cm (6"), C3 = 30 cm (12"), C4 = 45 cm (18"), C5 = 60 cm (24"), C6 = 75 cm (30").

Figure 4. Frontal damage to the Toyota Avalon

The CDC for the secondary impact to the ground with the left front area was 11-FLLE-1. Direct damage was noted on the lower left fender forward of the left front wheel **(Figure 5)**. The fender was deformed in a rearward direction and buckled outward above the left front wheel. Damage to the fender was also noted aft of the left front wheel.

Figure 5. Damage to the left fender

The CDC for the third impact to the culvert with the lower right rear area was 02-RBLW-1. Contact damage was noted approximately 5 cm (2") forward of the right rear bumper corner, and extended approximately 45 cm (18") longitudinally along the lower portion of the right rear quarter panel **(Figure 6)**.

Figure 6. Damage to the right rear area

Interior Damage

Interior damage for the 1998 Toyota Avalon was rated as moderate and attributed to exterior deformation and passenger compartment intrusion **(Figure 7)**. The glove box door was open. Instrument panel molding in the front center and front right positions had separated from impact forces. Longitudinal intruded components included the entire instrument panel, right toepan, and the right A-pillar. The front right seat back was noted to be in an almost fully reclined position and the adjustable head restraint appeared to be displaced rearward.

Figure 7. Interior view

REDESIGNED AIR BAG SYSTEM

The 1998 Toyota Avalon was equipped with redesigned frontal air bags for the driver and front right passenger positions. According to the VIN, the vehicle was also equipped with side air bags. The driver's side air bag and right front passenger's side air bag were located in the outboard aspects of the front seat backs. The driver's side air bag did not deploy. Due to limited photographs, the deployment status of the right front passenger's side air bag could not be determined.

The frontal air bags had deployed as a result of the impact with the concrete culvert. Based on photos of an exemplar vehicle, the driver's air bag was housed in the center of the steering wheel with a horizontally oriented flap tear seam (H-configuration). The cover flaps were symmetrical in shape.

The front right passenger's air bag deployed from the top right instrument panel area. Based on photos of an exemplar vehicle, the front right passenger's air bag had a horizontally oriented flap tear seam (H-configuration). The cover flaps were symmetrical in shape.

OCCUPANT DEMOGRAPHICS

Driver

Age/Sex:	26-year-old female
Height:	Not reported
Weight:	Not reported
Seat Track Position:	Mid-track (estimated from insurance photos)
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	Police report
Eyewear:	Not reported
Type of Medical Treatment:	Refused

Driver Injuries

Injury	Injury Severity (AIS 90)	Injury Mechanisms
Hip/Upper leg contusion	Minor (890402.1,9)	Lap belt (probable)

Injury source: Police accident report

Driver Kinematics

The 26-year-old female driver of the 1998 Toyota Avalon was seated in a presumed upright posture. She was restrained by the available 3-point lap and shoulder belt system. At impact, she initiated a forward trajectory in response to the 1 o'clock impact force and loaded the manual restraint system. She also loaded the driver's air bag which offered additional protection against the frontal crash forces. The police report identified her to be conscious with a hip/upper leg contusion. She was not transported to any medical facility.

Front Right Passenger

Age/Sex:	61-year-old male
Height:	180 cm (71")
Weight:	136 kg (300 lb)
Seat Track Position:	Mid-to-full rear position (estimated from insurance photos)
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	Police report, vehicle photographs
Eyewear:	Not reported
Type of Medical Treatment:	Expired at scene

Front Right Passenger Injuries

Injury	Injury Severity (AIS 90)	Injury Mechanisms
Lacerations of right atrium including laceration of tricuspid valve	Maximum (441016.6,4)	Shoulder belt webbing
Multiple fractures - right ribs 2-6, 8-9, left ribs 3-7	Severe (450240.4,3)	Shoulder belt webbing
Laceration of right pleura with hemothorax	Serious (441802.3,1)	Shoulder belt webbing
Fracture of sternum - upper half in two places	Moderate (450804.2,4)	Shoulder belt webbing
Laceration of pericardium	Moderate (441602.2,4)	Shoulder belt webbing
Transectional fracture T2	Moderate (650416.2,7)	Forward excursion over shoulder belt
Transectional fracture T3	Moderate (650416.2,7)	Forward excursion over shoulder belt
Fracture of right pelvic bone	Moderate (852600.2,1)	Lower instrument panel (indirect)
Fracture of left pelvic bone	Moderate (852600.2,2)	Lower instrument panel (indirect)
1.5cm laceration - superior inferior mid-forehead	Minor (290602.1,7)	Flying glass
1.2cm laceration under right eyebrow	Minor (290602.1,7)	Flying glass
1.5cm laceration -bridge of nose	Minor (290602.1,4)	Flying glass
Multiple superficial lacerations - lower extremities below knee	Minor (890602.1,3)	Glove compartment door
Multiple abrasions - right lower extremity below knee	Minor (890202.1,1)	Glove compartment door

Injury source: Autopsy report

Front Right Passenger Kinematics

The 61-year-old male front right passenger of the 1998 Toyota Avalon was seated in a presumed upright posture. He was restrained by the available 3-point lap and shoulder belt system. At impact, he initiated a forward trajectory in response to the 1 o'clock impact force and loaded the manual restraint. He sustained a laceration of the tricuspid valve, right pleura, right atrium, and pericardium, fractures of right ribs 2-6 and 8-9, fractures of left ribs 3-7, and two fractures of the upper half of the sternum from the loading to the shoulder belt. Although no specific photographs of the belt system were provided by the insurance company, the belt webbing was gathered at the sliding latch plate and D-ring as evidenced in **Figure 7**. The webbing was intact and retracted against the right B-pillar. He sustained a transectional fracture of the vertebral column at T2/T3 from probable forward excursion over the shoulder belt. He loaded the deployed redesigned front right passenger's air bag, which intruded into his occupant position. The passenger's knees loaded the glove compartment door. The energy was transmitted through the femurs into the pelvis that resulted in (indirect) bilateral fractures of the pelvis. He also sustained facial lacerations that were attributed to flying glass. The front right passenger expired at the scene.

Figure 7. Interior view