TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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REDESIGNED AIR BAG SPECIAL STUDY (RABSS)
SCI TECHNICAL SUMMARY REPORT

NASS RABSS CASE NO. 1998-12-808E

RABSS VEHICLE - 1999 TOYOTA COROLLA

LOCATION - STATE OF MICHIGAN

CRASH DATE - NOVEMBER, 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. *Abstract* This investigation focused on a two vehicle crash involving a 1999 Toyota Corolla 4-door sedan (subject vehicle) and a 1991 Ford Aerostar XL minivan. The Toyota Corolla was equipped with redesigned frontal air bags for the driver and right passenger positions which deployed as a result of a right angle collision with the Ford Aerostar. The driver of the Toyota Corolla was operating the vehicle northbound when he failed to observe the overhead traffic signal or eastbound Ford as he proceeded straight through a 4-leg intersection. As the Toyota entered the intersection, the frontal area impacted the right front side surface of the Ford resulting in moderate damage to both vehicles. The restrained 32 year old male driver of the Toyota Corolla initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. He sustained an acute cervical spine strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The Toyota driver was transported by ambulance to the emergency room of a local trauma center for treatment and released.			
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BACKGROUND

This investigation focused on a two vehicle crash involving a 1999 Toyota Corolla 4-door sedan (subject vehicle) and a 1991 Ford Aerostar XL minivan. The Toyota Corolla was equipped with redesigned frontal air bags for the driver and right passenger positions which deployed as a result of a right angle collision with the Ford Aerostar. The driver of the Toyota Corolla was operating the vehicle northbound when he failed to observe the overhead traffic signal or eastbound Ford as he proceeded straight through a 4-leg intersection. As the Toyota entered the intersection, the frontal area impacted the right front side surface of the Ford resulting in moderate damage to both vehicles. The restrained 32 year old male driver of the Toyota Corolla initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. He sustained an acute cervical spine strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The Toyota driver was transported by ambulance to the emergency room of a local trauma center for treatment and released.

This crash was initially selected for investigation by the National Automotive Sampling System (NASS) as case number 98-12-808E for the Redesigned Air Bag Special Study. The Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) assigned the Special Crash Investigation (SCI) team at Veridian the task of case review and final report preparation.

SUMMARY

Crash Site

This two vehicle crash occurred during the evening hours of November, 1998. At the time of the crash, it was dark (street lighted) with no adverse conditions as the roads were dry. The crash occurred in the eastbound lanes of an urban 4-leg intersection **(see Figure 7 - page 5)**. The eastbound roadway consisted of three straight/asphalt (one-way) travel lanes bordered by barrier curbs and sidewalks. The northbound (one-way) roadway was designated as a highway off-ramp which consisted of three level/asphalt travel lanes which curved left. Traffic flow through the intersection was controlled by an overhead signal system in a steady red (flashing) phase for northbound traffic. The posted speed limit at the crash site was 56 km/h (35 mph).

Pre-Crash

The 32 year old male driver of the 1999 Toyota Corolla was operating the vehicle northbound **(Figure 1)** on the inboard travel lane of the highway off-ramp at a (driver reported) speed of 56 km/h (35 mph) when he failed to observe the red overhead traffic signal or eastbound Ford as he proceeded straight through the 4-leg intersection. Upon recognition of the impending harmful event, the Toyota driver steered right/braked in avoidance. The 31 year old female driver of the 1991 Ford Aerostar was operating the vehicle eastbound **(Figure 2)** in the center travel lane when she observed the northbound Toyota cross

her path of travel. The front right seating position was occupied by a 44 year old male with the second row of seats occupied by a 6 year old male and 7 year old female, respectively. The third row of seats were occupied by 9 and 8 year old males, respectively.

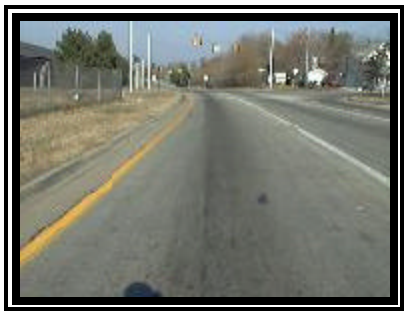

Figure 1. Northbound approach for the 1999 Toyota Corolla.

Figure 2. Eastbound approach for the 1991 Ford Aerostar.

Crash

As the Toyota Corolla entered the 4-leg intersection, the frontal area impacted the right front side surface of the Ford resulting in moderate damage to both vehicles. The *(SCI revised)* WinSMASH program computed velocity changes of 20.8 km/h (12.9 mph) for the subject vehicle and 13.4 km/h (8.3 mph) for the struck Ford. Respective longitudinal components were
-18.0 km/h (-11.2 mph) and -4.6 km/h (-2.9 mph). The impact induced deceleration was sufficient to deploy the Toyota's redesigned frontal air bag system. At this point, the Ford rotated counterclockwise as the right rear side surface struck (sideslapped) the left passenger area of the Toyota which resulted in minor damage to both vehicles. The *(SCI revised)* WinSMASH program computed velocity changes of 8.7 km/h (5.4 mph) for the subject vehicle and 5.6 km/h (3.5 mph) for the striking Ford. Respective latitudinal components were 8.7 km/h (5.4 mph) and
-5.6 km/h (-3.5 mph). Both vehicles came to rest in the east sector of the intersection facing southeast.

Post-Crash

The driver of the Toyota Corolla exited the vehicle under his own power. The exit status of the Ford occupants were unknown. Treatment was rendered at the scene by fire department personnel and emergency medical technicians (EMTs). The Toyota driver was transported by ambulance to the emergency room of a local trauma center for treatment and released. The Ford driver was reported by police as uninjured as the passengers were transported by ambulance to a local hospital for an unknown level of treatment *(with police reported minor injuries)*. Both vehicles were towed from the scene due to disabling damage.

RABSS VEHICLE

The 1999 Toyota Corolla was identified by the Vehicle Identification Number (VIN): 2T1BR12E3XC (production sequence deleted). The vehicle was a 4-door sedan equipped with front wheel drive and a 1.6 liter, 4-cylinder engine. The vehicle's odometer reading was approximately 1,609 km (1,000 miles) at the time of the crash. The police report listed the driver as the owner of the vehicle. The seating was configured with front bucket and rear bench seats (with folding backs). The driver reported no previous crashes or maintenance on the air bag system (original equipment). A portable cellular phone was present (unknown if in-use) at the time of the collision.

VEHICLE DAMAGE

Exterior Damage

Figure 3. Frontal damage to the 1999 Toyota Corolla.

The 1999 Toyota Corolla sustained moderate frontal damage as a result of the initial impact with the Ford Aerostar **(Figure 3)**. The direct contact damage encompassed the entire frontal width resulting in a combined direct and induced damage length (Field L) of 125.0 cm (49.2 in). Six crush measurements were documented at the level of the reinforcement bar *(bumper fascia separation)*: C1= 16.0 cm (6.3 in), C2= 19.0 cm (7.5 in), C3= 25.0 cm (9.8 in), C4= 21.0 cm (8.3 in), C5= 10.0 cm (3.9 in), C6= 0 cm. The *(SCI revised)* Collision Deformation Classification (CDC) for this initial impact to the Toyota was 11-FDEW-2 with a principal direction of force of (-)30 degrees. The bumper assembly shifted approximately 16.0 cm (6.3 in) to the right (entire end structure must shift to increment the principal direction of force). The grille and headlight assemblies fractured and separated from the vehicle during the collision sequence. The right fender was deformed rearward which restricted the right front wheel/tire (not deflated). The hood was displaced up and rearward from engagement against the side surface of the Ford. No reduction in the vehicle's wheelbase was sustained. The windshield was fractured from (exterior) impact forces and the (interior) front right air bag. All tempered glazing remained undamaged.

Direct contact damage was also identified on the left side surface attributed to the secondary (sideslap) impact. The direct contact damage began at the left rear axle and extended forward 150.0 cm (59.1 in). The direct and induced damage length (Field L) began 18.0 cm (7.1 in) aft of the left rear axle and extended forward 166.0 cm (65.4 in). Six crush measurements were documented at the level of the mid-door: C1= 0 cm, C2= 2.0 cm (0.8 in), C3= 5.0 cm (2.0 in), C4= 1.0 cm (0.4 in), C5= 0 cm, C6= 0 cm. The *(SCI revised)* CDC for this second and final impact to the Toyota was 09-LZEW-1 with a principal direction of force of (-)90 degrees. Although most of the damage pattern involved the left passenger area, direct damage was found rearward of the C-pillar area.

Figure 4. Right side surface damage to the 1991 Ford Aerostar.

The 1991 Ford Aerostar sustained moderate right front side surface damage as a result of the impact with the Toyota Corolla **(Figure 4)**. The direct contact damage began 18.0 cm (7.1 in) aft of the right front axle and extended rearward 112.0 cm (44.1 in). The combined direct and induced contact damage (Field L) began 53.0 cm (20.9 in) forward of the right front axle and extended rearward 187.0 cm (73.6 in). The *(SCI revised)* CDC for this initial impact to the Ford was 02-RYEW-3 with a principal direction of force of (+)70 degrees. This damage pattern was concentrated mainly along the right front door area with outward bowing of the upper door/window frame noted. All glazing remained undamaged.

Direct contact damage was also identified along the right rear side surface attributed to the secondary (sideslap) impact. The direct damage began at the right rear bumper corner and extended forward 123.0 cm (48.4 in). A maximum crush value of 11.0 cm (4.3 in) was identified between the C1 and C2 positions. The *(SCI revised)* CDC for this second and final impact to the Ford was 03-RZEW-2 with a principal direction of force of (+)90 degrees.

Interior Damage

There was no damage to the interior surfaces of the Toyota Corolla from intrusions or occupant contact.

REDESIGNED AIR BAG SYSTEM

The 1999 Toyota Corolla was equipped with redesigned frontal air bags for the driver and front right passenger positions. The air bags had deployed as a result of the crash. The driver air bag was housed in the center of the steering wheel with a horizontally oriented flap tear seam (H-configuration). No contact evidence was identified on the air bag or exterior surface of the module cover flaps. The flaps were symmetrical in shape and measured 16.0 cm (6.3 in) in width and 9.0 cm (3.5 in) in height. The NASS researcher measured the diameter of the driver air bag at 50.0 cm (19.7 in) in its deflated state **(Figure 5)**. The bag was tethered by two internal straps and vented by two ports located at the 11 o'clock and 1 o'clock sectors on the rear aspect of the air bag.

The front right passenger air bag deployed from the right top instrument panel area with a horizontally oriented flap tear seam (H-configuration). No contact evidence was identified on the air bag or exterior surface of the module cover flaps. The cover flaps were nearly symmetrical in shape as the forward flap measured 23.0 cm (9.1 in) in width and 4.0 cm (1.6 in) in height while the aft flap measured 23.0 cm (9.1 in) in width and 6.0 cm (2.4 in) in height. The NASS researcher measured the passenger air bag at 60.0 cm (23.6 in) in width and 70.0 cm (27.6 in) in height in its deflated state **(Figure 6)**. No internal tether straps were present. The bag was vented by two ports located at the 9 o'clock and 3 o'clock sectors on the side aspect of the air bag. No cutoff switch was found for the front right air bag.

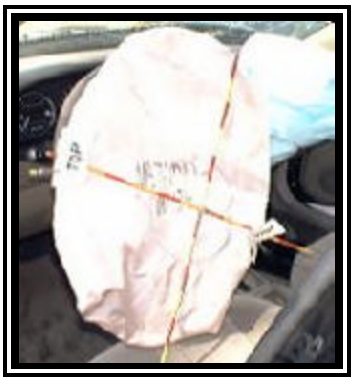

Figure 5. 1999 Toyota Corolla redesigned driver air bag.

Figure 6. 1999 Toyota Corolla redesigned passenger air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	32 year old male
Height:	180 cm (71 in)
Weight:	82 kg (180 lb)
Seat Track Position:	Mid-to-rear position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	NASS vehicle inspection, driver interview, police report
Eyeware:	None
Type of Medical Treatment:	Transported to the emergency room of a local trauma center and released

Driver Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
Acute cervical spine strain	Minor (640278.1,6)	Non-contact injury (flexion)
Acute left wrist sprain	Minor (751420.1,2)	Left A-pillar

Driver Kinematics

The 32 year old male driver of the 1999 Toyota Corolla was properly restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with the seat track adjusted to the mid-to-rear position. His hands were placed at the 10 o'clock and 2 o'clock sectors on the steering wheel rim. Belt usage was confirmed by the lack of significant interior contacts and injury. At impact, he initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. *Although sourced to the driver air bag in the NASS case file*, he sustained an acute cervical spine strain which was a result of the sudden forward movement of the head as the body loaded the belt system (flexion). The driver was transported to the emergency room of a local trauma center for treatment and released. The combination of restraint options provided protection against further contact to the steering wheel hub/rim and potential serious injury.

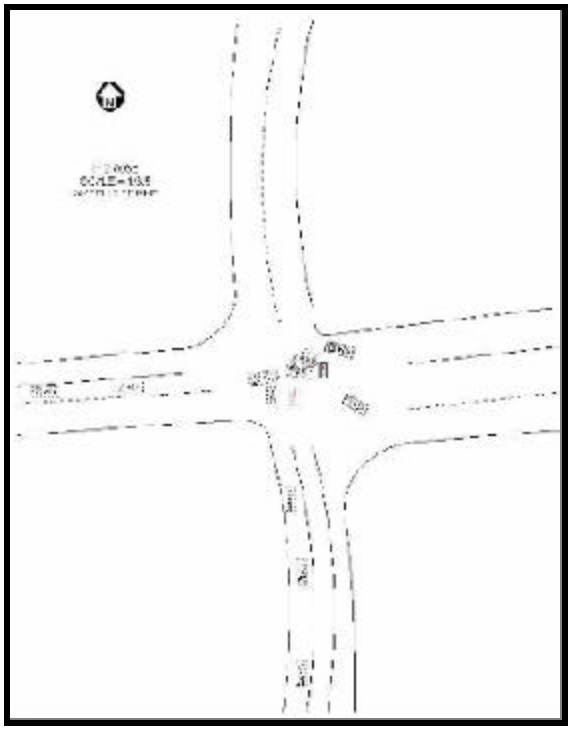

Figure 7. NASS Scene Diagram.