

CRASH DATA RESEARCH CENTER

Veridian
Engineering Division
Buffalo, New York 14225

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

NASS CDS CASE NO. 1999-43-085J

**RABSS VEHICLES - 1998 TOYOTA COROLLA VE
1998 JEEP CHEROKEE LIMITED**

LOCATION - STATE OF NORTH CAROLINA

CRASH DATE - APRIL, 1999

Contract No. DTNH22-94-D-07058

Prepared for:

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National Highway Traffic Safety Administration
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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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BACKGROUND

This investigation focused on a two vehicle crash involving a 1998 Toyota Corolla VE 4-door sedan and a 1998 Jeep Cherokee Limited 4x4 sport utility vehicle. Both vehicles were equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed as a result of an offset frontal collision. The driver of the Toyota Corolla was operating the vehicle eastbound when she failed to observe the westbound Jeep Cherokee as she attempted to turn left (north) at a 4-leg intersection. As the Toyota crossed the westbound lanes of the intersection, the front right area was impacted by the front right area of the Jeep resulting in moderate damage to both vehicles. The unrestrained 63 year old female driver of the 1998 Toyota Corolla initiated a forward and slightly lateral trajectory in response to the 1 o'clock impact force and loaded the knee bolster and deployed redesigned driver air bag. Loading of the knee bolster resulted in a left knee contusion and sprain. Her right forearm struck the rear-view mirror and windshield which resulted in a contusion with an underlying wrist sprain. She also sustained a left tibia/fibula fracture from contact to the foot controls. The Toyota driver was transported to a local hospital for treatment and admitted for 5 days. The restrained 47 year old male driver of the 1998 Jeep Cherokee initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. Loading of the manual restraint resulted in a contusion to the left abdomen. Contact to the deployed driver air bag resulted in a contusion to the anterior aspect of the left hand. The Jeep driver was transported to a local hospital for treatment and released.

This crash was initially selected for investigation by the National Automotive Sampling System (NASS) as CDS case number 1999-43-085J and also included in 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 April, 1999. At the time of the crash, it was dark (street not lighted) with rainy conditions as the roads were wet. The crash occurred at a hillcrest in the westbound lane of a (asphalt/straight) 4-leg rural intersection (see **Figure 9 - page 8**). The east sector of the intersection consisted of one left turn lane, one through lane and one channelized right turn lane as the west sector consisted of one left turn lane and two through lanes. Traffic control through the intersection was controlled by an overhead signal system in green phase for east/westbound traffic. The posted speed limit at the crash site was 72 km/h (45 mph).

Pre-Crash

The 63 year old female driver of the 1998 Toyota Corolla VE was operating the vehicle eastbound (**Figure 1**) on approach to a rural 4-leg intersection when she failed to observe the westbound Jeep as she attempted to turn left (north) at a (police reported) speed of 16 km/h (10 mph). The police reported no brake marks indicative of driver avoidance maneuvers.

The 47 year old male driver of the 1998 Jeep Cherokee Limited was operating the vehicle westbound at a (driver reported speed) of 64 km/h (40 mph) when he proceeded straight through the 4-leg intersection (**Figure 2**) and observed the eastbound Toyota cross his path of travel. Upon recognition of the impending harmful event, the driver steered right and braked in avoidance.



Figure 1. Eastbound approach for the 1998 Toyota Corolla VE.

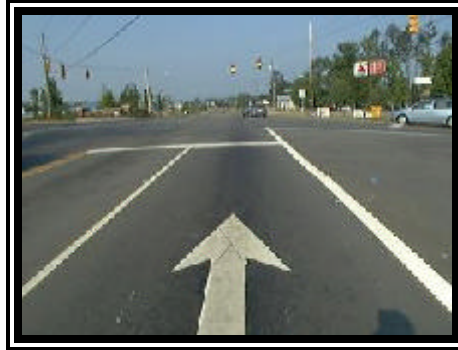


Figure 2. Westbound approach for the 1998 Jeep Cherokee Limited.

Crash

As the Toyota crossed the westbound lane of the 4-leg intersection, the front right area was impacted by the front right area of the Jeep resulting in moderate damage to both vehicles. The missing vehicle algorithm of the WinSMASH reconstruction program computed velocity changes of 25.0 km/h (15.5 mph) for the Toyota and 19.1 km/h (11.9 mph) for the striking Jeep. Respective longitudinal components were -23.5 km/h (-14.6 mph) and -19.1 km/h (-11.9 mph). The impact induced deceleration was sufficient to deploy the redesigned frontal air bag systems in each vehicle. Both vehicles came to rest in the northwest sector of the intersection with the Toyota facing north and the Jeep facing northwest.

Post-Crash

The exit status of the Toyota driver was unknown as the Jeep driver exited the vehicle with some assistance from rescue personnel. Both drivers were transported by ambulance to a local hospital as the Toyota driver was hospitalized for 5 days and the Jeep driver was treated and released. Both vehicles were towed from the crash site due to disabling damage.

RABSS VEHICLES

1998 Toyota Corolla VE

The 1998 Toyota Corolla VE was identified by the vehicle identification number (VIN): 2T1BR12E6WC (production number deleted). The vehicle was a 4-door sedan equipped with front wheel drive and a 1.8 liter, 4 cylinder engine. The police report listed the driver as the owner of the

vehicle. The odometer reading at the time of the crash was unknown. The seating was configured with front bucket and rear bench seats (with folding backs). The NASS interview was not obtained, therefore, previous crashes or maintenance on the Toyota's frontal air bag system were unknown.

1998 Jeep Cherokee Limited

The 1998 Jeep Cherokee Limited was manufactured in June, 1998 and identified by the vehicle identification number (VIN): 1J4FJ78S3WL (production number deleted). The vehicle was a 4-door sport utility equipped with four-wheel drive and a 4.0 liter, 6-cylinder engine. The police report listed the driver's spouse as the owner of the vehicle. The odometer reading at the time of the crash was unknown. The seating was configured with front bucket and rear bench seats (with a folding back). The driver reported no previous crashes or maintenance on the Jeep's frontal air bag system. No cell phone was present or in-use at the time of the collision.

EXTERIOR VEHICLE DAMAGE

Exterior - 1998 Toyota Corolla VE

The 1998 Toyota Corolla VE sustained moderate frontal damage as a result of the impact with the Jeep Cherokee (**Figure 3**). The direct contact damage began at the front right bumper corner and extended 60.0 cm (23.6 in) inboard. The impact deformed the entire front end width resulting in a combined direct and induced damage length (Field L) of 141.0 cm (55.5 in). Six crush measurements were documented at the level of the bumper: C1= 6.0 cm (2.4 in), C2= 2.0 cm (0.8 in), C3= 4.0 cm (1.6 in), C4= 6.0 cm (2.4 in), C5= 8.0 cm (3.1 in), C6= 14.0 cm (5.5 in). A secondary crush profile was obtained above the level of the bumper to capture the underride damage resulting in an *averaged profile of*: C1= 12.0 cm (4.7 in), C2= 16.0 cm (6.3 in), C3= 23.0 cm (9.1 in), C4= 33.0 cm (13.0 in), C5= 39.0 cm (15.4 in), C6= 66.0 cm (26.0 in). The Collision Deformation Classification (CDC) for this impact to the Toyota was 01-FZEW-3 with a principal direction of force of (+)20 degrees. The hood was deformed rearward. The right fender was displaced rearward which restricted the right front wheel/tire (not deflated). The windshield was fractured from (exterior) impact forces and the (interior) front right passenger air bag deployment. Reduction in the left side wheelbase measured 2.0 cm (0.8 in).



Figure 3. Front right damage to the 1998 Toyota Corolla VE.

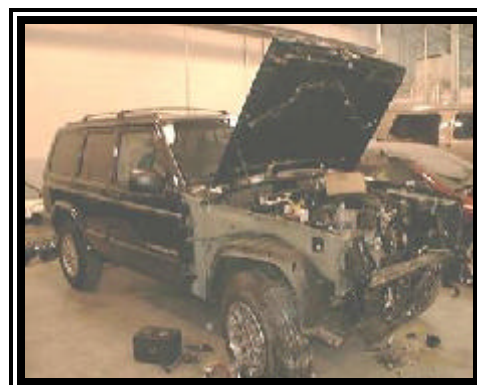


Figure 4. Frontal damage to the 1998 Jeep Cherokee Limited (vehicle under repair).

Exterior - 1998 Jeep Cherokee Limited

The 1998 Jeep Cherokee Limited sustained moderate frontal damage as a result of the impact with the Toyota Corolla (**Figure 4**). The *SCI revised* direct contact damage began 55.0 cm (21.7 in) to the right of the front left bumper corner and extended 93.0 cm (36.6 in) inboard. The impact deformed the entire front end width resulting in an estimated combined direct and induced damage length (Field L) of 119.0 cm (46.9 in). The vehicle was under repair at the time of the NASS inspection, therefore, a crush profile was not obtained. The Collision Deformation Classification (CDC) for this impact to the Jeep was 12-FZEW-9 (unknown crush extent zone represented by "9"). The right fender was removed as the right front wheel/tire was restricted (not deflated).

INTERIOR VEHICLE DAMAGE

Interior - 1998 Toyota Corolla VE

Interior damage to the Toyota Corolla identified through the vehicle inspection was minimal and was attributed to occupant contact. A small spider-web fracture pattern was identified to the mid-windshield area which was also fractured along the right lower windshield area from the passenger air bag deployment. The rear-view mirror was fractured and off the header mount. Hair strands were reportedly found on the windshield header. The front left restraint was noted to be restricted in the stowed position. A 2.0 cm (0.8 in) longitudinal penetration (intrusion) of the hood was documented to the right lower windshield area.

Interior - 1998 Jeep Cherokee Limited

Interior damage to the Jeep Cherokee identified through the vehicle inspection was also minimal and identified as a scuff mark on the left knee bolster. No intrusions were found in the vehicle.

REDESIGNED AIR BAG SYSTEM

1998 Toyota Corolla VE

The 1998 Toyota Corolla VE was equipped with redesigned frontal air bags for the driver and front right passenger positions. The air bags 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). The flaps were rectangular in shape as the upper flap measured 16.0 cm (6.3 in) in width and 6.0 cm (2.4 in) in height while the lower flap measured 16.0 cm (6.3 in) in width and 10.0 cm (3.9 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flaps, blood spattering was noted on the left upper quadrant of the air bag face and left portion on the rear aspect. The NASS researcher measured the diameter of the driver air bag at 45.0 cm (17.7 in) in its deflated state (**Figure 5**). The bag was vented by two ports located at the 11 o'clock and 1 o'clock sectors on the rear aspect of the air bag. No internal tether straps were present.

The front right passenger air bag deployed from the right top instrument panel area with a horizontally oriented flap tear seam (H-configuration). The flaps were symmetrical in shape and measured 23.0 cm (9.1 in) in width and 5.0 cm (2.0 in) in height. No contact evidence was identified on the air bag or exterior surface of the module cover flaps. The NASS researcher measured the passenger air bag at 52.0 cm (20.5 in) in width and 58.0 cm (22.8 in) in height in its deflated state (**Figure 6**). The bag was vented by two ports located at the 10 o'clock and 2 o'clock sectors on the side aspect of the air bag. No internal tether straps were present.



Figure 5. 1998 Toyota Corolla VE deployed redesigned driver air bag.



Figure 6. 1998 Toyota Corolla VE deployed redesigned passenger air bag.

1998 Jeep Cherokee Limited

The 1998 Jeep Cherokee Limited was equipped with redesigned frontal air bags for the driver and front right passenger positions. The air bags deployed as a result of the crash. The driver air bag was housed in the center of the steering wheel with a single cover flap design hinged at the top aspect. The flap was rectangular in shape and measured 15.0 cm (5.9 in) in width and 11.0 cm (4.3 in) in height. No contact evidence was identified on the air bag or exterior surface of the module cover flap. Black vinyl transfers were noted to the (front/back) left upper quadrant from expansion within the module. The NASS researcher measured the diameter of the driver air bag at 49.0 cm (19.3 in) in its deflated state (**Figure 7**). No vent ports or internal tether straps were reportedly present.

The front right passenger air bag deployed from the right mid-instrument panel area with a single cover flap design hinged at the top aspect. No contact evidence was identified on the air bag or exterior surface of the module cover flap. The cover flap was rectangular in shape and measured 39.0 cm (15.4 in) in width and 16.0 cm (6.3 in) in height. Black vinyl transfers were noted to the upper right quadrant of the air bag face. The NASS researcher measured the passenger air bag at 62.0 cm (24.4 in) square in its deflated state (**Figure 8**). No vent ports or internal tether straps were reportedly present.

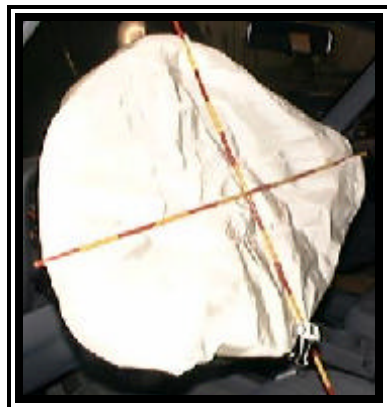


Figure 7. 1998 Jeep Cherokee Limited deployed redesigned driver air bag.



Figure 8. 1998 Jeep Cherokee Limited deployed redesigned passenger air bag.

DRIVER DEMOGRAPHICS

1998 Toyota Corolla VE

Age/Sex: 63 year old female
Height: Unknown
Weight: Unknown
Seat Track Position: Middle position
Manual Restraint Use: None
Usage Source: NASS vehicle inspection, police report
Eyewear: Unknown
Type of Medical Treatment: Transported to the emergency room of a local hospital for treatment and admitted (5 days).

Driver Injuries

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
*Fracture left tibia/fibula (bimalleolar)	Moderate (851612.2,2)	Foot controls
*Sprain right knee	Moderate (850826.2,1)	Left knee bolster
*Contusion right wrist/forearm	Minor (790402.1,1)	Rear view mirror
+Abrasion right wrist	Minor (790202.1,1)	Driver air bag
*Contusion left thumb	Minor (790402.1,2)	Steering wheel rim
*Sprain left thumb	Minor (750402.1,2)	Steering wheel rim
*Sprain right wrist	Minor (751420.1,1)	Rear view mirror
*Contusion right knee	Minor (890402.1,1)	Left knee bolster

sources-discharge summary/ER report+*

Driver Kinematics

The unrestrained 63 year old female driver of the 1998 Toyota Corolla VE was presumed to be seated in an upright posture with the seat back slightly reclined and the seat track adjusted to the middle position. The police report stated the driver was not restrained by the available 3-point manual lap and shoulder belt system, further evidenced by the restricted front left restraint noted during the NASS vehicle inspection. At impact, she initiated a forward and slightly lateral trajectory in response to the 1 o'clock impact force and loaded the knee bolster and deployed redesigned driver air bag. Loading of the knee bolster resulted in a contusion/abrasion to the right knee, evidenced by the location of the injury relative to the kinematic response pattern. Her right forearm struck the rear-view mirror and windshield resulting in a contusion with an underlying wrist sprain. *Contrary to the NASS case file, this*

injury mechanism was evidenced by the small spider-web fracture pattern documented to the mid-windshield area and displaced rear-view mirror. A possibility exists that the expanding air bag contacted the anterior aspect of the right wrist and propelled it upward into the above mentioned struck components, however, the lack of specific injury aspect information has prohibited further SCI analysis of this potential air bag “fling” type mechanism. Furthermore, typical hand placements at the 10 o’clock and 2 o’clock positions on the steering wheel rim would have placed the right hand at the top sector during a left steering maneuver. Her left thumb contacted the steering wheel rim/spoke which resulted in a contusion and sprain, evidenced by the location of the injury relative to the above mentioned typical hand placements on the rim. She also sustained a left tibia/fibula fracture from contact to the foot controls as evidenced by the distal aspect of the fracture site in conjunction with the driver’s pre-impact vehicle acceleration into the turn. Following the crash (exit status unknown), the driver was transported by ambulance to a local hospital for treatment and released. The deployed redesigned driver air bag provided protection against contact to the steering wheel hub/rim, and potential serious injury.

DRIVER DEMOGRAPHICS

1998 Jeep Cherokee Limited

Age/Sex: 47 year old male
 Height: 173 cm (68 in)
 Weight: 75 kg (165 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
 Eyewear: None
 Type of Medical Treatment: Transported to the emergency room of a local hospital for treatment and released.

Driver Injuries

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
*Contusion left anterior hand	Minor (790402.1,2)	Driver air bag
*Contusion left abdomen (stomach)	Minor (590402.1,2)	Lap belt webbing

*source-interviewee**

Driver Kinematics

The 47 year old male driver of the 1998 Jeep Cherokee Limited was 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. Belt usage was evidenced by the lack of significant interior contacts and injury sustained in this moderate severity crash. 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. Loading of the manual restraint resulted in a contusion to the left abdomen, and may be indicative of an

improper placement of the lap belt harness high across the stomach. Contact to the deployed driver air bag resulted in a contusion to the anterior aspect of the left hand, evidenced by the location of the injury relative to the driver's stated pre-crash placement of the left hand on the steering wheel rim. Following the crash, the driver exited the vehicle with some assistance from rescue personnel and was subsequently transported by ambulance to the emergency room of a local hospital for treatment and released. The deployed redesigned driver air bag provided additional protection against further contact to the steering wheel hub/rim, and potential serious injury.

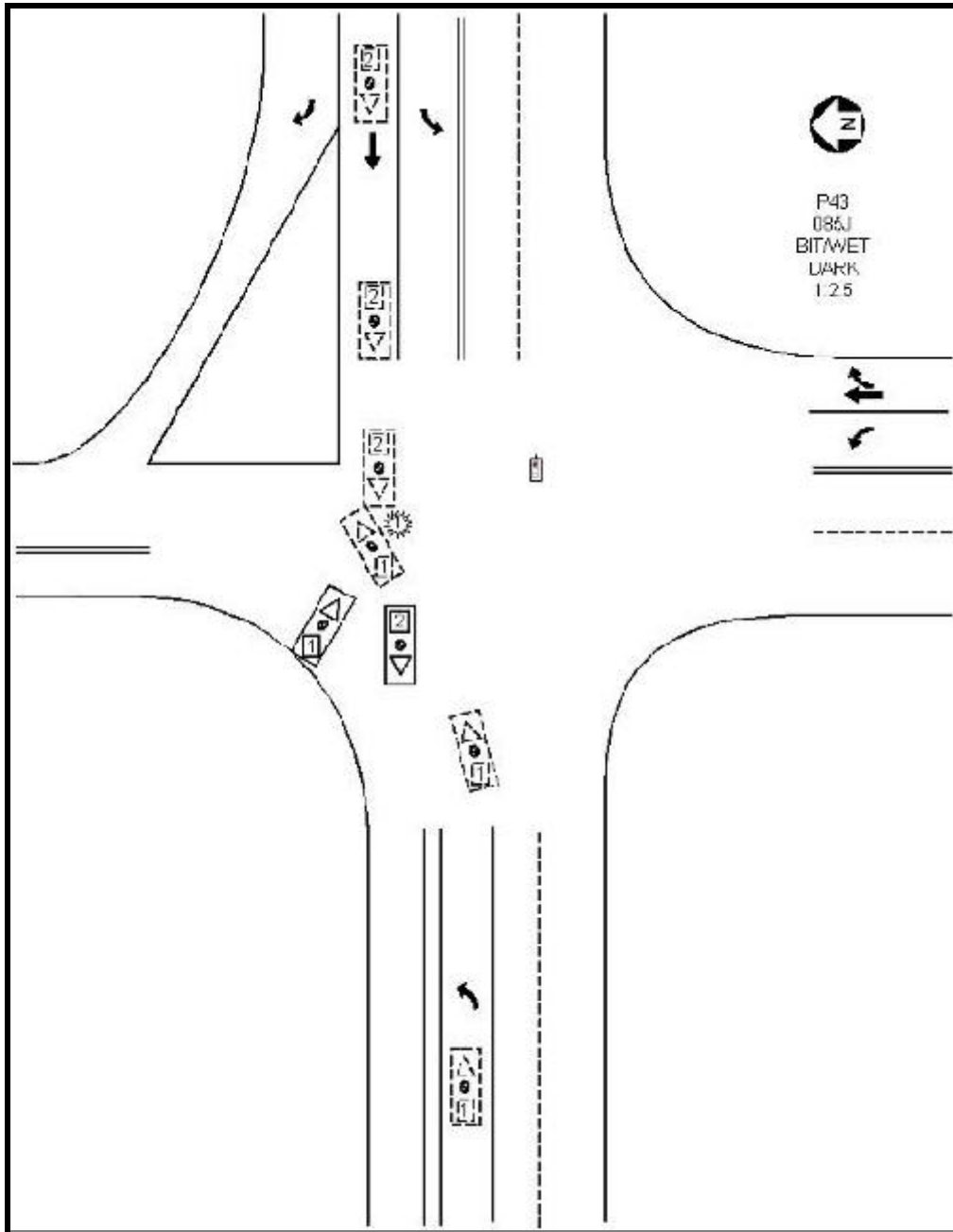


Figure 9. NASS Scene Diagram.