TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

Veridian Engineering
Buffalo, NY 14225

VERIDIAN REMOTE AIR BAG DEPLOYMENT/FRACTURED STEERING WHEEL ASSEMBLY INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

SCI/NASS COMBO CASE NO. : 97-45-032J

SUBJECT VEHICLE: 1997 JEEP GRAND CHEROKEE

LOCATION - STATE OF TENNESSEE

CRASH DATE - MARCH 1997

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 remote investigation focused on a single vehicle crash involving a 1997 Jeep Grand Cherokee equipped with a dual frontal air bag system. The Jeep Grand Cherokee was traveling westbound on a six-lane (three westbound, three eastbound), divided interstate roadway when it departed the right side of the roadway and sideswiped a concrete bridge wall with the right side plane of the vehicle. The Grand Cherokee crossed the three westbound travel lanes where it departed the left side of the roadway and struck the concrete median barrier with the left front corner area of the vehicle. The impact with the median barrier deployed the frontal air bag system in the vehicle and the driver initiated a forward trajectory. His upper body probably compressed the deployed driver's air bag and loaded the underlying steering wheel rim which contributed to the steering wheel spokes separating the wheel from the steering wheel assembly. The Grand Cherokee was redirected in a clockwise direction and struck the concrete median barrier a second time with the left rear side plane. It traveled back onto the travel lanes and came to rest in the center westbound travel lane. The 75-year-old driver was probably unrestrained and sustained a fracture of the left zygoma body with a slightly depressed left zygomatic arch fracture, fracture of the maxillary sinus, fractures of the left 4th , 5th ribs, and fracture of the left malleolus. He also suffered a laceration of the left eye, left periorbital ecchymosis, contusion of the left chest, abrasion of both wrists, and contusion of the left ankle. He was transported by ambulance to a trauma center and released two days following the crash.			
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BACKGROUND

Figure 1. Damaged 1997 Jeep Grand Cherokee

This remote investigation focused on a single vehicle crash involving a 1997 Jeep Grand Cherokee equipped with a dual frontal air bag system **(Figure 1)**. The Jeep Grand Cherokee was traveling westbound on a six-lane (three westbound, three eastbound), divided interstate roadway when it departed the right side of the roadway and sideswiped a concrete bridge wall with the right side plane of the vehicle. The Grand Cherokee crossed the three westbound travel lanes where it departed the left side of the roadway and struck the concrete median barrier with the left front corner area of the vehicle. The impact with the median barrier deployed the frontal air bag system in the vehicle and the driver initiated a forward trajectory. His upper body probably compressed the deployed driver's air bag and loaded the underlying steering wheel rim which contributed to the steering wheel spokes separating the wheel from the steering wheel assembly. The Grand Cherokee was redirected in a clockwise direction and struck the concrete median barrier a second time with the left rear side plane. It traveled back onto the travel lanes and came to rest in the center westbound travel lane. The 75-year-old driver was probably unrestrained and sustained a fracture of the left zygoma body with a slightly depressed left zygomatic arch fracture, fracture of the maxillary sinus, fractures of the left 4th , 5th ribs, and fracture of the left malleolus. He also suffered a laceration of the left eye, left periorbital ecchymosis, contusion of the left chest, abrasion of both wrists, and contusion of the left ankle. He was transported by ambulance to a trauma center and released two days following the crash.

This case was initially selected as NASS Case No. 97-45-032J. NHTSA subsequently assigned a remote investigation of the crash to the Veridian SCI team due to the deployment of the frontal air bag system and the fracture of the steering wheel in the Jeep Grand Cherokee. The primary focus in this case involved the separation of the steering wheel assembly from the steering column. The driver indicated that the air bag module separated from the steering column during the crash and struck him in the neck and left chest.

SUMMARY

Crash Site

This single vehicle crash occurred on the westbound lanes of a six-lane divided interstate highway during the daylight hours of March 1997 **(Figure 2)**. At the time of the crash, the asphalt roadway was dry and there were no adverse weather conditions. The eastbound and westbound travel lanes were separated by a concrete median barrier. The posted speed limit for the interstate highway was 89 km/h (55 mph).

Figure 2. Crash scene

Pre-Crash

The 75-year-old male driver of the Jeep Grand Cherokee was operating the vehicle on the outboard westbound lane on the interstate highway. Police reported that the driver lost consciousness and relinquished control of the vehicle. The Grand Cherokee drifted to the right toward the outboard concrete bridge wall.

Crash

The Jeep Grand Cherokee impacted the outboard concrete bridge wall in a sideswipe configuration. The vehicle continued forward in a tracking mode and traveled left across the westbound travel lanes. The front left aspect of the Grand Cherokee impacted the concrete median barrier. The delta-V computed by the WinSMASH speed reconstruction program was 20.9 km/h (13.0 mph) for this impact which appeared to be slightly lower then an observational estimate of 29-32 km/h (18-20 mph). The impact force was sufficient to deploy the Grand Cherokee's frontal air bag system. The Grand Cherokee rotated in a clockwise (CW) direction off of the median barrier while continuing its forward travel and the left rear aspect sideswiped the median barrier. The Grand Cherokee came to rest facing west between the inboard and center lanes approximately 53 meters (175') west of the frontal impact point.

Post-Crash

The driver exited the vehicle with some assistance. He was transported by ambulance to a trauma center where he was admitted for two days.

VEHICLE DATA - 1997 Jeep Grand Cherokee

The 1997 Jeep Grand Cherokee was identified by the Vehicle Identification Number (VIN): 1J4GZ58S7VC (production sequence omitted). The Grand Cherokee was a four-door sport-utility vehicle and equipped with a 5.0 liter, 8 cylinder engine, a four-speed automatic transmission, power steering, a tilt steering column, alloy wheels, and four-wheel anti-lock brakes. At the time of the vehicle inspection, the odometer read 999 km (621 miles).

The seating was configured with front bucket seats and a rear bench seat with a folding back. The front seats and outboard rear seats were configured with adjustable head restraints.

VEHICLE DAMAGE

Exterior Damage - *1997 Jeep Grand Cherokee*

The 1997 Jeep Grand Cherokee sustained moderate frontal damage as a result of the frontal impact with the concrete median and minor damage as a result of the sideswipe impacts. The initial right side impact resulted in abrasions and minor deformation to the right front and right center aspects **(Figure 3)**. The combined direct and induced damage began 237 cm (93") forward of the right rear axle and measured 285 cm (112") forward along the right side of the vehicle. The Collision Deformation Classification (CDC) was revised based on the SCI case review and was 12-RYES-1. The direct damage that resulted from the frontal impact with the concrete median barrier began 5 cm (2") left of center and extended laterally 73 cm (29") to the left bumper corner. The combined direct and induced damage measured 140 cm (55") from bumper corner to bumper corner **(Figure 4)**. The bumper fascia was fractured inboard of the front left corner and the entire fascia was displaced to the right. The front left fender sustained longitudinal and lateral crush from the impact. The entire frontal structure was displaced to the right as a result of direct contact and induced damage. The headlight assemblies and grille were separated from the vehicle. The offset frontal impact caused the rotation of the front axle which resulted in the shortening of the left wheelbase by 25 cm (10") and the extension of the right wheelbase by 19 cm (7"). Six crush measurements were taken by the NASS researcher along the front bumper and were as follows: C1 = 43 cm (17") C2 = 11 cm (4"), C3 = 4 cm (2"), C4 = 1 cm (1"), C5 = 0 cm , C6 = 1 cm (1"). The CDC for the frontal impact with the concrete median barrier was revised by SCI and was 11-FYEW-2. The left rear sideswipe impact resulted in minor damage to the left rear aspect of the Grand Cherokee **(Figure 5)**. The direct damage began 87 cm (34") rear of the left rear axle and measured 121 cm (48") forward along the left side. The max crush was located 48 cm (19") aft of the left rear axle at C3 and measured 3 cm (1"). The SCI revised CDC for this impact was 12-LBES-1.

Figure 3. Right side damage

Figure 4. Frontal damage

Figure 5. Left side damage

Interior Damage - ***1997 Jeep Grand Cherokee***

Interior damage to the 1997 Jeep Grand Cherokee was a result of occupant contact and compartment intrusion. The windshield was fractured from impact forces. Longitudinal intrusions included the left steering assembly and left floor pan. The knee bolster left side instrument panel trim were displaced **(Figure 6)**. The steering wheel fractured and separated from the tilt steering column. The tilt steering column was adjusted to the center position. The accelerator and brake pedals were displaced from occupant contact.

Figure 6. Interior view

MANUAL RESTRAINT SYSTEM - 1997 Jeep Grand Cherokee

The front seat positions in the 1997 Jeep Grand Cherokee were equipped with manual 3-point lap and shoulder belts with sliding latch plates and adjustable D-rings. The rear bench seat was configured with manual 3-point lap and shoulder belts with adjustable D-rings for the outboard positions and a 2-point lap belt for the center position.

FRONTAL AIR BAG SYSTEM - 1997 Jeep Grand Cherokee

The Supplemental Restraint System (SRS) was comprised of a driver air bag and front right passengers air bag. The driver's air bag module cover opened in the typical "H" pattern during the deployment sequence **(Figure 7)**. The air bag was designed with two tethers and no visible vent ports in the air bag membrane. It appeared to have fully inflated during the deployment sequence. The inflator unit was manufactured by Morton International. The front right passenger's air bag deployed from a mid-mount module configured with a single cover flap design. The cover flap was rectangular in shape and was hinged at the top aspect. The front right passenger's air bag was not vented and was not tethered.

Figure 7. Driver's air bag

STEERING WHEEL DAMAGE

The steering wheel rim and spokes fracture consisted of a one-piece cast alloy material. The spokes fractured at the flange adjustment in the steering shaft which resulted in the steering wheel separation **(Figures 8 and 9)**.

Figure 8. Lateral view of fractured steering wheel assembly

Figure 9. View of the rear aspect of the steering wheel

The first fractured area involved the left steering wheel spoke located near the center of the wheel while the second area was located radially at the outer limit of the right spoke **(Figures 10 and 11)**.

In the images below showing the underside of the steering wheel assembly **(Figure 12)**, it appeared that the inflator housing was not compromised during the inflation cycle. The base of the unit is clearly visible and is shown with the manufacturers identification labels still in place. Additionally, there were no reported hot spots or generant debris found in the vehicle interior which would have been present in a typical inflator housing failure.

Figure 10. Fractured mounting bracket

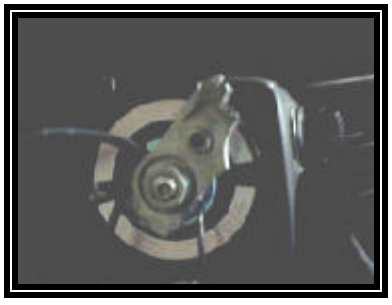

Figure 11. Close up view of fractured mounting bracket

Figure 12. Close-up of rear aspect of the steering wheel and inflator module

OCCUPANT DEMOGRAPHICS - 1997 Jeep Grand Cherokee

Driver

Age/Sex:	75-year-old male
Height:	180 cm (71")
Weight:	88 kg (194 lb)
Seat Track Position:	Between mid-track and full rear
Manual Restraint Use:	Probably unrestrained
Usage Source:	Medical data, vehicle inspection
Eyewear:	Eyeglasses/sunglasses
Type of Medical Treatment:	Transported by ambulance to a trauma center and admitted for two days

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Maxillary sinus fracture (NFS)	Moderate (250800.2,9)	Steering wheel rim
Left zygoma body fracture and slightly depressed zygomic arch fracture	Moderate (251800.2,2)	Steering wheel rim
Left 4th and 5th rib fractures	Moderate (450220.2,2)	Driver's air bag
Lateral left fibula fracture	Moderate (851608.2,2)	Left toe pan intrusion
Left eyelid contusion/periorbital ecchymosis	Minor (297402.1,2)	Driver's air bag
2-3 cm (1") left eyelid laceration	Minor (297602.1,2)	Driver's air bag
Left chest contusion	Minor (490402.1,2)	Driver's air bag
Right lateral wrist abrasion	Minor (790202.1,1)	Driver's air bag
Left elbow/wrist abrasion	Minor (790202.1,2)	Driver's air bag
Left ankle contusion	Minor (890402.1,2)	Left toe pan intrusion

Injury source: Emergency room records, radiology records, driver interview

Driver Kinematics

There was insufficient data in the NASS CDS case to support the positive identification of the injury mechanisms.

The 75-year-old driver of the 1997 Jeep Grand Cherokee was presumed to have been seated in an upright posture prior to the initial impact. The NASS researcher and police report indicated that the driver was restrained by the manual 3-point lap and shoulder belt, however, the steering wheel damage and the nature and magnitude of the driver's chest and facial injuries were more consistent with an unrestrained occupant. SCI field experience and laboratory crash test data have shown that restrained drivers don't have significant involvement with the steering wheel(significant to cause a steering wheel fracture). The police report also stated that a medical condition may have caused him to loose consciousness prior to the crash.

The driver may have been out of position with respect to the center of the air bag as the result of the first impact and subsequent vehicle trajectory across the roadway preceding the second impact sequence. At impact with the median barrier, the frontal air bag system deployed. The deploying driver's air bag contacted both wrists of the driver resulting in bilateral abrasions. It was reasoned that the air bag was fully inflated prior to contact by the driver's upper torso as there were no air bag-related injury lesion patterns noted (i.e., punch out or membrane injury type patterns) and no recorded injuries to his neck area. The intrusion of the left toe pan resulted in the left malleolus fracture and a left ankle contusion. His upper body more than likely compressed the deployed driver side air bag and loaded the underlying steering wheel rim as noted by a contusion of the left chest, fractures of the 4th and 5th left ribs, a fracture of the left zygoma body with a slightly depressed left zygomatic arch fracture, a fracture of the maxillary sinus, a laceration of the left eye, and a left periorbital ecchymosis. During this interaction, the steering wheel spokes separated from the column. The driver was redirected slightly as the left rear aspect of the Grand Cherokee sideswiped the median barrier.

The driver was assisted out the vehicle by rescue personnel and was transported by ambulance to a trauma center and admitted for two days.

In assessing the scope of the driver's injuries, it appeared plausible that the steering wheel spoke fractures during the second impact may have mitigated the severity of these injuries. Given his age of seventy-five years old, this may have been especially true for his skeletal injuries.