

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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**CALSPAN ON-SITE AIR BAG NON-DEPLOYMENT INVESTIGATION
CALSPAN CASE NO. 97-026
LOCATION: NEW YORK
VEHICLE: 1995 JEEP GRAND CHEROKEE
CRASH DATE: JULY, 1997**

Contract No. DTNH22-94-07058

Prepared for:

**U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, DC 20590**

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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 be 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 of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

<p>1. <i>Report No.</i> CA97-026</p>	<p>2. <i>Government Accession No.</i></p>	<p>3. <i>Recipient's Catalog No.</i></p>	
<p>5. <i>Title and Subtitle</i> Calspan On-site Air Bag Non-deployment Investigation Vehicle: 1995 Jeep Grand Cherokee Location: New York</p>		<p>4. <i>Weights</i></p>	
		<p>6. <i>Report Date:</i> March, 1998</p>	
<p>8. <i>Author(s)</i> Crash Research Section</p>		<p>7. <i>Performing Organization Code</i></p>	
		<p>9. <i>Performing Organization Report No.</i></p>	
<p>10. <i>Performing Organization Name and Address</i> Transportation Sciences Crash Research Section Calspan Corporation P.O. Box 400 Buffalo, New York 14225</p>		<p>11. <i>Work Unit No.</i> 1115 (7490-7499)</p>	
		<p>12. <i>Contract or Grant No.</i> DTNH22-94-D-07058</p>	
<p>13. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, DC 20590</p>		<p>14. <i>Type of Report and Period Covered</i> Technical Report Crash Date: July, 1997</p>	
		<p>15. <i>Sponsoring Agency Code</i></p>	
<p>16. <i>Supplementary Notes</i></p>			
<p>17. <i>Abstract</i></p> <p>This on-site investigation focused on an offset frontal collision that involved a 1995 Jeep Grand Cherokee and a 1990 GMC van. The unrestrained driver of the Jeep Grand Cherokee was fatally injured in the crash. The Jeep was equipped with a Supplemental Restraint System (SRS) that consisted of a driver air bag that did not deploy in the crash. Issues regarding the non-deployment of the air bag were raised by the local investigating authorities.</p> <p>The crash occurred when the driver of the GMC van lost control due to combination wet pavement and worn tires in the exit of a left curve. The GMC rotated counterclockwise and drifted left of center into the path of the Jeep. The vehicles impacted with the frontal plane of the GMC contacting the left front corner area of the Jeep in a 2 o'clock/11 o'clock impact configuration. There was a significant impact to, and extensive intrusion into, the Jeep's left front occupant compartment. The CDC of the Jeep was 11-FLEE-09 with an estimated delta V of 16 to 32 km/h (10 to 20 mph). The longitudinal delta V of the Jeep was within the air bag deployment threshold.</p> <p>The driver of the Jeep was pronounced dead at the scene approximately 30 minutes post-crash. He suffered massive blunt force trauma that included: lacerated aorta with hemoperitoneum (AIS 4), multiple ribs fractures (AIS 3), lacerated left lung (AIS 3), right and left side hemothorax, fractured sternum, lacerated liver, lacerated spleen and associated injuries. His fatal injuries were directly linked to the rearward intrusion and the driver's unrestrained kinematics.</p>			
<p>18. <i>Key Words</i> On-site investigation Supplemental Restraint System Air bag non-deployment Fatal injuries</p>		<p>19. <i>Distribution Statement</i> General Public</p>	
<p>20. <i>Security Classif. (of this report)</i> Unclassified</p>	<p>21. <i>Security Classif. (of this page)</i> Unclassified</p>	<p>22. <i>No. of Pages</i> 8</p>	<p>23. <i>Price</i></p>

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**CALSPAN ON-SITE AIR BAG NON-DEPLOYMENT INVESTIGATION
CALSPAN CASE NO: 97-026**

**LOCATION: NEW YORK
VEHICLE: 1995 JEEP GRAND CHEROKEE
CRASH DATE: JULY, 1997**

BACKGROUND

This on-site investigation focused on an offset head-on crash that occurred in the afternoon hours of July, 1997 in the state of New York. The crash involved a 1995 Jeep Grand Cherokee and a 1990 GMC full size van. The Jeep was equipped with a Supplemental Restraint System (SRS) that consisted of a driver air bag. The Jeep's SRS did not deploy in the crash. As a result of the crash, the driver of the Jeep was fatally injured. Questions regarding the air bag non-deployment were raised by local medical and police investigators and was the focus of this investigation. The National Highway Traffic Safety Administration (NHTSA) was informed of the crash by the local medical examiner on July 31, 1997. The Office of Defects Investigation requested an on-site investigative effort and NHTSA assigned the Calspan Special Crash Investigations Team the task on August 1, 1997. The Calspan SCI team began coordination activities with the local authorities and the Chrysler Corporation that same day. The vehicle was impounded pending SCI inspection. Two SCI investigators and two Chrysler representatives inspected the Jeep on August 7, 1997.

SUMMARY

Inspection of the crash scene revealed the crash occurred at the end of a curve on a two lane east/west road in a rural area of the state. The road was paved asphalt approximately 7 m (23 ft) in width, with 2.6 m (8.5 ft) paved shoulders bordering the travel lanes. A left curve for westbound traffic led into the crash scene. There was a hill crest approximately 76 m (250 ft) west of the impact area, with a downgrade (estimated -2%) for eastbound traffic. The speed limit in the area of the crash was 89 kph (55 mph). At the time of the crash, it was daylight and raining. The roads were wet with an estimated coefficient of 0.55. **Figure 1** is an eastbound approach view into the crash scene.



Figure 1: Eastbound trajectory view of the Jeep.

The 1995 Jeep Grand Cherokee was traveling eastbound operated by the 38 year old male driver. The driver had a reported height/weight of 183 cm (72 in) and 93 kg (205 lb). He was seated unrestrained with the left front seat adjusted to a mid-track position. Two passengers of foreign nationality occupied the Jeep's rear seat. The left rear seated male was reported as 30 years of age, 178 cm (70 in) in height and 75 kg (165 lb) in weight. The right rear seated female, age 30, was approximately 168 cm (66 in) and 52 kg (115 lb) in height and weight respectively. Both rear seated occupants were unrestrained. The westbound 1990 GMC van was operated by a 25 year old male. Immediately prior to the crash, the

westbound GMC van rounded the left curve and the vehicle lost traction due to a combination of the wet road surface and worn (bald) rear tires. The average tread depth of the rear tires measured <1 mm (1/32 in). The van began rotating counterclockwise while drifting into the eastbound lane. The driver of the eastbound Jeep recognized the impending collision and steered his vehicle to the right.

The crash occurred in the approximate center of the eastbound lane, with the left frontal area of GMC contacting the left front fender/corner area of the Jeep in a 2 o'clock/11 o'clock impact configuration. The investigating police referenced a gouge mark in the eastbound lane, as the point of impact, **Figure 1**. The mark was located in the approximate center of the eastbound lane and was directed toward the right (south) shoulder. The mark was 3.3 m (10.7 ft) long and began 1.8 m (5.9 ft) north of the south fog line and ended 1.3 m (4.25 ft) north of the fog line. The mark was caused by the left front suspension of the Jeep during the impact. The vehicle's SRS did not deploy.

The front of the GMC then slid along the left side of Jeep during a protracted engagement as the vehicles passed each other. The GMC disengaged due to its counterclockwise rotation and slid to rest in the westbound lane of the road facing westward, approximately 49 m (160 ft) west of the point of impact. The Jeep began rotating counterclockwise upon impact and slid to the southeast off the roadway. The right side of the Jeep contacted some brush and small trees that bordered the roadside and came to rest facing north, approximately 18 m (60 ft) from the point of impact.

The left front corner of the Jeep sustained approximately 46 cm (18 in) of longitudinal crush over a lateral width of 20.3 cm (8.0 in) from the left side of the vehicle inboard right (**Figures 2 and 3**). This deformation occurred outboard of the left unibody frame rail. The left front tire and suspension were heavily impacted causing the left side wheelbase to be foreshortened 23.4 cm (9.2 in). The left A-pillar and left side of the instrument panel (IP) were deformed longitudinally rearward into the driver's space. The A-pillar and lower sill deformed laterally right 23 cm (9 in). The toe pan also intruded rearward into the foot well. The direction of force was from 11 o'clock. The left side damage of the Jeep continued rearward to the C-pillar, approximately 305 cm (120 in) from the front of the vehicle. The Collision Deformation Classification (CDC) of the vehicle was 11-FLEE-9. The estimated delta V of the Jeep was moderate, approximately 16 to 32 kph (10 to 20 mph). There was also secondary superficial damage to the right side of the Jeep caused by contact with a small tree and brush when the vehicle came to rest off the road edge.



Figure 2: Front view of the Jeep.



Figure 3: Left front view of the Jeep.

The GMC van sustained 170 cm (67 in) of direct contact damage across the full width of the front bumper. The maximum crush was 89 cm (35 in) at the left front corner (**Figure 4**). The right front corner was displaced laterally to the left 64.8 cm (25.5 in). The direction of force was in the 2 o'clock sector. The CDC of the vehicle was 02-FDEW-6. Inspection of the tread depths of the rear tires revealed the tires were worn. Measured tread depths ranged from 0/32 in. to a maximum of 2/32 in. The minimum legal tread depth per New York State law is 2/32 in.



Figure 4: Left lateral view of the GMC van.

At impact, the driver of the Jeep was seated in a presumed normal posture. Given the large stature of the driver, the mid-track position of his seat positioned him forward, somewhat “close” to the steering wheel. Upon impact, the driver assumed a left front trajectory in response to the 11 o'clock direction of the impact force and loaded the steering wheel with his chest. The impact caused the left A-pillar, left door and left side of the instrument panel to deform rearward and intrude into the driver's space, **Figure 5**.



Figure 5: Left side view of the front interior.

The intrusion prevented inspection of the steering column's shear capsules, but there appeared to be separation on the left side. The right capsule was not accessible. The lower end of the column showed signs of having stroked, however, this could be caused by occupant loading, intrusion or a combination. The post-crash horizontal measurement from the center hub of the steering wheel to the left front seat back was 38 cm (15 in). Contacts to the left A-pillar, interior trim panel, and left side knee bolster from the driver's head and knees respectively were identified during the inspection.

The driver was extricated from the vehicle by the responding medical personnel prior to the arrival of the police. He was pronounced dead at the scene, approximately 30 minutes post-crash. The cause of death was ruled Blunt Force Trauma by the medical examiner's office. The driver sustained a lacerated aorta with a 200 ml hemoperitoneum (AIS 4), lacerated left lung (AIS 3), fourteen rib fractures (12 left side, 2 right side) (AIS 3), fractured sternum, right and left hemothorax, lacerated spleen, lacerated liver, and fracture of the left humerus, radius and ulna with a near complete avulsion of the left arm. The driver's chest injuries were directly linked to contact with the steering column and left side interior.

The rear seated occupants of the Jeep responded to the 11 o'clock direction of the impact force by moving forward and left. The occupants loaded the seat backs of the front seats as evidenced by the identified contacts. The left rear seated male reportedly suffered a right side neck laceration and unspecified chest and internal injuries. The right rear seated female reportedly suffered a laceration to the left side of the cheek and chin and a detached left ear lobe. The driver of the GMC van was a male, age 25, and only sustained a right ankle laceration.

VEHICLE 1

The 1995 Jeep Grand Cherokee was identified by a vehicle identification number (VIN) of 1J4GZ58Y1SC

(production sequence deleted). The date of manufacture was 4/95. The Jeep was a 4-door sport utility vehicle equipped with 4-wheel drive, and a 5.2 liter, V-8 engine linked to a 4-speed automatic transmission. The odometer indicated 10,623 km (6601 miles) at the time of the inspection.

MANUAL RESTRAINT SYSTEM

The vehicle was equipped with a manual 3-point restraint system that consisted of a continuous loop webbing and a sliding latch plate for the four outboard occupants. The webbing of the left front restraint was found in the stowed position with the retractor locked due to the impact. The restraint webbing was taut and captured between the left front seat back and B-pillar, **Figure 6**. The webbing could not have returned to this position post-crash, therefore the driver was unrestrained. The rear restraints were found in the stowed position and the rear seated occupants admitted to being unrestrained in the crash.



Figure 6: View of the left front restraint.

INTERIOR DAMAGE

The left front interior of the Jeep sustained impact as the GMC engaged the left side of the vehicle. The lower left A pillar was displaced 33 cm (13 in) longitudinally and 23 cm (9 in) laterally. The windshield fractured from the external impact forces. Multiple driver contacts were identified on the interior. A strand of hair was found at the junction upper left A-pillar and windshield header. Two scuffs were located on the steering wheel rim in the 6 and 10 o'clock sectors respectively. The driver air bag module in the center hub of the steering wheel exhibited signs of contact and there was an area of dried blood and bodily fluids on the 12 o'clock aspect of the module. The tilt mechanism of the steering column was fractured. A scuff from the left knee was located on the left aspect of the knee bolster centered 45.2 cm (17.8 in) left of vehicle center and 28 cm (11 in) below the top surface of the instrument panel. The right knee strike was located directly under the steering column centerline.

SUPPLEMENTAL RESTRAINT SYSTEM

The Supplemental Restraint System in the Jeep was an electro-mechanical system that consisted of a driver air bag module, three impact sensors, an air bag control module (ACM) and the associated wiring harness. The air bag module was located in the typical manner in the center hub of the steering wheel, **Figure 7**.



Figure 7: Driver air bag module.

Two impact sensors were symmetrically mounted in the forward crush zone. The design locations of the forward sensors were longitudinally rearward of the front bumper at the radiator support plane and laterally outboard of the left and right unibody frame rails. The third sensor was the safing sensor located in the ACM. The ACM was mounted under the center console in the occupant compartment. The purpose of the ACM was to monitor system readiness, store the on-board diagnostics and control the air bag deployment, if necessary. The air bag system was designed to deploy when at least one forward impact sensor and the safing sensor close under vehicle specific parameters

related to crash severity and direction.

Chrysler personnel were present on-site and inspected the Jeep with the Calspan SCI investigators. Chrysler was asked to participate in the inspection of the air bag system and specifically to download any diagnostic trouble codes stored in the ACM. The first step in this inspection was to read the air bag indicator located in the instrument cluster. The DRB II version 9.4 scan tool was used to download the stored codes. The DRB II was connected to the ACM and the Jeep's electrical system was energized. The ignition switch was turned to run and the air bag indicator in the instrument cluster illuminated for 6 to 8 seconds. During this interval, the ACM was designed to monitor air bag system readiness. The indicator turned off and then remained illuminated. This would indicate to the driver there was a fault in the air bag system. The scan tool was then used to read the stored fault codes. The diagnostics were as follows:

1 fault code: sensor open
16 min 0 cycles

There was only one fault code stored in the ACM and that code indicated there was an open sensor. The 16 min refers to 16 minutes of electrical power to the circuit after the fault code and the 0 cycles refers to the number of ignition cycles that occurred following the fault. The sensor was opened presumably by the crash, the ignition was on for 16 minutes post-crash and there were no ignition cycles since the crash. The time (16 minutes) and ignition cycles (zero) indicated that prior to the crash the air bag system was functioning properly.

The open sensor was determined to be the left front sensor, **Figure 8**. In the crash and subsequent deformation of the left front fender and radiator support panel, the outboard section of the left front sensor's mounting deformed rearward. This caused the sensor to rotate counterclockwise, miss-aligning the longitudinal direction of the sensor with respect to that of the vehicle, **Figure 9**. The wiring harness connecting the sensor into the system ran internally through the built-up sheet metal section. The collapse of the sheet metal section, in the crash, pulled the connector from the rear of the sensor causing the open circuit fault, **Figure 10**.

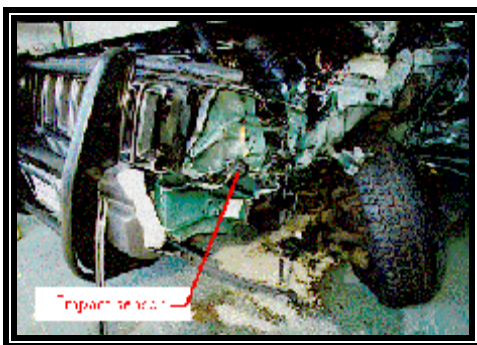


Figure 8: Forward left sensor location.

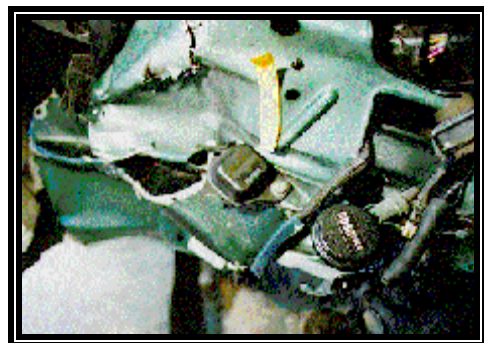


Figure 9: Close-up view of the post-crash sensor misalignment.

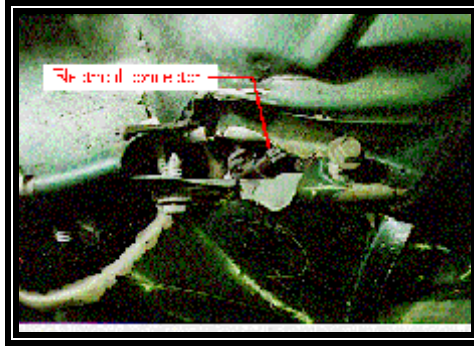


Figure 10: Close-up view of the electrical connector after sensor removal.

DELTA V AND SRS NON-DEPLOYMENT ISSUES

Reconstruction of the crash indicated the delta V of the Jeep was in the threshold required for SRS deployment. Chrysler indicated the deployment threshold of the Jeep was in the range of 16 to 26 km/h (10 to 16 mph). Forensic estimates based on vehicle damage indicated the delta V of the Jeep was moderate, approximately 16 to 32 km/h (10 to 20 mph). The Barrier model of the SMASH program calculated a barrier equivalent speed of 20.0 km/h (12.4 mph). The vehicle-to-vehicle crash dynamics were beyond the scope of the SMASH model. Those crash dynamics included a number of confounding factors. The crash was an offset angular corner impact into initially “soft structure”(the left front fender of the Jeep) from a bullet vehicle with an aggressive front structure (GMC). The vehicle’s did not reach a common velocity in the crash and the vehicle interaction involved a significant amount of rotation. The Jeep’s deformation appeared extensive, however there was a severe impact to and intrusion in the driver’s space. The crash pulse was a long duration pulse which may have delayed triggering to a time when the left front sensor was misaligned with the vehicle’s longitudinal axis and/or the connector had been pulled due to the mounting section collapse. Conversely, the deceleration level sufficient to cause deployment have not have been achieved over the lengthened pulse duration. At the request of the Office of Defects Investigation, the driver air bag module, front sensors and ACM were removed from the vehicle. These components were shipped to ODI for analysis.

DRIVER INJURIES

Injury	Injury Severity (AIS 90)	Injury Mechanism
Lacerated aorta, hemoperitoneum 200 ml	Severe (520299.4,4)	Steering wheel
Multiple fractures left ribs (1-12) and right ribs (1,2), right hemothorax - 500 ml	Serious (450230.3,3)	Intruding left door/steering wheel

Injury	Injury Severity (AIS 90)	Injury Mechanism
Lacerated left lung, left hemothorax - 500 ml	Serious (441430.3,2)	Steering wheel
Fractured sternum	Moderate (450804.2,3)	Steering wheel
Lacerated spleen	Moderate (544220.2,2)	Steering wheel
Lacerated liver	Moderate (541820.2,1)	Steering wheel
Near complete avulsion left arm	Moderate (790804.2,2)	Frontal structures of Vehicle 2
Fractured left humerus	Moderate (752600.2,2)	Frontal structures of Vehicle 2
Fractured left radius	Moderate (752800.2,2)	Frontal structures of Vehicle 2
Fractured left ulna	Moderate (753200.2,2)	Frontal structures of Vehicle 2
25.4 cm (10.0") area laceration of the left arm	Moderate (790604.2,2)	Frontal structures of Vehicle 2
Right ankle fracture	Moderate (850210.2,1)	Intruding floor pan/foot controls
5.1 cm (2") contusion left forehead and eyelid	Minor (290402.1,2) Minor (297402.1,2)	Intruding left A-pillar
6.4 cm (2.5") laceration left frontal parietal scalp	Minor (190600.1,2)	Intruding left A-pillar
7.6 cm (3.0") sub-scalp contusion	Minor (190402.1,2)	Intruding left A-pillar
Superficial lacerations anterior chest and left shoulder	Minor (490602.1,2) Minor (790602.1,2)	Left front window glazing/ Frontal structures of Vehicle 2
Multiple contusions right and left legs and thighs	Minor (890402.1,3)	Knee bolster
7.6 cm (3.0") abraded contusion right ankle	Minor (890202.1,1) Minor (890402.1,1)	Intruding floor pan/foot controls

DRIVER KINEMATICS

Upon impact, the unrestrained driver exhibited a left front trajectory in response to the 11 o'clock direction of the impact force. The driver's chest contacted and compressed the steering column, fracturing the tilt mechanism. The unrestrained left rear seated occupant also initiated a forward trajectory and loaded the front seat back. The loaded seat back would have increased the driver's effective mass and his inertial

loading of the steering column.

The driver's upper torso, neck and head then began to pitch forward in the direction of the left A-pillar. Coincident to this the left side of the instrument panel and A-pillar were deforming rearward. The fatal chest injuries occurred due a combination of the intrusion and the unrestrained forward kinematics. The driver's forward kinematic pattern displaced the knees into the bolster. The driver's left shoulder and arm were displaced to the left. The arm went through the open portal and contacted the front of the GMC. The intruding floor pan and foot controls fractured the driver's right ankle.