

**TRANSPORTATION SCIENCES  
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**GENERAL DYNAMICS ON-SITE ALLEGED SEAT FAILURE INVESTIGATION  
SCI TECHNICAL SUMMARY REPORT**

**CASE NO. CA03-054**

**VEHICLE – 2003 JEEP GRAND CHEROKEE**

**LOCATION - STATE OF GEORGIA**

**CRASH DATE – JULY 2003**

Contract No. DTNH22-01-C-17002

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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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<i>16. Abstract</i> <p>This on-site investigative effort focused on the crash severity, the performance of the rear seat cushions, manual restraint systems, and the resulting injury mechanisms for the occupants of a 2003 Jeep Grand Cherokee. The 2003 Jeep Grand Cherokee was involved in a severe head-on crash with a 1999 Pontiac Grand Am that crossed the centerline of a two-lane roadway. The Grand Cherokee was occupied by a 42-year-old male driver, a 14-year-old female front right passenger, and three 14-year-old female rear seat passengers. All of the outboard occupants were restrained by the manual 3-point lap and shoulder belts. The rear center female passenger was restrained by the 2-point lap belt. At impact, the frontal air bag system in the Grand Cherokee deployed and the front-seated occupants initiated forward trajectories. The driver sustained right and left forearm contusions, a fractured hip, a right knee contusion, and safety belt-related abrasions and contusions. The front right passenger sustained safety belt-related abrasions and contusions, a left elbow contusion, bilateral knee contusions, and a right hand contusion. The rear-seated female passengers initiated forward trajectories and loaded the safety belts and the front seat backs. The rear split bench seat cushions disengaged from the receiver brackets as a result of the impact. The seat cushions rotated forward and the hinged brackets on the forward aspect of the seat cushion deformed as a result of the impact. The rear left female passenger sustained a self-inflicted tongue laceration, facial contusions, right leg contusion, left knee abrasion, a left elbow abrasion, and safety belt-related contusions. The rear right female passenger sustained safety belt-related abrasions and contusions, and a cervical neck strain. The center rear female passenger jackknifed over the lap belt, which resulted in perforated jejunal perforations and serosal tear, a right colon serosal tear and an L-3 fracture. She subsequently struck her face on the rear aspect of the center console and sustained a left facial laceration, a left eyelid laceration, and a left complex orbital fracture. She also sustained a left knee abrasion and laceration.</p>				
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## TABLE OF CONTENTS

<b>BACKGROUND .....</b>	<b>1</b>
<b>VEHICLE DATA – 2003 JEEP GRAND CHEROKEE .....</b>	<b>2</b>
<b>VEHICLE DATA – 1999 PONTIAC GRAND AM.....</b>	<b>3</b>
<b>CRASH SITE .....</b>	<b>3</b>
<b>CRASH SEQUENCE .....</b>	<b>3</b>
PRE-CRASH .....	3
CRASH .....	4
POST-CRASH.....	5
<b>VEHICLE DAMAGE.....</b>	<b>5</b>
EXTERIOR DAMAGE – 2003 JEEP GRAND CHEROKEE.....	5
INTERIOR DAMAGE – 2003 JEEP GRAND CHEROKEE .....	6
EXTERIOR DAMAGE – 1999 PONTIAC GRAND AM.....	7
<b>MANUAL RESTRAINT SYSTEMS – 2003 JEEP GRAND CHEROKEE .....</b>	<b>7</b>
<b>FRONTAL AIR BAG SYSTEM – 2003 JEEP GRAND CHEROKEE .....</b>	<b>9</b>
<b>REAR SEAT – 2003 JEEP GRAND CHEROKEE .....</b>	<b>10</b>
<b>OCCUPANT DEMOGRAPHICS – 2003 JEEP GRAND CHEROKEE.....</b>	<b>13</b>
DRIVER.....	13
DRIVER INJURIES .....	14
DRIVER KINEMATICS .....	14
FRONT RIGHT PASSENGER .....	15
FRONT RIGHT PASSENGER INJURIES .....	15
FRONT RIGHT PASSENGER KINEMATICS .....	15
REAR LEFT PASSENGER .....	16
REAR LEFT PASSENGER INJURIES .....	16
REAR LEFT PASSENGER KINEMATICS .....	16
REAR CENTER PASSENGER .....	17
REAR CENTER PASSENGER INJURIES .....	17
REAR CENTER PASSENGER KINEMATICS .....	18
REAR RIGHT PASSENGER.....	19
REAR RIGHT PASSENGER INJURIES .....	19
REAR RIGHT PASSENGER KINEMATICS .....	19
<b>FIGURE 23. SCENE SCHEMATIC .....</b>	<b>20</b>

**GENERAL DYNAMICS ON-SITE ALLEGED SEAT FAILURE INVESTIGATION**

**SCI SUMMARY TECHNICAL REPORT**

**CASE NO. – CA03-054**

**SUBJECT VEHICLE – 2003 JEEP GRAND CHEROKEE**

**LOCATION - STATE OF GEORGIA**

**CRASH DATE – JULY 2003**

**BACKGROUND**

This on-site investigative effort focused on the crash severity, the performance of the rear seat cushions, manual restraint systems, and the resulting injury mechanisms for the occupants of a 2003 Jeep Grand Cherokee. The 2003 Jeep Grand Cherokee (**Figure 1**) was involved in a severe head-on crash with a 1999 Pontiac Grand Am that crossed the centerline of a two-lane roadway. The Grand Cherokee was occupied by a 42-year-old male driver, a 14-year-old female front right passenger, and three 14-year-old female rear seat passengers. All of the outboard occupants were restrained by the manual 3-point lap and shoulder belts. The rear center female passenger was restrained by the 2-point lap belt. At impact, the frontal air bag system in the Grand Cherokee deployed and the front-seated occupants initiated forward trajectories. The driver sustained right and left forearm contusions, a fractured hip, a right knee contusion, and safety belt-related abrasions and contusions. The front right passenger sustained safety belt-related abrasions and contusions, a left elbow contusion, bilateral knee contusions, and a right hand contusion. The rear-seated female passengers initiated forward trajectories and loaded the safety belts and the front seat backs. The rear split bench seat cushions disengaged from the receiver brackets as a result of the impact. The seat cushions rotated forward and the hinged brackets on the forward aspect of the seat cushion deformed as a result of the impact. The rear left female passenger sustained a self-inflicted tongue laceration, facial contusions, a right leg contusion, a left knee abrasion, a left elbow abrasion, and safety belt-related contusions. The rear right female passenger sustained safety belt-related abrasions and contusions, and a cervical neck strain. The center rear female passenger jackknifed over the lap belt, which resulted in jejunal perforations and serosal tear, a right colon serosal tear and an L-3 fracture. She subsequently struck her face on the rear aspect of the center console and sustained a left facial laceration, a left eyelid laceration, and a left complex orbital fracture. She also sustained a left knee abrasion and laceration.



**Figure 1. Damaged 2003 Jeep Grand Cherokee**

The investigating police agency reported this crash to the Crash Investigation Division (CID) of NHTSA through the NHTSA website, due to the potential failure of the rear seat cushion. The case was assigned by NHTSA as an on-site investigation on September 17, 2003. The SCI team located the Jeep Cherokee and the Pontiac Grand Am at salvage facilities for this July crash. At the time of the on-site investigation, the investigating officer had completely removed the rear seats, mounting hardware, and the rear center safety belt from the Cherokee.

## VEHICLE DATA – 2003 JEEP GRAND CHEROKEE

The 2003 Jeep Grand Cherokee was identified by the Vehicle Identification Number (VIN): 1J4GX48NX3C (production sequence omitted). The Grand Cherokee's owner estimated the vehicle's odometer reading to be 16,000 km (10,000 miles). The vehicle was a 4 x 2, four-door sport-utility-vehicle (SUV) that was equipped with a 4.7 liter, V-8 engine, a 5-speed, automatic transmission, four-wheel disc brakes with ABS, power steering, a tilt steering wheel, and power door locks, power windows, and power mirrors. The Grand Cherokee was configured with 41 x 18 cm (16 x 7") alloy wheels and Goodyear Wrangler ST P225/75R16 tires. The manufacturer's recommended tire pressure for each tire was 227 kpa (33 psi). The specific tire data was as follows:

Tire	Measured Pressure	Maximum Pressure	Tread Depth	Restricted	Damage
LF	0.0 kpa	303.4 kpa (44.0 psi)	6 mm (8/32")	Yes	Debeaded
LR	217.2 kpa (31.5 psi)	303.4 kpa (44.0 psi)	6 mm (8/32")	Yes	None
RF	217.2 kpa (31.5 psi)	303.4 kpa (44.0 psi)	6 mm (8/32")	No	None
RR	213.7 kpa (31.0 psi)	303.4 kpa (44.0 psi)	6 mm (8/32")	No	None

The front seating positions in the Grand Cherokee were configured with leather-trimmed bucket seats with adjustable head restraints. The driver's seat was configured with a 6-way power adjustment and the seat track was adjusted to 15.2 cm (6.0") rear of the full-forward position and 6.4 cm (2.5") forward of the full-rear position. The front right passenger stated that the front right seat was positioned between the mid-track and full-rear positions. The seat was moved post-crash by police, while the extrication of the rear seat occupants took place.

The rear seating positions were configured with a 40/60 split bench seat with folding backs. The left and right rear seat head restraints were adjusted 5.1 cm (2.0") and 3.8 cm (1.5") above the seat back, respectively. The seat cushion was constructed of a 3.0 mm (1/8") thick plastic bottom and the thickness of the leather seat cushions measured 20.3 cm (8.0") on the forward aspects and 6.4 cm (2.5") on the rear aspects. The seat cushions folded forward to accommodate the folding seat backs, as shown by the exemplar rear left seat in **Figure 2**. The cushions were anchored to the floor by two hinged brackets located under each outboard position. The metal brackets measured 3.0 mm (1/8") in thickness and were hinged at the bottom aspect adjacent to the floor. Metal locking tabs on the rear seat cushions were located on the rear outboard aspects of the seat bottom. The tabs measured 2.5 cm (1.0") in width and measured 3.0 mm (1/8") in thickness. The tabs were located 7.0 cm (2.8") inboard of the outboard aspects of the respective seat bottoms. A leather release handle was affixed to a spring-tensioned metal bar that was connected to each metal tab. Pulling rearward (relative to the seat) on the handle of the



**Figure 2. Exemplar rear left seat rotated forward**

spring-tensioned bar rotated the tab slightly forward (relative to the seat) and upward to release the seat cushion from the bracket, which allowed the seat cushions to rotate forward 90 degrees.

### **VEHICLE DATA – 1999 PONTIAC GRAND AM**

The 1999 Pontiac Grand Am was identified by the VIN: 1G2NE52TXXM (production sequence omitted). The vehicle was a four-door sedan equipped with a 2.4 liter, four-cylinder engine, an automatic four-speed transmission, front disc/rear drum power brakes with ABS, power steering, and a tilt steering wheel. The seating in the Grand Am was configured with front bucket seats and a rear bench seat. The Grand Am was configured with Sumitomo 205/50ZR16 tires. The manufacturer's recommended tire size for the Grand Am was P225/50R16, and the recommended tire pressure was 210 kpa (30 psi). The specific tire data is as follows:

Tire	Measured Pressure	Maximum Pressure	Tread Depth	Restricted	Damage
LF	172.4 kpa (25.0 psi)	351.6 kpa (51.0 psi)	7 mm (9/32")	No	None
LR	220.6 kpa (32.0 psi)	351.6 kpa (51.0 psi)	7 mm (9/32")	No	None
RF	0.0 kpa	351.6 kpa (51.0 psi)	7 mm (9/32")	Yes	Sidewall tear
RR	241.3 kpa (35.0 psi)	351.6 kpa (51.0 psi)	7 mm (9/32")	No	None

### **CRASH SITE**

This two-vehicle crash occurred during the daylight hours of July 2003 on a two-lane arterial roadway in the state of Georgia. At the time of the crash, the weather was clear and the asphalt roadway surface was dry. The north/south roadway was configured with one travel lane in each direction separated by a double-yellow centerline. The roadway was bordered by grassy areas and trees. The crash site was located on the south aspect of a southbound left curve where the roadway returned to a straight trajectory. A slight hillcrest was located at the apex of the curve 55 m (180') north of the crash site. The roadside environment consisted of residential properties and a cemetery. There were no traffic controls present at the crash site and the posted speed limit for the north/south roadway was 64 km/h (40 mph). The scene schematic is included as **Figure 21** of this report.

### **CRASH SEQUENCE**

#### **Pre-Crash**

The 42-year-old male driver of the Jeep Grand Cherokee was operating the vehicle in a northbound direction (**Figure 3**) on the straight aspect of the two-lane roadway on approach to the right curve and hillcrest. The driver stated that his travel speed was approximately 64 km/h (40 mph) and that the occupants were conversing, however, there were no additional distractions within the vehicle. The 36-year-old female driver of the Grand Am was operating the vehicle in a southbound direction on the two-lane



**Figure 3. Northbound approach for the Grand Cherokee**

roadway. The vehicle entered the left curve on approach to the hillcrest (**Figure 4**). The driver failed to negotiate the left curve and the Grand Am departed the right roadside. The driver of the Grand Am steered left in an attempt to re-enter the roadway. The Grand Am initiated a slight counterclockwise (CCW) yaw and re-entered the roadway south of the apex of the curve. The Grand Am continued the CCW yaw across the southbound travel lane, across the centerline, and into the path of the Grand Cherokee. The driver of the Cherokee stated that he observed the Grand Am depart the roadway and thought that the Grand Am might come to a controlled stop or continue to rotate on the roadside. He further stated that he attempted to apply the brakes immediately prior to the impact. Police documented the yaw marks from the Grand Am post-crash. Although the yaw marks were not visible at the time of the SCI inspection, paint marks present on the roadway from the police documentation (**Figure 5**) were documented and plotted on the scene schematic. The pre-crash speed of the Grand Am was not known.

### Crash

The front aspect of the Jeep Grand Cherokee struck the front right corner aspect of the Grand Am in an angular configuration (**Figure 6**) as the Grand Am encroached into the northbound lane. The impact resulted in severe damage to both vehicles and was sufficient to deploy the frontal air bags and safety belt pretensioners in the Grand Cherokee and the frontal air bags in the Grand Am. The directions of force were in the 12 o'clock and the 1 o'clock sectors for the Grand Cherokee and the Grand Am, respectively. The damage algorithm of the WinSMASH program computed a total delta-V of 33.0 km/h (20.5 mph) for the Grand Cherokee and a total delta-V of 47.0 km/h (29.2 mph) for the Grand Am. The delta-V results for both vehicles appeared low based on the visual damage comparisons of NHTSA New Car Assessment Program (NCAP) test results. Visual comparisons between the damaged Grand Cherokee and damage patterns of similar NCAP test vehicles, suggested that the total delta-V for the Grand Cherokee may have been closer to 56 km/h (35 mph). The Grand Cherokee rotated 100 degrees in a CW direction and came to rest facing east on the east roadside. The Grand Am rotated 90 degrees in a CCW direction and came to rest facing northeast on the northbound lane.



**Figure 4. Southbound approach for the Grand Am**



**Figure 5. View of police paint marks and the Grand Am's trajectory across the travel lanes**



**Figure 6. Post-crash police photograph depicting impact configuration**

## Post-Crash

The driver and front right passenger of the Grand Cherokee exited the vehicle under their own power. The driver opened the left rear door of the Grand Cherokee to assist the rear seated occupants, and the rear left passenger exited the vehicle under her own power. The right rear door would not open, however, the Grand Cherokee had electrical power, and the rear right passenger was able to lower the right rear door window during the extrication process. Rescue personnel removed the rear center female passenger from the vehicle on a backboard. As the center rear passenger was being extricated, police assisted the rear right female passenger out of the vehicle through the right front door, after police repositioned the front right seat track to a forward position. All of the occupants were transported by ambulance to a local hospital for treatment. All occupants except the rear center female passenger were released approximately four hours after the crash, following treatment. The driver of the Grand Am expired as a result of her injuries.

## VEHICLE DAMAGE

### Exterior Damage – 2003 Jeep Grand Cherokee

The 2003 Jeep Grand Cherokee sustained severe frontal damage (**Figure 7**) as a result of the impact with the Pontiac Grand Am. The maximum crush was located 24.1 cm (9.5") left of the centerline and measured 37.5 cm (14.8"). The direct damage began 76.2 cm (30.0") left of the centerline and extended laterally 124.5 cm (49.0") across the frontal plane. The leading edge of the hood was buckled downward and rearward, and direct contact abrasions were present on the right aspect. The grille, headlights, bumper fascia, and bumper beam were separated. The upper and lower radiator supports were crushed rearward, and direct contact scuffs and deformations were present on the radiator core. As shown in **Figure 8**, the left front tire was debeaded and the left front alloy rim was abraded. The front axle was crushed rearward. The rearward displacement of the front axle resulted in the reduction of the left side wheelbase by 8.0 cm (3.1") and the reduction of the right wheelbase by 14.0 cm (5.5"). The left front tie rod was fractured inboard of the left front wheel. The left front fender was crushed rearward and partially separated. The combined direct and induced damage involved the entire frontal width of the vehicle and measured 124.5 cm (49.0"). The frontal structure was shifted to the right 10.2 cm (4.0") on the left aspect and 6.4 cm (2.5") on the right aspect. The roof side rails were buckled at the B-pillars and the left and right side doors were displaced rearward. Six crush measurements were documented at the lower radiator support and were as follows: C1 = 21.6 cm (8.5"), C2 = 22.9 cm (9.0"), C3 = 30.5 cm (12.0"), C4 = 26.7 cm (10.5"), C5 = 17.8 cm (7.0"),



**Figure 7.** Frontal view of the damaged Grand Cherokee



**Figure 8.** Left side view of the damaged Grand Cherokee

$C_6 = 20.3$  cm (8.0"). The Collision Deformation Classification (CDC) for the frontal impact with the Grand Am was 12-FDEW-2.

### Interior Damage – 2003 Jeep Grand Cherokee

The Jeep Grand Cherokee sustained moderate interior damage as a result of passenger compartment intrusion and occupant contact. The windshield was fractured from crash forces. The right rear door was jammed shut. The top half of the steering wheel was deflected forward 8.9 cm (3.5") from driver bracing, as shown in **Figure 9**. The steering column was compressed forward as a result of driver loading, evidenced by shear capsule displacement. The left shear capsule was displaced 1.3 cm (0.5"), and the right shear capsule was displaced 0.6 cm (0.3"). The knee bolster was displaced and scuffed from contact with the driver's knees and a dark fabric transfer was located on the center of the bolster to the left of the steering column. The left side of the center console was scuffed on the lower aspect. The rear view mirror was deflected in a CW direction. The glove box door was completely separated and exhibited a light blue fabric transfer on the upper left aspect and a scuff on the upper right aspect. **Figure 10** illustrates the rear seating positions and related occupant contacts.

The left rear interior door panel was scuffed below the armrest, and minor scuffs were present on the forward aspect adjacent to the window opening. A scuff was also present on the lower rear aspect of the B-pillar trim, possibly from the rear left passenger's shoe.

The rear aspect of the left and right front seat backs sustained damage as a result of contact from the rear-seated occupants. Minor deformation was noted on the lower rear aspect of the left front seat cushion from contact with the rear left passenger's lower legs. The deformation began 8.9 cm (3.5") right of the seat's centerline and extended 31.8 cm (12.5") to the left corner. Body fluid (blood) was present on the right aspect of the seat back from the rear center passenger. A small 1.3 x 1.3 cm (0.5 x 0.5") scuff was located 8.3 cm (3.3") above the rear seat back pocket and 2.5 cm (1.5") left of center from contact with the rear left occupant. The bottom rear aspect of the front right seat cushion also sustained minor deformation as a result of loading from the rear right occupant's lower legs. The front right seat was moved by police after the crash, and the seat back exhibited 1.9 cm (0.8") of slack in the recline adjustment at the time of the inspection. The center console/armrest sustained direct contact with the rear center passenger's face due to her jackknifing over the lap belt. Scuffs and body fluid (blood) were present on the entire width of the rear aspect of the top cover. The cover, which was hinged at the rear aspect, was displaced



**Figure 9. Interior view showing driver contacts and steering wheel rim deflection**



**Figure 10. View of rear seating positions and related occupant contacts**

slightly to the left. The rear plastic panel on the center console was also displaced from occupant contact.

Multiple passenger compartment intrusions were documented as follows:

<b>Position</b>	<b>Intruded Component</b>	<b>Magnitude of Intrusion</b>	<b>Direction</b>
Front left	Toe pan	8.3 cm (3.3")	Longitudinal
Front left	Left instrument panel	4.4 cm (1.8")	Longitudinal
Front left	Center console	3.2 cm (1.3")	Lateral
Front center	Center instrument panel	7.0 cm (2.8")	Longitudinal
Front right	Toe pan	5.1 cm (2.0")	Longitudinal

### **Exterior Damage – 1999 Pontiac Grand Am**

The 1999 Pontiac Grand Am sustained severe frontal damage (**Figure 11**) as a result of the impact with the Grand Cherokee. The direct damage on the Grand Am began 10.2 cm (4.0") left of the centerline and extended laterally 68.6 cm (27.0") to the right across the frontal structure. Direct contact abrasions were present on the leading edge of the hood, and the hood was crushed and buckled rearward. The entire bumper fascia was separated and the bumper beam was crushed rearward, most severely on the right side. The right front fender was crushed rearward, and the angled impact resulted in direct contact abrasions and deformation on the right front fender, right front wheel, and right aspect of the hood. The combined direct and induced damage involved the entire frontal width of the vehicle and measured 69.9 cm (27.5"). The angled impact resulted in the lateral end shift of the frontal structure to the left. At the time of the inspection, the centerline of the bumper beam was located 36.8 cm (14.5") left of the centerline of the windshield header. The severe crush displaced the front right wheel rearward and resulted in the reduction of the right wheelbase by 76.0 cm (29.9"). The left wheelbase was reduced by 3.0 cm (1.2"). The right sill was buckled downward and both right side doors were displaced rearward. Six crush measurements were documented along the front bumper beam of the Grand Am and were as follows: C1 = 1.3 cm (0.5"), C2 = 17.8 cm (7.0"), C3 = 27.9 cm (11.0"), C4 = 53.3 cm (21.0"), C5 = 74.9 cm (29.5"), C6 = 97.8 cm (38.5"). The CDC for the impact with the Grand Cherokee was 01-FZEW-4. The incremented CDC adjusted for the lateral end shift to the left was 81-FZEW-4.



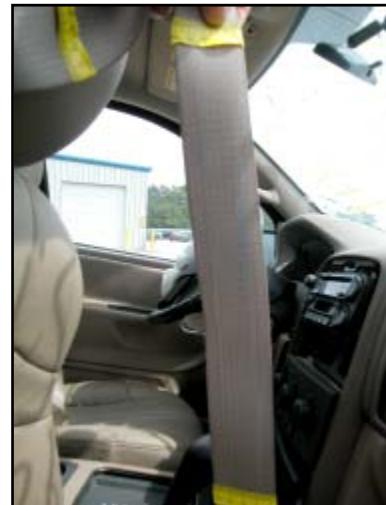
**Figure 11. Damaged 1999 Pontiac Grand Am**

### **MANUAL RESTRAINT SYSTEMS – 2003 JEEP GRAND CHEROKEE**

The Grand Cherokee was equipped with manual 3-point lap and shoulder belts for all four outboard positions and a 2-point lap belt with a locking latch plate for the rear center position. The driver's safety belt was configured with a sliding latch plate and an Emergency Locking

Retractor (ELR). The adjustable plastic-coated D-ring was located in the full-down position and exhibited heavy abrasions from loading. A 7.6 cm (3.0") section of the safety belt webbing that began 116.2 cm (45.8") above the anchor displayed a matching heavy plastic transfer from the D-ring. The plastic-coated latch plate also exhibited heavy abrasions and the safety belt webbing was stretched from occupant loading.

The front right safety belt was configured with a sliding latch plate and switchable ELR/automatic locking retractor (ALR). The adjustable plastic-coated D-ring was positioned one detent up from full-down and exhibited heavy abrasions from occupant loading. The webbing displayed a matching heavy plastic transfer that measured 12.1 cm (4.8") in length and was located 154.9 cm (61.0") from the anchor. The plastic-coated latch plate also exhibited abrasions from loading. The shoulder and lap belt portions of the webbing were stretched from occupant loading and an area of blue fabric transfer was located 49.5 cm (19.5") above the anchor and extended 32.4 cm (12.5") in length up the webbing (**Figure 12**). The outboard aspect of the plastic seat cushion adjacent to the seat bight was abraded from engagement with the lap belt webbing. The top of the seat back was also abraded on the outboard aspect from contact with the shoulder belt webbing.



**Figure 12. View of blue fabric transfers on the front right safety belt webbing**

The rear outboard safety belts were configured with cinching latch plates, ELR's, and fixed D-rings. Both D-rings exhibited abrasions from occupant loading, and the webbing of each safety belt displayed stretching from occupant loading. A 2.5 cm (1.0") wide plastic transfer from the left rear latch plate was located 68.6 cm (27.0") above the anchor and extended upward 6.4 cm (2.5"). A faint blue fabric transfer was located 102.9 cm (40.5") above the anchor. The right rear safety belt webbing exhibited a 5.1 cm (2.0") long blue fabric transfer located 116.8 cm (46.0") above the anchor.

The rear center lap belt had been removed by the investigating agency prior to the SCI inspection, and was inspected separately. The fixed-length, adjustable, lap belt (**Figure 13**) measured 129.5 cm (51.0") in total length. Creases in the webbing from latch plate loading began 74.9 cm (29.5") from the anchor and extended 2.5 cm (1.0") along the full width of the webbing. Significant stretching on the webbing began 31.1 cm (12.5") from the anchor and extended 29.2 cm (11.5") along the webbing, most notably on the bottom aspect (facing toward the occupant). The top aspect of the webbing (facing away from the occupant) exhibited a scuff mark from the engagement against the bottom aspect of the rear seat back. The scuff mark began 12.1



**Figure 13. View of rear center lap belt (removed)**

cm (4.8") from the anchor and extended 7.0 cm (2.8") along the webbing. Body fluid (blood) was also present on various aspects of the safety belt webbing.

#### **FRONTAL AIR BAG SYSTEM – 2003 JEEP GRAND CHEROKEE**

The 2003 Jeep Grand Cherokee was equipped with dual-stage frontal air bags for the driver and front right passenger positions. The driver's air bag (**Figure 14**) deployed from the center of the steering wheel from an asymmetrical H-configuration cover flap design. Both flaps measured 17.1 cm (6.8") in width. The top flap measured 8.9 cm (3.5") in height and the bottom flap measured 5.1 cm (2.0") in height. The driver's air bag measured 61.0 cm (24.0") in diameter and was vented back through the air bag module. The air bag was tethered by two internal straps at the 3 and 6 o'clock positions. There was no occupant contact evidence on the air bag.



**Figure 14. Deployed driver's air bag**

The front right passenger's air bag deployed from a mid-mount module with a rectangular cover flap hinged at the forward aspect. The cover flap measured 40.0 cm (15.8") in width and 14.0 cm (5.5") in height. The top aspect of the cover flap was contoured to the curvature of the top aspect of the instrument panel. The front right passenger's air bag (**Figure 15**) measured 35.6 cm (14.0") in width and 61.0 cm (24.0") in height. The air bag was vented back through the module and was not tethered. There was no contact evidence present on the air bag.

The 2003 Jeep Grand Cherokee was equipped with retractor-mounted safety belt pretensioners for the driver and front right positions that actuated as a result of the crash.



**Figure 15. Deployed front right passenger's air bag**

### **REAR SEAT – 2003 JEEP GRAND CHEROKEE**

The rear seat cushions, seat hardware, and rear center lap belt had been removed from the vehicle by the investigating officer prior to this SCI investigation. The rear seat cushion (**Figures 16 and 17**) was inspected at a separate location, and later transported to the vehicle inspection for photographs. The seat cushion consisted of two sections. The left outboard position measured 55.9 cm (22.0") in width (lateral) and 52.1 cm (20.5") in length (longitudinal). The rear center and rear right positions were combined into a single section that measured 78.7 cm (31.5") in width and 52.1 cm (20.5") in length. The center seating position measured 43.2 cm (17.0") in length. The thickness of the front of the cushion measured 20.3 cm (8.0") on the outboard positions and measured 16.5 cm (6.5") at the center position. Each position measured 6.4 cm (2.5") in thickness at the rear aspect. Two receiving holes in the plastic were present under the center aspect of each outboard seat position for stowage of the removable head restraints. The driver stated that the seats were rarely rotated forward for stowage and there had been no previous issues with the seat system. Upon inspection, there were no scuffs or deformation on the top of the receiver brackets to suggest misalignment of the seat bottoms.



**Figure 16.** View of top aspect of the damaged rear seat and receiver brackets



**Figure 17.** View of bottom aspect of the damaged rear seat and receiver brackets

**Figure 18** illustrates the components of the rear seat from an exemplar Grand Cherokee. The 40/60 split bench seat was fixed to the vehicle floor by four angled, hinged brackets. Each seat section was configured with two brackets, located at the forward aspect of the seat bottom, spaced 19.1 cm (7.5") apart, under the center aspects of the outboard seating positions. The seat was designed to rotate forward about the hinges for stowage. A metal tab that measured 2.5 cm (1.0") in width was located on the bottom rear outboard aspect of each seat section. The tab was linked to a release handle via a metal rod and spring release mechanism. The tab was angled toward the front of the vehicle, and engaged the top lip of a raised rectangular opening that measured 4.4 cm (1.8") wide on the forward aspect of a metal receiver bracket. The receiver bracket was secured by two bolts to the outboard floor of the vehicle under the rear outboard aspects of the seat, and the top aspect of the bracket supported the outboard aspects of the seat. A leather loop handle was present on the end of the release lever at the rear outboard aspects of the seat, and pulling on the lever would move the tab rearward and upward to disengage it from the metal receiver bracket.



**Figure 18.** Exemplar view of rear seat components

The rear seat cushions sustained moderate damage as a result of the crash. The bottom aspect (mounted to the vehicle) of each hinged bracket was deformed laterally to the right. The maximum lateral deformation measured 1.3 cm (0.5") on the left inboard and right outboard brackets. The plastic seat bottom fractured around the hinged mounting brackets under the right seating position. The fractures were noted around the forward and side aspects of each bracket and the brackets were partially torn away from the seat bottom. Lateral fractures in the plastic seat bottom were present around the metal tabs and underlying release mechanisms, as result of the loading of the tabs pulling against the receiver brackets. The left and right linear fractures measured 14.0 cm (5.5") in length extended to the outboard aspects of the plastic seat bottom. The release mechanism was displaced and protruding slightly through the fracture on the right side (**Figure 19**). Although each metal tab exhibited scuffing consistent with loading and engagement with the metal receiver bracket, there was only minor deformation and deflection of the tabs. An additional large fracture was located on the inboard aspect of the left seat bottom that began at the outboard aspect near the inboard hinge bracket. The fracture radiated toward the outboard side of the seat bottom and measured 31.2 cm (12.5") longitudinally to the rear edge. Scuff marks were present on the right seat bottom in the area of the head restraint receiver holes. Close-up photographs of the damaged left and right seat bottoms are included as **Figures 20 and 21** on the following page.



**Figure 19.** Close-up of right side locking tab and related fracture



**Figure 20. Close-up of damaged left seat bottom and receiver bracket**



**Figure 21. Close-up of damaged right/center seat bottom and receiver bracket**

The metal receiver brackets for the locking tabs were deformed as a result of the rear seat loading. The left side bracket was moderately deformed as a result of the seat loading. The overall contour of the bracket was deformed and the upper inboard aspect of the receiver cutout was strained in an upward direction (**Figure 22**). Scuff marks and abrasions were also present on the upper inboard corner of the receiver cutout from engagement and loading of the metal seat tab. Small notches and scuffing were present on the upper inboard aspect of the receiver cutout on the right bracket from the forward loading of the seat tab. Minor scuffs were present on the top aspect of the bracket above the receiver cutout from post-impact engagement of the tab.



**Figure 22. Close up of deformed left receiver bracket**

At impact, the occupants' forward trajectories combined with the Grand Cherokee's high delta-V resulted in the forward loading of the seat cushion. The significant crash forces caused the seat to pull forward and the metal locking tabs to engage against the upper lips of the receiver brackets. Based on the damage pattern on the rear seat, it appears that the tabs remained secured in the receiver brackets early in the crash, which increased the stress on the plastic seat bottom. The plastic seat bottom fractured in multiple locations as a result of the loading, and the linear lateral fractures of the plastic around the locking tabs probably allowed for the rear aspect of the seat to move slightly upward around the tabs. The slight lateral displacement of the seat, evidenced by the lateral deflection of the hinged brackets also contributed to the instability of the seat bottom. The continued stress on the locking tabs coupled with the seat's instability that resulted from the plastic fractures, resulted in the tabs pulling away from the receiver brackets. It should be noted that the rear seat safety belts were anchored to the vehicle floor, and were independent of the rear seat cushion. Although the rear aspect of the seat dislodged from the receiver brackets, the performance of the vehicle's manual restraints was not compromised due to the independent anchors. Given the independent nature of the safety belt anchors, the manual restraints most likely held the occupants in position. The weight of the occupants, in addition to the use of the manual restraints, prevented the full forward rotation of the seat until the occupants released and removed the safety belts.

## **OCCUPANT DEMOGRAPHICS – 2003 JEEP GRAND CHEROKEE**

### **Driver**

Age/Sex:	42-year-old male driver
Height:	180 cm (71")
Weight:	93 kg (205 lb)
Seat Track Position:	15.2 cm (6.0") rear of the full-forward position
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection, interview
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local hospital for treatment and released approximately four hours following the crash

## Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Fractured right hip*	Moderate (852600.2,1)	Indirect, knee bolster (compression of right leg)
Left chest abrasion	Minor (490202.1,2)	Shoulder belt webbing
Chest wall contusion	Minor (490402.1,2)	Shoulder belt webbing
Abdominal contusion*	Minor (590402.1,0)	Lap belt webbing
Left shoulder strain	Minor (751020.1,2)	Shoulder belt webbing
Right forearm contusion*	Minor (790402.1,1)	Driver's air bag
Left forearm contusion*	Minor (790402.1,2)	Driver's air bag
Left shoulder contusion*	Minor (790402.1,2)	Shoulder belt webbing
Right hip abrasion	Minor (890202.1,1)	Lap belt webbing
Right knee abrasion	Minor (890202.1,1)	Knee bolster
Right knee contusion	Minor (890402.1,1)	Knee bolster

Injury source: Hospital records, \*Interview (fractured right hip discovered during a follow-up visit with the driver's chiropractor)

## Driver Kinematics

The 42-year-old male driver was seated in an upright posture and restrained by the manual 3-point lap and shoulder belt. His hands were positioned at the 10 and 2 o'clock positions on the steering wheel rim. At impact, the frontal air bag system deployed, the retractor pretensioner deployed, and the driver initiated a forward trajectory. The bracing of his hands against the steering wheel caused the forward deflection of the steering wheel rim. He sustained right and left forearm contusions as a result of the air bag expansion against his forearms. He loaded the manual restraint, evidenced by stretching of the safety belt webbing and significant D-ring abrasions. The loading of the safety belt resulted in a left shoulder contusion, a left shoulder strain, a chest wall contusion, a left chest abrasion, an abdominal contusion, and a right hip abrasion. He loaded the deployed air bag, which mitigated additional contact with the steering wheel. His pre-crash bracing and loading against the air bag resulted in the compression of the steering column, evidenced by the shear capsule displacement. His right knee struck the knee bolster, which resulted in a right knee abrasion and contusion, and he sustained a right hip fracture, which resulted from the energy transmitted through the femur from the knee loading. He rebounded rearward and remained in place as the vehicle came to rest. The driver came to rest in the driver's seat, removed the safety belt, and exited the vehicle under his own power through the driver's door. He assisted other occupants out of the vehicle and was transported by ambulance to a local hospital for treatment. He was released approximately four hours following the crash. The hospital did not detect the fractured right hip. The hip fracture was discovered during a follow-up visit with the driver's chiropractor one week following the crash.

### **Front Right Passenger**

Age/Sex: 14-year-old female  
 Height: 160 cm (63")  
 Weight: 52 kg (115 lb)  
 Seat Track Position: Between mid-track and full-rear  
 Manual Restraint Use: Manual 3-point lap and shoulder belt  
 Usage Source: Vehicle inspection, interview  
 Eyewear: Prescription contact lenses  
 Type of Medical Treatment: Transported by ambulance to a local hospital for treatment and released approximately four hours after the crash

### **Front Right Passenger Injuries**

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Chest contusion*	Minor (490402.1,2)	Shoulder belt webbing
Left hip (upper thigh) contusion*	Minor (890402.1,2)	Lap belt webbing
Cervical strain	Minor (640278.1,6)	Non-contact injury: Head motion over the shoulder belt
Right shoulder strain	Minor (740402.1,1)	Shoulder belt webbing
Right shoulder abrasion	Minor (790202.1,1)	Shoulder belt webbing
Right elbow contusion*	Minor (790402.1,1)	Interior door panel
Right hand contusion	Minor (790402.1,1)	Windshield header
Right knee abrasion	Minor (890202.1,1)	Glove box door
Left hip abrasion	Minor (890202.1,2)	Lap belt webbing
Right knee contusion	Minor (890402.1,1)	Glove box door
Left knee contusion*	Minor (890402.1,2)	Glove box door

Injury source: Hospital records, \*Interview

### **Front Right Passenger Kinematics**

The 14-year-old female front right passenger was seated in an upright posture and restrained by the manual 3-point lap and shoulder belt system. Her clothing included blue cotton shorts and a sleeveless white shirt with a blue collar and blue embroidery. Prior to the crash, she had been turned CCW in the seat to converse with the rear-seated occupants. She had resumed a forward-facing upright posture prior to the impact and stated that her left hand was positioned on the center console and her right hand was bracing on the instrument panel as she detected the impending crash. At impact, the frontal air bag system deployed, the front right retractor pretensioner deployed, and the front right passenger initiated a forward trajectory. The expansion of the front right passenger's air bag deflected her right hand upward and into the windshield header, which resulted in a right hand contusion. She loaded the manual restraint, evidenced by blue fabric transfers, significant D-ring abrasions, and sustained a chest contusion, a right

shoulder strain, a right shoulder abrasion, a left hip abrasion, and a left hip contusion. She sustained a cervical sprain as a result of forward head motion over the shoulder belt. Her knees struck the glove box door, which completely detached during the crash sequence. She sustained a right knee abrasion and bilateral knee contusions as a result of the glove box door contact. She rebounded rearward and remained in position as the Grand Cherokee rotated to final rest. She removed the safety belt and exited the vehicle under her own power. She was transported by ambulance to a local hospital for treatment and was released approximately four hours following the crash.

### Rear Left Passenger

Age/Sex:	14-year-old female
Height:	160 cm (63")
Weight:	54 kg (120 lb)
Seat Track Position:	Fixed
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection, interview
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local hospital for treatment and released approximately four hours after the crash

### Rear Left Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Self-inflicted tongue laceration, NFS	Minor (243400.1,8)	Indirect – driver's seat back
Right facial contusion	Minor (290402.1,1)	Driver's seat back
Abdominal contusion	Minor (590402.1,0)	Lap belt webbing
Left elbow abrasion	Minor (790202.1,2)	Interior door panel
Left shoulder contusion	Minor (790402.1,2)	Shoulder belt webbing
Left knee abrasion	Minor (890202.1,2)	Rear aspect of driver's seat
Right lower leg contusion	Minor (890402.1,1)	Rear aspect of driver's seat

Injury source: Interview

### Rear Left Passenger Kinematics

The 14-year-old female rear left passenger was seated in an upright posture and restrained by the manual 3-point lap and shoulder belt. She was dressed in the same clothing as the front right passenger. At impact, she initiated a forward trajectory and loaded the manual restraint, evidenced by blue fabric transfers on the shoulder belt webbing and significant D-ring abrasions. She sustained an abdominal contusion and a left shoulder contusion as a result of the safety belt loading. Although her upper torso was restrained, her head flexed forward which allowed her face to contact the rear aspect of the driver's seat back which resulted in a right facial contusion and a self-inflicted tongue laceration. Her left elbow contacted the interior surface of the left rear door, which resulted in a left elbow abrasion. As the rear seat disengaged from the receiver brackets, the use of the safety belt mitigated additional forward movement of the occupant and

prevented the seat from rotating fully upward. Her legs struck the lower rear portion of the driver's seat, which resulted in a left knee abrasion and a right lower leg contusion. She rebounded rearward and remained in place as the Grand Cherokee rotated to final rest. Her head probably contacted the head restraint, which mitigated additional neck injuries. She came to rest upright on the seat cushion and stated that she felt that she was sitting in a slightly more forward posture than usual, but that it was not very noticeable. She also stated that her legs were not pinned or trapped. She exited the vehicle under her own power through the left rear door. She was transported by ambulance to a local hospital for treatment. She was released approximately four hours following the crash.

#### **Rear Center Passenger**

Age/Sex: 14-year-old female  
 Height: 152 cm (60")  
 Weight: 43 kg (95 lb)  
 Seat Track Position: Fixed  
 Manual Restraint Use: Manual 2-point lap belt  
 Usage Source: Vehicle inspection, interview  
 Eyewear: None  
 Type of Medical Treatment: Transported by ambulance to a local hospital, transferred to a regional children's hospital and admitted for 16 days

#### **Rear Center Passenger Injuries**

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Multiple fractures involving the lateral, medial, and inferior walls of the left bony orbit, as well as the inferior orbital rim (complex left orbital fracture, left LeFort fracture, and left zygomatic fracture)	Serious (251204.3,2)	Center console
Jejunal perforations and jejunal serosal tear	Serious (541424.3,8)	Loading against/jackknifing over lap belt
Chance fracture through the superior endplate of L3 involving a fracture of the pedicles but intact posterior spinous process (with overlying soft tissue contusion)	Serious (650626.3,8)	Loading against/jackknifing over lap belt
Vertebral body compression fracture of L3 with extension into the posterior elements bilaterally	Moderate (650632.2,8)	Loading against/jackknifing over lap belt
Fracture of right transverse process of L2	Moderate (650620.2,8)	Loading against/jackknifing over lap belt

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Bilateral transverse process fractures of L3	Moderate (650620.2,8)	Loading against/jackknifing over lap belt
Right colon serosal tear	Moderate (540822.2,8)	Loading against/jackknifing over lap belt
Left facial laceration	Minor (290600.1,2)	Center console
Left eyelid laceration	Minor (297602.1,2)	Center console
Abdominal contusion*	Minor (590402.1,0)	Lap belt webbing
Excoriated areas on the right and left pelvic region at the area of the lap belt	Minor (890202.1,1) Minor (890202.1,2)	Lap belt webbing
Left knee abrasion	Minor (890202.1,2)	Rear aspect of center console
4 cm (1.6") left knee laceration	Minor (890602.1,2)	Rear aspect of center console

Injury source: Hospital records, \*Interview with other vehicle occupants

### Rear Center Passenger Kinematics

The 14-year-old female rear-center passenger was seated in an upright posture and restrained by the available fixed-length, adjustable, 2-point lap belt. She was also dressed in the same clothing as the other female occupants. Based on the position of the locking latch plate, it appeared that the lap belt was probably adjusted snugly at the time of the crash. At impact, she initiated a forward trajectory and loaded the manual restraint, evidenced by significant stretching to the webbing and a distinct crease from loading of the locking latch plate. Due to the lack of a shoulder belt, her upper body jackknifed over the lap belt, which resulted in a Chance fracture through the superior endplate of L3, a vertebral body compression fracture of L3 with extension into the posterior elements bilaterally, a fracture of right transverse process of L2, bilateral transverse process fractures of L3 jejunal perforations, a jejunal serosal tear, a right colon serosal tear, an abdominal contusion, and excoriated areas on the right and left pelvic region at the area of the lap belt. Her left knee struck the rear aspect of the center console, which resulted in a left knee abrasion, and a 4.0 cm (1.6") left knee laceration. Due to the jackknifing effect, her face struck the upper aspect of the rigid plastic center console. She sustained multiple fractures involving the lateral, medial, and inferior walls of the left bony orbit, as well as the inferior orbital rim, a left facial laceration, and a left eyelid laceration from contact with the center console. Although the rear seat disengaged from the receiver brackets, the fixed-length lap belt prevented additional forward movement of the rear center passenger's lower body and combined with the weight of the occupant, mitigated additional forward motion of the rear seat. There was no evidence to suggest that she was displaced out of the safety belt. She rebounded rearward and her upper body may have been redirected slightly as the vehicle rotated CW and came to final rest. She was removed from the vehicle by rescue personnel. She was transported by ambulance to a local hospital and transferred to a regional children's hospital for treatment. She was released 16 days following the crash.

### Rear Right Passenger

Age/Sex: 14-year-old female  
Height: 155 cm (61")  
Weight: 54 kg (120 lb)  
Seat Track Position: Fixed  
Manual Restraint Use: Manual 3-point lap and shoulder belt  
Usage Source: Vehicle inspection, interview  
Eyewear: None  
Type of Medical Treatment: Transported by ambulance to a local hospital for treatment and released approximately four hours after the crash

### Rear Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Abdominal abrasion	Minor (590202.1,0)	Lap belt webbing
Abdominal contusion	Minor (590402.1,0)	Lap belt webbing
Cervical neck strain	Minor (640278.1,6)	Non-contact injury: Head motion over the shoulder belt webbing
Right shoulder abrasion	Minor (790202.1,1)	Shoulder belt webbing
Right shoulder contusion	Minor (790402.1,1)	Shoulder belt webbing

Injury source: Hospital records

### Rear Right Passenger Kinematics

The 14-year-old female rear right passenger was seated in an upright posture and restrained by the manual 3-point lap and shoulder belt. She was dressed in the same clothing as the other female occupants. At impact, she initiated a forward trajectory and loaded the manual restraint, evidenced by blue fabric transfers on the shoulder belt webbing, stretch marks on the webbing, and significant D-ring abrasions. She sustained an abdominal contusion, abdominal abrasion, a right shoulder abrasion, and a right shoulder contusion as a result of the loading to the manual restraint. Although the safety belt prevented additional forward movement of her upper body, her head flexed forward and contacted the rear aspect of the front right seat back. She sustained a cervical neck strain as a result of the forward head motion over the shoulder belt webbing. Although the rear seat disengaged, the use of the manual restraint prevented additional forward motion of the occupant. She rebounded rearward and remained in position as the Grand Cherokee rotated to final rest. Her head probably contacted the head restraint, which mitigated additional neck injuries. She stated that her feet were stuck under the front right seat, although she was able to free them after the crash with minimal effort. The right rear door was jammed shut, and police moved the front right seat forward to assist her out of the vehicle through the right front door as they simultaneously removed the rear center passenger. She stated that as she unbuckled the safety belt and exited the vehicle, she noticed that rear seat rotated forward. She was transported by ambulance to a local hospital for treatment and was released approximately four hours following the crash.

**SCI**  
Case No.: CA03-054  
State of Georgia  
July 2003

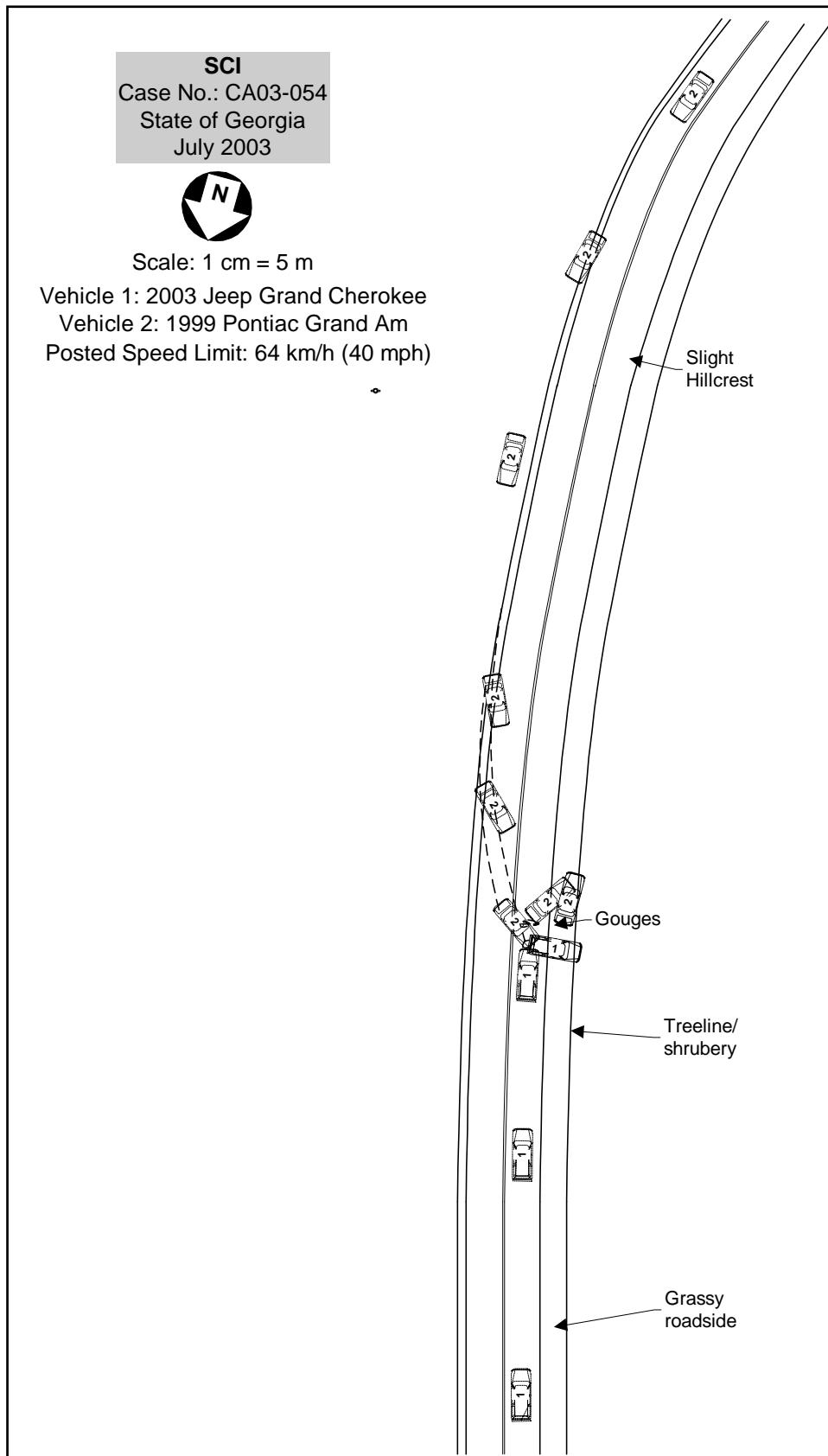


Scale: 1 cm = 5 m

Vehicle 1: 2003 Jeep Grand Cherokee

Vehicle 2: 1999 Pontiac Grand Am

Posted Speed Limit: 64 km/h (40 mph)



**Figure 23. Scene schematic**