CRASH DATA RESEARCH CENTER
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ON-SITE AIR BAG RELATED CHILD FATALITY INVESTIGATION
CALSPAN CASE NO: CA05-028

VEHICLE – 1997 JEEP CHEROKEE
LOCATION – GEORGIA
CRASH DATE – APRIL 2005

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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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An investigation of a frontal impact with a fixed-object with air bag deployment in a 1997 Jeep Cherokee resulting in the death of a 3-year old unrestrained front right passenger.

16. Abstract

This on-site investigation focused on the crash dynamics and fatal injury sources of a 3 year old female seated in the front right position of a 1997 Jeep Cherokee. The Jeep Cherokee was equipped with a frontal air bag system that consisted of driver and front right passenger air bags. The air bags deployed as a result of a frontal impact with a 99 cm x 99 cm (39 in x 39 in) brick column that supported an overhang to a building located adjacent to a parking lot. The child was initially seated on a Cosco Ambassador backless booster seat and improperly restrained by only the lap portion of the vehicle's manual 3-point safety belt system. However, as the Jeep neared its destination, the child released the safety belt and attempted to exit the vehicle prior to its coming to a full stop. The child moved forward off the seat and was positioned in-close proximity to the front right passenger air bag module. The driver became distracted by the pre-crash actions of the child precipitating the crash. At impact, the child suffered multiple thoracic injuries as a result of her interaction with the deploying air bag resulting in her death. The driver of the Jeep was not injured in the crash.

This crash was identified through an Internet news search conducted by the Crash Investigation Division of the National Highway Traffic Safety Administration and subsequently was assigned as an on-site investigation to the Calspan Special Crash Investigations team on April 27, 2005. Calspan SCI initiated a follow-up investigation and cooperation was established with the investigating police officer. The Jeep was being held in the impound pending the completion of the police investigation and was available for inspection. The on-site portion of the investigation took place May 9, 2005.

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BACKGROUND

This on-site investigation focused on the crash dynamics and fatal injury sources of a 3 year old female seated in the front right position of a 1997 Jeep Cherokee, **Figure 1**. The Jeep Cherokee was equipped with a frontal air bag system that consisted of driver and front right passenger air bags. The air bags deployed as a result of a frontal impact with a 99 cm x 99 cm (39 in x 39 in) brick column that supported an overhang to a building located adjacent to a parking lot. The child was initially seated on a Cosco Ambassador backless booster seat and improperly restrained by only the lap portion of the vehicle's manual 3-point safety belt system. However, as the Jeep neared its destination, the child released the safety belt and attempted to exit the vehicle prior to its coming to a full stop. The child moved forward off the seat and was positioned in-close proximity to the front right passenger air bag module. The driver became distracted by the pre-crash actions of the child precipitating the crash. At impact, the child suffered multiple thoracic injuries as a result of her interaction with the deploying air bag resulting in her death. The driver of the Jeep was not injured in the crash.

Figure 1: 1997Jeep Cherokee front right view.

This crash was identified through an Internet news search conducted by the Crash Investigation Division of the National Highway Traffic Safety Administration and subsequently was assigned as an on-site investigation to the Calspan Special Crash Investigations team on April 27, 2005. Calspan SCI initiated a follow-up investigation and cooperation was established with the investigating police officer. The Jeep was being held in the impound pending the completion of the police investigation and was available for inspection. The on-site portion of the investigation took place May 9, 2005.

SUMMARY

Crash Site

This single vehicle crash occurred during the evening hours in April 2005. At the time of the crash, it was dark with artificial overhead lighting. The weather was clear and was not a factor. The crash occurred on private property in the parking lot of a local business. At the time, the driver (grandmother) of the Jeep was transporting the 3 year old child passenger to return her to her mother. The parking lot was a convenient location for the exchange and this exchange had been done on previous occasions. The parking lot measured approximately 50 m x 38 m (165 ft x 125 ft) and was empty except for the non-contact vehicle owned by the child's mother. A

private business was located on the south side of the parking lot. Two brick columns supported a 9.8 m (32.0 ft) long overhang that extended from the building and covered its entrance. The brick columns measured 99 cm x 99 cm (39 in x 39 in) and were approximately 3.6 m (12 ft) tall. The west-most brick column was the point of impact. **Figure 2** is a southeast trajectory view along the Jeep's path of travel at the point where the vehicle entered the parking lot. **Figure 3** is a view of the point of impact.

Figure 2: Trajectory view at the parking lot entrance.

Figure 3: View of the POI (highlighted).

Crash Sequence

Pre-Crash

The 1997 Jeep Grand Cherokee was driven by a 64 year old restrained female. The 3 year old child (the driver's granddaughter) was initially seated in a Cosco Ambassador backless booster seat positioned in the front right of the vehicle. The driver reported in her interview that the child was restrained by only the lap portion of the vehicle's safety belt. The shoulder portion of the restraint webbing was routed behind the front right seat back. The driver was transporting the child to the parking lot to meet and return the child to her mother.

As the Jeep entered the parking lot, the child passenger became excited at seeing her mother because she was holding a present. The driver reported that the child unbuckled the safety belt and opened the front right door while the Jeep was still in motion. The driver became distracted by the child's actions and relinquished control of the Jeep. She indicated that she reached to her right and grabbed the child preventing her from exiting the moving vehicle.

Crash

During the driver's distraction, the Jeep continued its forward trajectory and struck the brick column. The approximate distance from the entrance of the parking lot to the point of impact was 27 m (90 ft). The crash occurred with the center aspect of the Jeep's frontal plane impacting the corner of the brick column. The brick column was not damaged in the crash. The impact halted the vehicle's forward momentum and the Jeep came to rest. The delta V of the impact calculated by the Damage Algorithm of the WINSMASH model was 16.9 km/h (10.5 mph). The final rest position of the Jeep was documented by the police investigation, **Figure 4**. The distance between the front plane of the Jeep and the column measured 2.7 m (9.0 ft). It was

probable the Jeep rolled backward to this location after the impact; this final rest location was not associated to rebound. There was no evidence of pre-impact braking observed during the police investigation or SCI scene inspection. A schematic of the crash is attached to the end of this narrative report as **Figure 13.**

Figure 4: Jeep final rest position.

Post-Crash

The child's mother witnessed the crash and ran to the right side of the vehicle. She opened the front right door and found the child unresponsive in the seat. She was bleeding from the nose and mouth. The grandmother driver told her to take the child and run to the emergency room of the hospital that was located approximately 275 m (300 yards) away. The driver exited the vehicle and proceeded to the hospital with the aid of a bystander. The driver was not injured in the event.

Upon initial examination in the emergency room, the child was unresponsive and bleeding from the nose. Her pupils were fixed and dilated. Medical intervention to revive the child over the course of the next hour proved unsuccessful and the child was pronounced deceased 65 minutes after entering the emergency room. The child was diagnosed with a probable tracheal separation, T2 comminuted fracture with distraction and other associated injuries.

VEHICLE DATA

1997 Jeep Grand Cherokee

The 1997 Jeep Grand Cherokee was identified by the Vehicle Identification Number (VIN): 1J4FX58S4VC (production sequence deleted). The vehicle had a June 1997 date of manufacture. The five passenger, rear-wheel drive sport utility vehicle was equipped with the Laredo trim package. The power train consisted of a 3.0 liter/V6 engine linked to a four speed automatic transmission. The manual restraint system consisted by 3-point lap and shoulder restraint for the four outboard seat positions and a center rear lap belt. The air bag system consisted of driver and front right passenger air bags that deployed as a result of the crash. The Jeep was equipped with Liberator All Terrain P225/75R15 mounted on the OEM alloy wheels. The manufacturer's recommended tire pressure was 248 kpa (36 psi). The specific measured tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	179 kpa (26 psi)	7.1 mm (9/32)	No	None
LR	172 kpa (25 psi)	7.1 mm (9/32)	No	None
RF	241 kPa (35 psi)	7.1 mm (9/32)	No	None
RR	48 kpa (7 psi)	7.1 mm (9/32)	No	None

Exterior Damage

Figures 5 and 6 are view of the Jeep's frontal damage. The front plane of the Jeep exhibited 19.1 cm (7.5 in) of direct contact damage as a result of the impact with the corner of the brick column. The direct contact 5.6 cm (2.2 in) left of the vehicle's center and ended 13.5 cm (5.3 in) right of center. The combined width of the direct and induced damage measured 93.5 cm (36.8 in). The induced damage began 27.6 cm (14.8 in) left of center and ended 50.8 cm (20.0 in) right of center. The crush profile measured along the bumper reinforcement bar was as follows: C1 = 0, C2 = 1 cm (0.4 in), C3 = 11.0 cm (4.3 in), C4 = 14.0 cm (5.5 in), C5 = 1.0 cm (0.4 in), C6 = 0. The maximum crush measured 16.0 cm (6.3 in) and was located 14.2 cm (5.6 in) left of the centerline. The bumper fascia and energy absorber fractured in the impact and separated from the vehicle. The energy of the impact was managed/absorbed by the deformation of the reinforcement bar. The reinforcement bar deformed rearward to the radiator support plane. There was direct contact between the radiator and deformed reinforcement bar which punctured the radiator core. There was no exterior damage to the Jeep rearward of the radiator support plane. The wheelbase dimensions were unchanged. All the doors remained operational post-crash and there was no damage to the windshield or side window glazing. The Collision Deformation Classification (CDC) of the Jeep was 12-FCEN-1. The total delta V of the impact based on the Damage Algorithm of the WINSMASH model was 16.9 km/h (10.5 mph). The longitudinal and lateral components of the delta V were -16.9 km/h (-10.5 mph) and 0, respectively.

Figure 5: Right front view of the Jeep.

Figure 6: Close-up view of the frontal damage.

Interior Damage

The interior damage of the Jeep consisted of damage related to the deployment of the frontal air bags. There was no interior damage or intrusion related to the exterior force of the crash. There were no identified occupant contacts to the interior structures of the Jeep.

The driver seat was located in a mid-to-rear track position that measured 3.8 cm (1.5 in) forward of full rear. The total seat track travel measured 18.5 cm (7.3 in). The seat back was reclined 25 degrees aft of vertical. The horizontal distance between the seat back and center of the driver air bag module measured 58.4 cm (23.0 in). This distance was measured 40.6 cm (16.0 in) above the seat bight.

Figure 7 is a view of the driver's position. There was no deformation of the three-spoke steering wheel rim. The tilt steering wheel was adjusted to the full up position. There was no displacement of the steering column's shear capsules. There was no occupant contact to the driver's knee bolster.

Figure 7: Driver's position.

The front right passenger seat was adjusted to a mid-to-rear track position that measured 3.8 cm (1.5 in) forward of full rear. The total seat track travel measured 18.5 cm (7.3 in). The seat back was reclined 25 degrees aft of vertical. The position of the front right seat was consistent with the driver's seat position. The horizontal distance from the center of the seat back to the vertical face of the instrument panel (directly below the front right passenger air bag module) measured 78.7 cm (31.0 in). The horizontal distance was measured 35.6 cm (14.0 in) above the seat bight.

Inspection of the right aspect of the instrument panel revealed evidence of an impeded air bag deployment. Refer to **Figure 8**. The cavity in the right aspect of the instrument panel that housed the passenger air bag module was deformed due to an over-pressurization. The forward position of the child obstructed the normal deployment path of the air bag resulting in a partial expansion of the air bag within the module. Two linear cracks were observed in the vinyl instrument panel as a result of the deformation. The cracks were located 2.5 cm (1.0 in) and 21.1 cm (8.3 in) right of the inboard edge of the module flap, respectively. The centermost crack radiated forward 23 cm (9 in) to the lower aspect of the windshield. The outboard air conditioner/heater vent louver was also deformed during the impeded deployment. The top surface of the trim panel located immediately below the air bag module was abraded by the air bag during the altered deployment.

Figure 8: Right aspect of the instrument panel.

Manual Restraint System

The driver reported in her interview that she was restrained at the time of the crash by the vehicle's manual safety belt. The restraint consisted of a sliding latch plate, continuous loop webbing, adjustable D-ring and Emergency Locking Retractor (ELR). The webbing was stowed in the retractor upon initial examination. The D-ring was adjusted to the full up position. Examination of the latch plate and webbing revealed evidence of historical use. There was no crash related evidence identified on any of the restraint's components. However, given the relative minor severity of the impact, crash related evidence was not expected.

The front right passenger restraint consisted of a light-weight locking latch plate, continuous loop webbing, adjustable D-ring, and ELR retractor. The webbing was extended from the retractor upon initial inspection and the shoulder portion of the webbing was looped behind the back of the front right seat, **Figure 9**. The D-ring was adjusted to its lowest position. The position of the webbing was consistent with only the lap portion of the restraint being used by the child occupant. This improper use was confirmed during an interview with the driver. The driver stated that she placed the child in the front right position and only utilized the lap portion of the restraint. She reported that the shoulder portion of the restraint came across the child's neck; therefore she placed it behind the seat. She further stated, that prior to the crash, the child unbuckled the restraint and attempted to exit the vehicle prior to the crash. An inspection of the restraint's webbing and the friction surfaces of the hardware was unremarkable for crash related evidence, consistent with its non-use at the time of the crash.

Figure 9: Front right passenger seat and restraint.

Frontal Air Bag System

The 1997 Jeep Grand Cherokee was equipped with a frontal air bag system that consisted of driver and front right passenger air bags. The air bag system was controlled by an electronic module located under the center console and utilized two forward impact sensors symmetrically located on the outboard corners of the upper radiator support.

The driver air bag module was located in the typical manner in the center hub of the steering wheel and had deployed as a result of the crash. The module cover flaps were designed with an asymmetrical H-configuration. The width of the center seam measured 16.0 cm (6.3 in). The height of the upper and lower cover flaps measured 3.8 cm (1.5 in) and 7.6 cm (3.0 in), respectively. The diameter of the driver air bag measured 61 cm (24 in) in its deployed state. It was tethered by two internal straps located in the 12 and 6 o'clock sectors. The air bag was not externally vented. There was no residual evidence of driver contact to deployed air bag.

The front right passenger air bag module was a mid-mount design located in the right aspect of the instrument panel. Refer to **Figure 10**. The module cover flap was rectangular and measured 36.3 cm x 10.2 cm (14.3 in x 4.0 in), width by height, respectively and was hinged along its top aspect. There was no evidence of occupant contact to the cover flap. The cover flap rotated open upon deployment; however, the forward position of the child altered the deployment path of the air bag at the inboard aspect of the module. The deploying air bag was deflected to the right resulting in the asymmetrical opening of the flap and the over-pressurization of the module. Inspection of the front right passenger air bag membrane revealed indications of its impeded deployment as well. The dimensions of the

Figure 10: Top surface of the deflated front right passenger air bag.

deflated air bag measured 46 cm x 51 cm (18 in x 20 in), width by height, and the air bag extended 46 cm (18 in) rearward from the vertical face of the instrument panel. The top, face, and bottom surfaces of the air bag exhibited areas of black vinyl transfer related to frictional contact with the interior surfaces of the module during the impeded deployment. The expanding air bag also contacted and abraded the forward aspect of the booster seat (refer to the Booster seat section of this report below).

BACKLESS BOOSTER SEAT

Prior to the crash, the 3 year old front right passenger was seated in a Cosco Ambassador backless booster seat. The seat was identified by the model number 22-296-WAL and was manufactured on 07/26/2004. The seat was rated for children over 1 year of age, 74 cm to 145 cm (29 in to 57 in), and 14 kg to 45 kg (30 lb to 100 lb). The manufacturer's labels were still attached to the seat and the instruction manual was found in the front right foot well. At the time of the inspection, the seat was found in the second row interior. Inspection of the seat revealed the leading edges of the seat (outboard the cushion) were abraded by the expansion of the front right passenger air bag. The lengths of the left and right abrasions, measured along the circumference of the seat, were 21 cm (8.3 in) and 22 cm (8.7 in), respectively. Refer to **Figure 11.** The inspection of the seat was otherwise unremarkable. **Figure12** is an interior view of the front right seat and the reconstructed at-crash position of the booster seat.

Figure 11: Cosco Ambassador BBS.

Figure 12: Reconstructed position of the BBS.

OCCUPANT DEMOGRAPHICS

1997 Jeep Grand Cherokee

	Driver	***Front Left Child Passenger***
Age/Sex:	64 year old/Female	5 year old/Female
Height:	Not reported	Not reported
Weight:	Not reported	Not reported
Seat Track Position:	Mid-to-rear	Mid-to-rear
Restraint Use:	3-point lap and shoulder	None used
Usage Source:	SCI inspection, interview	SCI inspection, interview
Medical Treatment:	Not injured	Fatally injured

DRIVER INJURY
1997 Jeep Grand Cherokee
The driver was not injured in the crash. She was examined in the emergency room, treated for hypertension and released.

DRIVER KINEMATICS
1997 Jeep Grand Cherokee
The 64 year old female driver of the Jeep was seated in a mid-to-rear track position and was restrained by the 3-point lap and shoulder belt. Immediately prior to the crash, she became distracted by the actions of the front right child passenger and relinquished control of the vehicle. She reported that she was reaching to her right toward the child.

Upon impact, the ELR retractor of the driver's manual restraint locked and the vehicle's frontal air bags deployed. The driver initiated a forward trajectory, loaded the locked restraint with her upper body and rode down the force of the impact. The driver's head and upper chest contacted and loaded the deployed air bag. The combination of the manual restraint and driver air bag mitigated the driver's contact with the interior vehicle structures and minimized her injury. She then rebounded back into her seat.

FRONT RIGHT CHILD PASSENGER INJURY
1997 Jeep Grand Cherokee

Injury	***Injury Severity (AIS 98 Update)***	***Injury Mechanism***
Comminuted fracture of T2 with distraction of the spine at T2-3	Moderate (650416.2,7)	Deploying front right passenger air bag
Left first rib fracture	Minor (450212.1.2)	Deploying front right passenger air bag
Cervical spine injury, NFS	Unknown (615099.7,6)	Deploying front right passenger air bag
Bleeding – bilateral nostrils, epitaxis	Minor (251090.1,4)	Deploying front right passenger air bag

Note: the above injuries were identified in the emergency room and radiology reports obtained from the treating hospital. An autopsy was not performed.

Discussion:
The emergency room records documented the possibility of the additional injuries that were not codeable under AIS rules due to the uncertainty. However, the nature and location of those injuries would have been consistent with the deploying front right passenger air bag as the injury source. The identified possible injuries were as follows:

- Likely developing bilateral lung contusions – AIS 4
- Probable tracheal fracture/separation – AIS 5

It should be noted that both the documented major injuries and the above-mentioned possible injuries all occurred in the upper thoracic region at approximately the T1 elevation. This pattern of injury was consistent with the circumstances of the child standing in the front right foot well directly in front of the front right passenger air bag module at the time of its deployment.

FRONT RIGHT CHILD PASENGER KINEMATICS

1997 Jeep Grand Cherokee

The 3 year old child passenger was initially seated on the booster seat and restrained by only the lap portion of the manual 3-point restraint. Immediately prior to the crash, the child released the seat belt and in her excitement to see her mother attempted to exit the vehicle prior to its coming to a stop. The distracted driver relinquished control of the Jeep and the impact occurred. Reportedly, the driver reached to her right and grabbed the child to prevent her from leaving the vehicle.

At impact, the frontal air bag system deployed. The child was standing in the front right passenger foot well and impeded the normal deployment of the bag. The forward position of the child caused an over-pressurization of the module. The expanding air bag impacted the child in the upper chest and the force of the impact resulted in the left first rib fracture, the cervical and thoracic spine injuries and epitaxis. In addition, it was probable that the child also sustained bilateral lung contusions and a tracheal fracture/separation. The child then rebounded back into the seat where she was found.

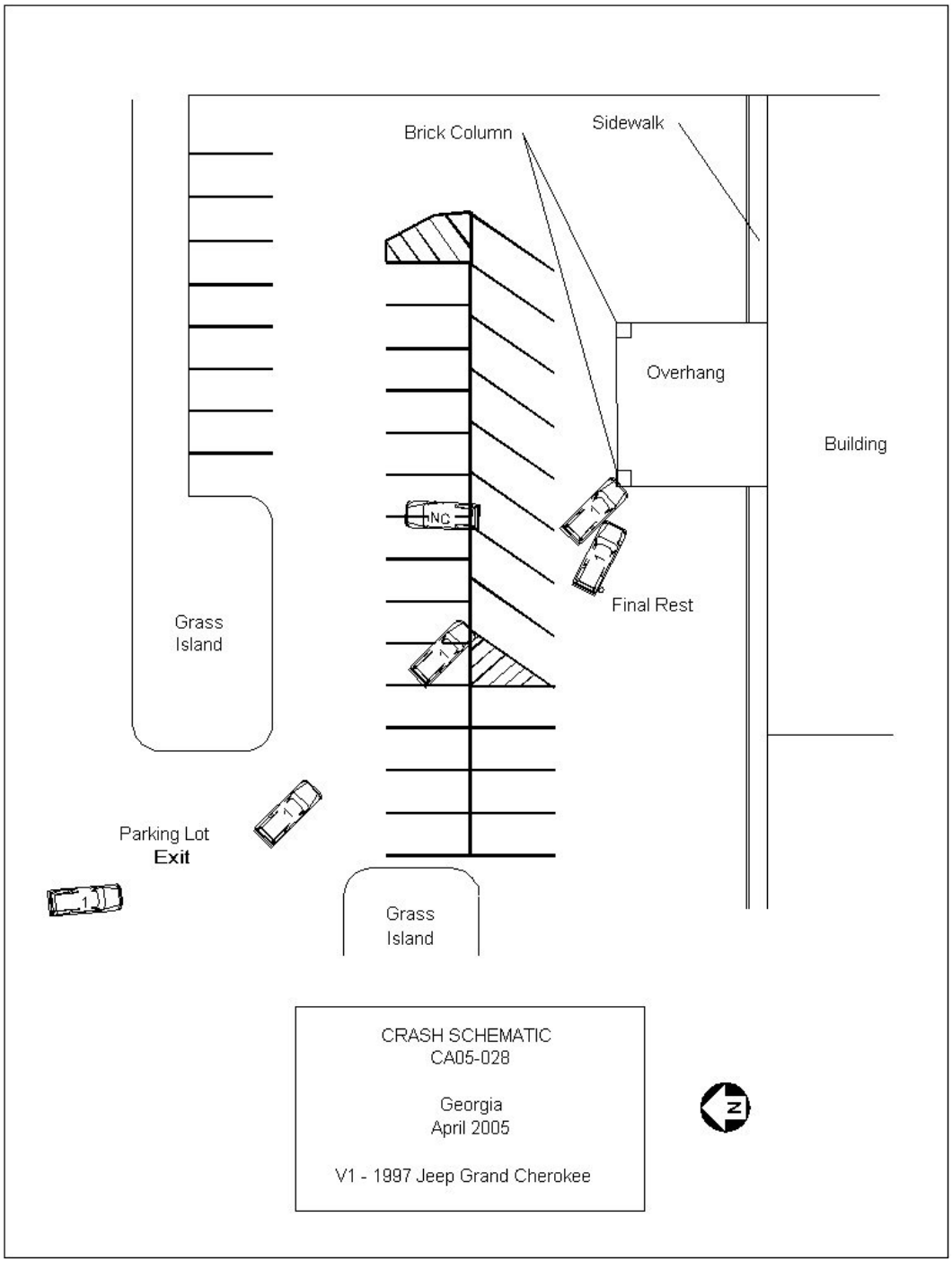

Figure 13: Crash Schematic.