Rear Facing Child Safety Seat Air Bag Fatality Investigation/ Vehicle to Object Dynamic Science, Inc. / Case Number: DS04012 2003 Jeep Grand Cherokee Laredo California May, 2004 This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

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

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16. Abstract

This on-site investigation focused on the interaction of a passenger air bag and a Rear Facing Child Safety Seat (RFCSS) that was installed in the front right seat of a 2003 Jeep Grand Cherokee Laredo. The Jeep Grand Cherokee was occupied by a restrained 28-year-old female driver, a 10-month-old female front right passenger restrained in the RFCSS, and an unrestrained 6-year-old male rear seat middle passenger. The RFCSS was anchored to the vehicle using the vehicle's manual 3-point lap and shoulder belt. The belt was routed through the RFCSS rear facing belt path. The Jeep Grand Cherokee was traveling southbound on a city street; the driver was distracted by her cell phone. As she reached for the phone, she lost control of the vehicle and struck a curb with the front right tire (Event #1) and then struck a concrete light pole (Event #2). Both front air bags deployed at this time. The pole then fell onto the top-right of the roof (Event #3) of the vehicle. The driver of the Jeep sustained facial and abdominal contusions. The 10-month-old sustained major head trauma and was fatally injured. The 6-year-old sustained a liver laceration, a laceration to the forehead, an abdominal wall contusion, and multiple abrasions. All three occupants were initially transported by a private party to a fire station and then transported to various hospitals.

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BACKGROUND:

This on-site investigation focused on interaction of the passenger air bag and a Rear Facing Child Safety Seat (RFCSS) that was installed in the front right seat of a 2003 Jeep Grand Cherokee Laredo. The Jeep Grand Cherokee was occupied by a restrained 28-year-old female driver, a 10-monthold female front right passenger restrained in the rear-facing RFCSS, and an unrestrained 6-year-old male rear seat middle passenger. The RFCSS was anchored to the vehicle using the vehicle's manual 3-point lap and shoulder belt. The belt was routed through the RFCSS rear facing belt path. The Jeep Grand Cherokee was traveling southbound on a city street and was distracted by her cell phone. As she reached for the phone, she lost control of the vehicle and struck a curb with the front right tire (Event #1) and then struck a concrete light pole (Event #2). Both front air bags deployed at this time. The pole then fell onto the top-right of the roof (Event #3) of the vehicle. The driver of the Jeep sustained facial and abdominal contusions. The 10-month-old sustained major head trauma and was fatally injured. The 6-year-old sustained a liver laceration, a laceration to the forehead, an abdominal wall contusion, and multiple abrasions. All three occupants were initially transported by a private party to a fire station and then transported to various hospitals.



Figure 1. 2003 Jeep Cherokee (news image)



Figure 2. Rear facing RFCSS in front right seat

This case was identified by DSI from a local television news report. DSI notified the National Highway Traffic Safety Administration of the case on June 1, 2004 and DSI was assigned the case on June 2, 2004. The investigating police agency impounded the vehicle and held it in evidence for an extended period of time. After it was released to the owner, it was then placed in storage by the owner's attorney. Permission to interview the driver was given on May 2, 2005. The vehicle inspection took place on May 3, 2005.

SUMMARY

Crash Site

This single vehicle crash occurred in May, 2004 at 0008 hours. It was dark, but streetlights were present. At the time of the crash, there were no adverse weather conditions and the asphalt

roadway was dry. The north/south roadway was configured with two lanes in each direction that were separated by a raised center median. The roadway is slightly curved to the right and there is a +1.3% grade at impact. The roadway edge for southbound travel was comprised of a 94 cm (37 in) concrete rain gutter and a 23 cm (9 in) high concrete curb. The 71 cm (28 in) diameter concrete pole was located 71 cm (28 in) off the road edge. The poles are spaced 42 m (137 ft) apart. The posted speed limit was 72 km/h (45 mph).



Figure 3. Approach to area of impact (south)

Pre-Crash

The 2003 Jeep Grand Cherokee was traveling southbound in the right hand lane at a driver reported speed of between 56 km/h (35 mph) and 64 km/h (40 mph). The Jeep Grand Cherokee was occupied by a restrained 28-year-old female driver, a 10-month-old female front right passenger (79 cm/31 in, 11.8 kg/26 lbs) restrained in the RFCSS, and an unrestrained 6-year-old male in the rear middle seat. The driver had just gotten off the cell phone and had placed the phone in the cup holder. The cell phone began to ring and she picked it up to see who was calling. As she looked down, the vehicle drifted to the right towards the curb.

Crash

As the Jeep struck the curb with its front right tire (12FRWN3), the driver stepped on the accelerator instead of the brake, and the vehicle continued forward and struck the concrete pole with its front end (12FREE3). Both front air bags in the Jeep deployed at this time. The concrete pole fractured and fell onto the right side hood, windshield and roof (00TYRW4).

Post-Crash

The Jeep rotated clockwise after the pole impact and came to rest on its wheel facing west. The driver was able to exit the vehicle under her own power. She removed the front right seat passenger from the Graco RFCSS. The 6 year-old boy, who was laying across the rear seat prior to the crash, apparently was also able to exit the vehicle under his own power. The driver was holding the infant and signaled for help from witnesses. The driver indicated that her baby was dying and needed help to get to a hospital. The witnesses took all three passengers to a local fire station.

The driver of the Jeep sustained facial and abdominal contusions. She was transported from the fire station by ambulance to a local trauma center where she was examined in the emergency room and then released.

The 10 month-old infant sustained major head injuries, including fractures to the left parietal and occipital bones, subdural hemorrhage, subarachnoid hemorrhage, cerebral lacerations and contusions, and cerebral edema. She was intubated while on scene and then transported to the

pediatric intensive care unit at a local trauma center where she arrived in a comatose state. Her measured GCS was a 3. She was observed moving her limbs in an inappropriate manner and her pupils were fixed and dilated. Her condition continued to worsen. Her EEG found a consistency of brain death by delineating flattened waves, and she was pronounced dead at 1631 hours–approximately 16 hours post-crash.

The 6 year-old boy sustained a liver laceration, a laceration to the forehead, an abdominal wall contusion, and multiple abrasions. He was transported by paramedics to the same trauma center that had received his mother. His GCS was a 15 upon arrival. The boy was admitted for one day.

The Jeep was towed from the scene due to damage. It was placed under police hold for several months. After it was released to the owner, it was then placed in storage by the owner's attorney. The RFCSS remained in the vehicle, anchored to the seat, during this entire time frame and was not removed until the vehicle inspection.

VEHICLE DATA - 2003 Jeep Cherokee

The 2003 Jeep Grand Cherokee Laredo four-door was identified by the Vehicle Identification Number (VIN): 1J4GGX48S23Cxxxxx. The vehicle's odometer could not be read, as there was no power to the instrument panel when power was applied to the vehicle. The Jeep was a 4 X 2 sport utility vehicle that was equipped with a 4.0 liter, 6 cylinder engine, automatic transmission, front and rear disc brakes with ABS, rear wheel drive, and a tilt steering wheel.

The 2003 Jeep Cherokee was configured with Goodyear Wrangler ST P225/75R16 tires. The manufacturer's recommended cold pressure was 228 kPa (33 psi). The specific tire information is as follows:

Tire	Tread	Measured pressure	Manufacturer recommended pressure
LF	6 mm (7/32 in)	179 kPa (26 psi)	228 kPa (33 psi)
LR	6 mm (8/32 in)	228 kPa (33 psi)	228 kPa (33 psi)
RR	5 mm (6/32 in)	Flat	228 kPa (33 psi)
RF	6 mm (8/32 in)	145 kPa (21 psi)	228 kPa (33 psi)

The front seating positions in the 2003 Jeep Cherokee was configured with front fabric covered bucket seats with adjustable head restraints that were in the full down position and rear split bench seats with folding backs. The driver's seat was located between the mid and rear most track position. The seat back angle was 28 degrees from vertical, the seat bottom angle was 10 degrees from horizontal. The front right seat was located between the mid and rear most track position–one click from the rear most position. The seat back angle was 24 degrees from vertical, the seat bottom angle was 10 degrees from horizontal.

VEHICLE DAMAGE

Exterior Damage - 2003 Jeep Grand Cherokee Laredo

The 2003 Jeep Cherokee sustained minor rim damage from the impact with the curb (12FRWN3). The vehicle sustained moderate front end damage as a result of the impact with the concrete pole (12FREE3). The direct damage began at the right front bumper corner and extended laterally 32.0 cm (12.5 in). The maximum crush at the right bumper corner backing bar was 28.0 cm (11.0 in). The front end damage extended rearward in a pole shaped pattern 277.0 cm (109.0 in) across the hood, windshield and roof as the pole fractured and fell down onto the vehicle (00TYGN4). The right A pillar was crushed



Figure 4. Front, 2003 Jeep Cherokee

vertically 22.0 cm (8.7 in).

Damage Description:	Moderate damage to the frontal plane and the roof area			
CDC:	Event #1 (curb): 12FRWN3 Event #2 (pole): 12FREE3 Event #3 (pole): 00TYRN4			
Delta V:	Total	Unknown		
	Longitudinal	Unknown		
	Latitudinal	Unknown		
	Energy	Unknown		

Although the pole impact (Event #2), which occurred to a yielding object (the pole fractured) invalidated the parameters of the Win Smash program, both a *Pole damage only* run and a *Barrier damage only* run were generated. These were done to provide a rough estimate of the energies which the case vehicle was being subjected to during the second event in the crash sequence. It must also be noted that 5 of the 6 C values, once free space was taken into account, were 0. The maximum crush was located at the front-right corner (C6) and extended across the front-right plane for a total of only 32 cm. This resulted in an E being assigned to Column 6 of the CDC, and an extent zone of 3 being assigned to Column 7. Because there was no direct contact along the right side plane the extent zone was based upon crush through the frontal plane, since the pole, rather than proceeding along the right side plane, actually remained inside the front right quarter panel.

An offset Pole run generated a total Delta V of 13.0 km/h) 8.1 mph and a longitudinal Delta V of -13 km/h (-8.1 mph).

A Barrier Only run generated a total Delta V of 17.0 km/h (10.6 mph) and a longitudinal Delta V of -17.0 km/h (10.6 mph).



Figure 5. Roof, windshield, hood crush



Figure 6. Front right rim damage

Interior Damage - 2003 Jeep Grand Cherokee Laredo

The 2003 Jeep Grand Cherokee sustained significant interior damage as a result of passenger compartment intrusion. The windshield header, roof, visor, window frame, and A/B pillars sustained vertical intrusion to the center and right front seating areas.

Position	Intruded Component	Magnitude of Intrusion	Direction
FR	Windshield	13.0 cm (5.1 in)	Vertical
FR	Windshield header	14.0 cm (5.5 in)	Vertical
FR	Roof	21.0 cm (8.3 in)	Vertical
FR	Visor	25.0 cm (9.8 in)	Vertical
FR	Window frame	15.0 cm (5.9 in)	Vertical
FR	A pillar	10.0 cm (3.9 in)	Vertical
FR	B pillar	2.0 cm (0.8 in)	Vertical
RR	Window frame	3.0 cm (1.2 in)	Vertical
FC	Windshield header	\geq 15 cm but < 30 cm	Vertical
FC	Roof	\geq 15 cm but < 30 cm	Vertical

The specific passenger compartment intrusions were field documented as follows:

These listed intrusions seem to be less severe than the interior photographic evidence would indicate. However, a review of the exterior photos show that the front-right roof is not as vertically displaced as the interior photos suggest.



Figure 7. Overview of front seating area

MANUAL RESTRAINT SYSTEMS - 2003 Jeep Cherokee

The 2003 Jeep Cherokee was configured with manual 3-point lap and shoulder belts for each outboard seating position. The second row middle seat position was configured with a manual lap belt. Both front seat safety belts were equipped with adjustable D-rings that were in the full up position. The driver's safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). The remaining outboard safety belts were configured with sliding latch plates and switchable ELR/Automatic Locking Retractors (ALR). The front right safety belt was used to anchor the RFCSS. The belt had not been switched and remained in ELR mode. No locking clip was used.

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 frontal air bags deployed as a result of the longitudinal deceleration of the Jeep during the impact with the concrete pole (Event #2).

The driver's air bag deployed from the center of the steering wheel hub through asymmetrical Hconfiguration module cover flaps. The top flap measured 17.0 cm (6.7 in) wide by 8.0 cm (3.1 in) high. The bottom flap measured 17.0 cm (6.7 in) wide by 5.0 cm (1.9 in) high. The deployed driver's air bag measured 51.0 cm (20.0 in) in diameter in its deflated state. The air bag was internal vented and was tethered by two internal straps. The air bag had a maximum excursion of 21.0 cm (8.3 in). There was a makeup contact found on the bottom right of the air bag face.

The front right passenger's air bag deployed from a mid-mount module with a rectangular cover flap that was hinged at the top. The cover flap measured 40.0 cm (15.7 in) wide by 17.0 cm (6.7 in) high. There was a 5.0 cm (1.9 in) wide cut to the top of flap to the top of the flap that began 20.0 cm (xx in) from the right edge. The cut was caused by windshield contact. The deployed front right passenger's air bag measured 38.0 cm (14.9 in) wide by 61.0 cm (24.0 in) high. The air bag had a maximum excursion of 46.0 cm (18.1 in). There were no contacts visible on the air bag. At the time of inspection the air bag was covered by dust and dirt and had been exposed to the elements. Two circular vent ports that measured 4.0 cm (1.6 in) in diameter were located at the 3 and 9 o'clock aspects of each side panel of the air bag.

CHILD SAFETY SEAT - 2003 Jeep Cherokee

A Graco SnugRide RFCSS was positioned in the front right seat of the Jeep. The model number was 7456 MON and the date of manufacture was April 30, 2003. The seat was given to the driver as a gift. The RFCSS seat was configured with a fivepoint harness system. The seat was designed for use with or without a stay-in-vehicle base. The base was not present during this crash. The manufacturer recommends that the seat be used for children weighing up to 9.0 kg (19.8 lbs) and who are less than 66 cm (25.9 in) in height. The child in this crash was 2.2 kg (6.0 lbs) too heavy and 13.0 cm (5.1 in) too tall for this seat.

At the time of inspection, the harness straps were routed through the bottom set of harness slots. The harness retainer clip was position 26.0 cm (10.2 in) below the harness slots, which resulted in a remaining shoulder harness length of 5.0 cm (1.9 in) between the retainer clip and the RFCSS latch plates. The length of the crotch strap was 9.0 cm (3.5 in).

The RFCSS was installed in a rear-facing orientation and was anchored using the manual 3point lap and shoulder belt system. The seat belt had not been switched and was found in the ELR mode. There was seat movement both side to side and from front to back. It is not known if the seat was level at the time of the crash. The carrying handle was in the down position. Post-crash, it appears that the seat had rotated rearward.

The child seat sustained minor damage as a result of the crash. A small, faint stress mark was present on the outboard aspect of the upper left side of the seat under the fabric cover. The harness straps did not exhibit any deformation from the crash.



Figure 8. Graco SnugRide RFCSS



Figure 9. Harness length and slot routing



Figure 10. Stress mark to seat back shell

OCCUPANT DEMOGRAPHICS - 2003 Jeep Cherokee

	Driver	Occupant 2	Occupant 3
Age/Sex:	28/Female	10 month/Female	6 years/Male
Seated Position:	Front-left (driver)	Front-right	Laying across the rear seat
Seat Type:	Fabric bucket	Fabric bucket	Fabric split bench w/folding backs
Height:	155 cm (61 in)	79 cm (31 in)	Unknown
Weight:	66 kg (146 lbs)	11.8 kg (26 lbs)	23 kg (52 lbs)
Occupation:	Unknown	N/A (infant)	N/A (child)
Pre-existing Medical Condition:	None reported	None reported	None reported
Alcohol/Drug Involvement:	None reported	None reported	None reported
Driving Experience:	Unknown	N/A	N/A
Body Posture:	Picking up her ringing cell phone	Facing rearward in a rear facing RFCSS	Possibly laying down across the rear seat
Hand Position:	Left hand on wheel, right hand holding cell phone	Unknown	Unknown
Foot Position:	Right foot on the gas (hit gas instead of the brake)	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used with RFCSS	None used
Air bag:	Steering wheel mounted front air bag, deployed	Top instrument panel mounted front air bag, deployed	None

OCCUPANT INJURIES - 2003 Jeep Cherokee

Driver: Injuries obtained from interviewee.

Injury	OIC Code	<u>Injury</u> Mechanism	Confidence Level
Facial contusions (NFS)	290402.1,0	Air bag	Certain
Abdominal contusions (NFS)	590402.1,0	Seat belt webbing	Certain

<u>Right Front Occupant</u>: Injuries obtained from Autopsy Report and Medical Records.

Injury	OIC Code	Injury Mechanism	Confidence Level
Bilateral subdural hematomas, 0.9 cm (0.35 in) thick (thickness just less than one cm)	140654.5,3	RFCSS seat back being propelled by the air bag	Probable
Subarachnoid hemorrhage, over entire occipital region	140684.3,1 140684.3,2	RFCSS seat back being propelled by the air bag	Probable
Large scalp hematoma (over right occipital/parietal)	190402.1,1	RFCSS seat back being propelled by the air bag	Probable
Some area of abrasion across the left forehead	290202.1,7	Sun visor	Probable
Scattered small abrasion on her extremities	790202.1,3 890202.1,3	Unknown	Unknown
Fracture of left parietal bone	150402.2,2	RFCSS seat back being propelled by the air bag	Probable
Non-displaced left occipital calvarial fracture at the lip of the posterior sagittal suture, maximal diameter measures 0.9 cm (0.35 in) (Radiology Report support injury)	150405.2,2	RFCSS seat back being propelled by the air bag	Probable
Laceration of right occipital tip (cerebrum)	140688.4,1	RFCSS seat back being propelled by the air bag	Probable

Contusion of left temporal tip (cerebrum)	140602.3,2	RFCSS seat back being propelled by the air bag	Probable
Contusion of the central chest	490402.1,4	RFCSS retainer clip and webbing	Certain
Contusions, left thigh and left calf	890402.1,2 890402.1,2	RFCSS webbing	Certain
Contusions left upper arm	790402.1,2	Side of RFCSS	Possible

<u>Passenger (Occupant #3)</u>: Injuries obtained from discharge summary, history and physical, and emergency room records.

<u>Injury</u>	OIC CODE	<u>Injury</u> <u>Mechanism</u>	<u>Confidence</u> <u>Level</u>
Minor liver laceration, posterior segment of right lobe	541822.2,1	Rear of 1-3 seat back	Probable
Abdominal wall contusion	490402.1,9	Rear of 1-3 seat back	Probable
3.0 cm (1.18 in.) forehead laceration, midline	290602.1,7	Rear of 1-3 seat back	Probable
Facial abrasions, left side	290202.1,2	Rear of 1-3 seat back	Probable
Scattered abrasions across the back	690202.1,0	Unknown	Unknown
Hemoperitoneum and pelvic hematoma	850602.1,9	Rear of 1-3 seat back	Probable

OCCUPANT KINEMATICS - 2003 Jeep Cherokee

Driver kinematics

The 28-year-old female driver was restrained by the manual 3-point lap and shoulder belt. The seat was located between the mid and rear most track position. The seat back angle was 62 degrees and the seat bottom angle was 10 degrees. Her left hand was on the steering wheel, while her right hand may have been holding her cell phone. Her right foot had pressed down on the accelerator just prior to the impact with the pole. She had intended to apply the brake, but hit the gas in error. She had leaned slightly to the right while looking at the cell phone. At impact with the curb, there was likely little occupant motion. At impact with the pole, the driver initiated a forward trajectory in response to the 12 o'clock direction of force. She loaded the lap and shoulder belt. This resulted in a contusion across her entire abdominal area. As the impact deployed the driver's air bag she contacted the bag with her right cheek. This resulted in a minor contusion. After being driven to a local fire station by a passerby, she was eventually transported to a local trauma center. Upon arrival she was evaluated and released quickly so she could be with her children, who were in the same medical center.

Front right child kinematics

The 10-month-old female infant was restrained in Graco RFCSS and was wearing its internal five-point harness. It must be noted that the child was both too tall and too heavy for the recommendations listed on the label of the RFCSS. The shoulder webbing harness was located in the lower set of slots. The safety seat was installed in the front right position of the Jeep using the vehicle lap and shoulder belt. The lap and shoulder belt was in the ELR mode and the RFCSS was not tightly anchored. The front right seat was located between the mid and rear most track position–one click from the rear most position. The seat back angle was 66 degrees, the seat bottom angle was 10 degrees. At impact with the curb there was likely little occupant motion. At impact with the pole, the child and RFCSS initiated forward trajectories in response to the 12 o'clock direction of force. The front right passenger air bag deployed at this time and struck the back of the RFCSS. The child and the seat were accelerated rearward. The seat rotated rearward approximately 15-20 degrees. While there were intrusions to this area of the vehicle, the skull/brain injuries appear to be directly related to the interaction between the RFCSS seat back and the child's head as the air bag deployed.

Second row middle passenger kinematics

The 6-year-old boy was positioned in an unknown fashion in the center rear of the Jeep. The mother stated that he may have been sitting upright while sleeping. The medical records indicate that he may have been lying down, which would appear more likely if the child were indeed sleeping in the rear seat area. It was determined that he was definitely not using the lap belt in the rear middle seat position; the lap belt was found beneath the seat. At impact with the curb, there was likely little occupant motion. At impact with the pole, the child initiated forward trajectories in response to the 12 o'clock direction of force. It is not clear what the child may have struck to cause the liver laceration and a laceration to the forehead but there is a prominent indention along the left quadrant of the front-right seat back. Although there were pieces of the damaged case vehicle shoved into the rear seating area post-crash, this dent appears to have been located above the area where the damaged car parts were initially observed. If the child was

laying across the rear seat prior to the impact he would have slid forward, in the direction of the 360 degree pole force, and thus impacted the seat back immediately forward of him. After exiting the vehicle unaided, he was taken to a fire station by a bystander. He was then transported to the same trauma center as his mother, and was hospitalized overnight. He was discharged the following day.

Attachment 1. Scene Diagram

