INDIANA UNIVERSITY
TRANSPORTATION RESEARCH CENTER
School of Public and Environmental Affairs
222 West Second Street
Bloomington, Indiana 47403-1501
(812) 855-3908 Fax: (812) 855-3537

ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN07015
LOCATION - WISCONSIN
VEHICLE - 1995 JEEP CHEROKEE SPORT 4X4
CRASH DATE - May 2007

Submitted:

January 3, 2008
Revised: June 5, 2008

Contract Number: DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

DISCLAIMERS

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.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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.

Technical Report Documentation Page

1. *Report No.* IN07015	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* On-Site Child Safety Seat Investigation Vehicle - 1995 Jeep Cherokee Sport 4x4 Location - Wisconsin		5. *Report Date:* January 3, 2008 6. *Performing Organization Code*	
7. *Author(s)* Special Crash Investigations Team #2		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Research Center Indiana University 222 West Second Street Bloomington, Indiana 47403-1501		10. *Work Unit No. (TRAIS)* 11. *Contract or Grant No.* DTNH22-07-C-00044	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation (NPO-122) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. *Type of Report and Period Covered* Technical Report Crash Date: May 2007 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site child safety seat investigation involving a 1995 Jeep Cherokee Sport 4x4 equipped with manual safety belts, driver's front air bag system and a child safety seat installed in the back center position.			
16. *Abstract* This report covers an on-site child safety seat investigation that involved a 1995 Jeep Cherokee Sport 4x4 and a 1997 Chevrolet C1500 extended cab pickup truck, which collided head-on on a two-lane state highway. This crash is of special interest because the Jeep's back center passenger (5-week-old, male) was seated in a child safety seat and sustained fatal injuries as a result of the crash. The Jeep Cherokee was traveling north in the northbound lane and the Chevrolet C1500 was traveling south in the southbound lane. The Jeep entered the southbound lane resulting in an offset frontal impact with the Chevrolet. The impact caused the Jeep's driver air bag to deploy. The Chevrolet's driver and front right passenger air bags also deployed. Following the impact, the Jeep rotated clockwise, departed the west side of the roadway and rolled over driver side leading, two quarter turns into a ditch. The Jeep came to rest on its top in the ditch heading southeast. The Chevrolet rotated clockwise and came to final rest in the middle of the roadway heading northwest. At the time of the crash, it was daylight, cloudy with no precipitation, and the bituminous road surface was dry and free of defects. The Jeep's back center passenger was restrained in an Evenflo Discovery rear-facing infant seat with the base. The infant seat base was secured in the back center seat position with the Jeep's lap belt and the infant seat was snapped into the base. The infant seat was deformed and cracked as a result of this severe crash. The back center passenger sustained fatal injury including multiple skull fractures and brain injuries due to impacting his head on the intruding roof structure during the crash.			
17. *Key Words* Child Safety Seat Child Fatality Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
19 *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 18	22. *Price*

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

IN07015

Page No.

BACKGROUND

IN07015

This crash was brought to the National Highway Traffic Safety Administration's attention on or before May 8, 2007 by an on-line news article from a Wisconsin television station. This crash involved a 1995 Jeep Cherokee Sport 4x4 and a 1997 Chevrolet C1500 extended cab 4x2 pickup truck. The crash occurred in May, 2007, at 3:11 p.m., in Wisconsin and was investigated by the applicable county sheriff's department. This crash is of special interest because the Jeep's back center passenger (5-week-old, male), was seated in a child safety seat and sustained fatal injuries as a result of the crash. This contractor interviewed the Jeep's driver on June 1, 2007. The Jeep, the Chevrolet and the crash scene were inspected on June 2 and 3, 2007. This report is based on the sheriff's department crash report, scene and vehicle inspections, an interview with the Jeep's driver and the investigating sheriff's deputy, occupant kinematic principles, occupant medical records and this contractor's evaluation of the evidence.

SUMMARY

The Jeep Cherokee was traveling north in the northbound lane of a rural, two-lane, state highway. The Chevrolet C1500 was traveling south in the southbound lane. The Jeep entered the southbound lane resulting in an offset frontal impact with the Chevrolet. The impact caused the Jeep's driver air bag to deploy. The Chevrolet's driver and front right passenger air bags also deployed. Following the impact, the Jeep rotated clockwise, departed the west side of the roadway and rolled over, driver side leading, two quarter rolls into a ditch. The Jeep came to final rest on its top in the ditch heading southeast. The Chevrolet rotated clockwise and came to final rest in the middle of the roadway heading northwest. At the time of the crash, it was daylight, cloudy with no precipitation, and the bituminous road surface was dry and free of defects. As a result of the crash, the Jeep's front end sustained 103 centimeters (40.6 inches) of residual maximum crush occurring at C_6. The Chevrolet's front end sustained 144 centimeters (56.7 inches) of residual maximum crush occurring at C_6. The presence of a winch and brush guard on the Jeep's front bumper altered the Jeep's stiffness properties and rendered the vehicle out of scope for the WinSMASH reconstruction program. However, based on experience and the crush to both vehicles, the Jeep's crash severity was estimated to be in a range of 72 to 89 km.p.h. (45 to 55 m.p.h.).

The Jeep's back center passenger was restrained in an Evenflo Discovery rear-facing infant seat with base. The infant seat was manufactured by Evenflo on December 22, 2006. The model number was 3911698L2. The infant seat base was secured in the back center seat position with the Jeep's lap belt, and the infant seat was snapped into the base. The infant seat was deformed and cracked as a result of this crash. The back center passenger sustained fatal injuries including multiple skull fractures and brain injuries due to impacting his head on the intruding roof structure during the crash. The Jeep's driver was restrained. She sustained a police reported A (incapacitating injury) and was hospitalized. The Jeep's front right passenger and back left passenger were both unrestrained and sustained fatal injuries.

Crash Environment: The trafficway on which the Jeep Cherokee was traveling was a straight, two-lane, undivided, state highway, traversing in a north-south direction. The Chevrolet C1500 was traveling in the opposite direction on the same trafficway. There was one travel lane in each direction and each was approximately 3.6 meters (12 feet) in width. Roadway pavement markings consisted of solid white edge lines, broken yellow passing permitted line for northbound traffic and a solid yellow no-passing line for southbound traffic. The roadway was bordered by bituminous shoulders. The east shoulder was 0.9 meter (3 feet) in width and the west shoulder was 0.7 meter (2.3 feet) in width. There were also wide gravel shoulders on the outside of each paved shoulder. The east gravel shoulder was 2.6 meters (8.5 feet) in width and the west gravel shoulder was 2.8 meters (9.1 feet) in width. In addition, there was a ditch on each side of the roadway. The roadway grade on the Jeep's approach to impact was 1.3% negative. The roadway grade on the Chevrolet's approach to impact was 2% positive. The speed limit was 89 km.p.h. (55 m.p.h.). At the time of the crash, the light condition was daylight, the atmospheric condition was cloudy, and the roadway pavement was dry, traveled bituminous with an estimated coefficient of friction of 0.68. Traffic density was moderate and the site of the crash was a rural farming area. See the Crash Diagram at the end of this report.

Pre-Crash: The Jeep Cherokee was traveling north in the northbound lane (**Figure 1**). The Jeeps's driver was intending to continue northbound. The Chevrolet C1500 was traveling south in the southbound lane (**Figure 2**). The Chevrolet's driver was intending to continue southbound. As the Jeep and the Chevrolet approached one another, the Jeep suddenly crossed the centerline and entered the southbound travel lane. The Jeep's driver had no recollection of the crash events and did not know why she crossed into the southbound lane. The statements of two witnesses, who were traveling northbound behind the Jeep, indicated that the Jeep appeared to lose control. One of the witnesses indicated that he saw no brake lights from the Jeep indicating that the Jeep's driver took no pre-crash braking action. The crash occurred in the southbound lane (**Figure 3**).

Figure 1: Approach of Jeep northbound to impact area (arrow)

Figure 2: Approach of Chevrolet southbound to impact (arrow)

Crash: As the Jeep entered the southbound lane, its front right (**Figure 4**) impacted the front right of the Chevrolet (**Figure 5**). The impact caused the Jeep's driver air bag to deploy. The Chevrolet's driver and front right passenger air bags also deployed. Following the impact, the

Jeep rotated clockwise, departed the west side of the roadway and rolled over, driver side leading, two quarter turns into a ditch (**Figure 6**).

Figure 3: View north to impact gouges in southbound lane

Figure 4: Damage to Jeep from impact with front of the Chevrolet; vertical scale in tenths of meter, each increment on measurement rods in 5 cm (2 in)

Figure 5: Overview of damage to front of Chevrolet due to impact with front of Jeep

Figure 6: View northwest through impact area to area where Jeep rolled over into ditch (arrow)

Post-Crash: The Jeep came to rest on its top in the ditch on the west side of the roadway heading southeast. The Chevrolet rotated clockwise approximately 150 degrees and came to final rest in the middle of the roadway heading northwest. The sheriff department's crash report indicated that the jeep's driver was trapped inside the vehicle, and the front right passenger was partially ejected through the right front window.

CASE VEHICLE

The 1995 Jeep Cherokee Sport was a four wheel drive, four-door sport utility vehicle (VIN: 1J4FJ68S3SL------) equipped with a 4.0L, I-6 engine and an automatic transmission. The front seating row was equipped with a driver's air bag, bucket seats with integral head restraints and lap-and-shoulder, safety belts. The back seating row was equipped with a bench seat with

folding back, lap-and-shoulder safety belts in the outboard seating positions and a two-point lap belt in the middle seating position.

CASE VEHICLE DAMAGE

Exterior Damage: The Jeep Cherokee's impact with the Chevrolet C1500 involved the front end. The front bumper, grille, hood and right fender were directly contacted and crushed rearward. The Jeep was equipped with a winch and brush guard on the front bumper, which was also directly contacted and crushed rearward. The direct damage from the front plane extended down the right side in a sideswipe type configuration. The direct damage to the front end began at the front right bumper corner and extended 76 centimeters (29.9 inches) across the front end. Crush measurements were taken at the bumper level, and the residual maximum crush was measured as 103 centimeters (40.6 inches) occurring at C_6 (**Figure 7**). The rollover damage was minor and involved only surface scratches to the hood and the roof. The majority of the damage to the roof structure (**Figure 8**) was due to induced damage related to the collapse of the passenger compartment from the severe front impact. The table below shows the Jeep's front crush profile.

Figure 7: Top view of crush to front of Jeep

Figure 8: Induced damage folds to roof structure of Jeep due to front impact with the Chevrolet

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	76	103	77	0	26	49	66	84	117	21	0
in		29.9	40.6	30.3	0.0	10.2	19.3	26.0	33.1	46.1	8.3	0.0

The front impact reduced the right side wheelbase 85 centimeters (33.5 inches) and extended the left side wheelbase 12 centimeters (4.7 inches). Induced damage involved the hood, left fender, left and right quarter panels and the roof.

Damage Classification: The Jeep's front impact with the front of the Chevrolet produced extensive front crush, which then became sideswipe type damage that extended down the right side of the Jeep. This damage pattern met the requirements for a conversion CDC, which is intended to capture both damage patterns resulting from a single impact with two CDCs. The two CDCs were determined be: **12-FZEK-4** (**0** degrees) and **12-RYAS-2** (**0** degrees). The CDC for the rollover damage was determined to be **00-TDDO-1**.

The presence of a winch and brush guard on the Jeep's front bumper altered the Jeep's stiffness properties. In addition, the crush to the front of the Jeep was severe enough to collapse the passenger compartment. This indicated that this crash is beyond the scope of the WinSMASH reconstruction program's stiffness coefficients, regardless of the presence of the winch and brush guard, to reasonably model the Jeep's crush characteristics. The stiffness coefficients used in the WinSMASH program are derived from 35 m.p.h. barrier tests, which do not adequately model the dynamics of the crush sustained by the Jeep in this crash. Based on experience and the crush to both vehicles, this contractor estimated the crash severity to be in a range of 72 to 89 km.p.h. (45 to 55 m.p.h.). The crash severity of the rollover was determined to be minor. The Jeep was towed from the scene due to damage.

The Jeep's manufacturer's recommended tire size was P215/75R15. The Jeep was equipped with P225/75R15 size tires. The Jeep's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	303	44	228	33	6	7	None	No	No
RF	Flat	Flat	228	33	5	6	Cut in tread	Yes	Yes
LR	193	28	228	33	7	9	None	No	No
RR	255	37	228	33	7	9	None	No	No

Vehicle Interior: Inspection of the Jeep's interior revealed that the passenger compartment had been severely compromised due to the offset frontal impact, and several areas of occupant contact were identified. The top left of the steering wheel rim was displaced forward approximately 2 centimeters (0.8 inch) indicating the driver had ridden down her deployed air bag and loaded the steering wheel. Rescue personnel had cut the steering wheel off the column. The driver's seat back was deformed forward and hair transfers was found on the roof just behind the driver's seat, indicating the unrestrained back left passenger had impacted the driver's seat back, rode up the seat back and impacted the roof. There was hair transfer and blood on the intruded roof just behind the front right passenger's seat, as well as hair transfer on the back left portion of the front right passenger's seat back. Both of these were due to contact by the back left passenger. There was also a heavy blood deposit on the roof near the left roof side rail in the cargo area indicating the location where the back left passenger came to final rest. The right instrument panel was

heavily intruded and with the panel fractured indicating the unrestrained front right passenger had heavily loaded the right instrument panel. A large blood deposit was also found on the roof above the driver's seat indicating the driver came to rest with her head against the roof.

The Jeep sustained numerous intrusions in this crash. The most severe intrusions occurred in the front right occupant space: The right instrument panel intruded longitudinally 88 centimeters (34.6 inches). The right toe pan intruded longitudinally 111 centimeters (43.7 inches). The right A-pillar intruded longitudinally 88 centimeters (34.6 inches), and the windshield header intruded vertically 27 centimeters (10.6 inches). There was also severe intrusion of the roof into the back right occupant space of 52 centimeters (20.5 inches), in addition the roof intruded into the back center seat position 45 centimeters (17.7 inches).

AUTOMATIC RESTRAINT SYSTEM

The Jeep Cherokee was equipped with a driver air bag, which deployed due to the front impact with the Chevrolet. The vehicle was not equipped with a front right passenger air bag. The driver's air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points. There was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with four tether straps. The air bag was not equipped with vent ports, so the width of the tether straps could not be determined. The deployed driver's air bag was round with and 60 centimeters (23.6 inches) in diameter. The air bag had been contacted and ridden down by the driver during the crash as evidenced by the deformation of the steering wheel; however, there was no evidence of scuffs or transfers on the air bag. There was, however, blood splatters on the front and back of the air bag.

Figure 9: Jeep's back center infant seat

CHILD SAFETY SEAT

The Jeep's back center passenger was restrained in an Evenflo Discovery rear-facing infant seat with a base (**Figures 9** and **10**). The infant seat was manufactured by Evenflo on December 22, 2006. The model number was 3911698L2. The infant seat was designed with a three-point harness, which buckled into a recessed buckle located between the infant's legs. There were two sets of slots on the back of the infant seat to thread the harness straps through, depending on the size of the infant. The harness straps were threaded through the bottom set of slots. A harness retainer clip was found attached to the harness straps at a level that would probably

correspond to the infant's chest area. The infant seat base was designed to be installed with a vehicle's safety belt system. In addition, the base was equipped with a Lower Anchors and Tethers for Children (LATCH) attachment for use with a vehicle's LATCH system; however, the Jeep was not equipped with lower anchors or a tether hook. The infant seat base had been secured with the Jeep's lap belt, which was equipped with a locking latch plate. A blanket had been folded up and placed under the base in order to level it (**Figure 10**). The Jeep's driver indicated that when she installed the base, she pressed down on it and pulled the lap belt tight. She also indicated that the infant seat's three-point harness was snug on the infant, the harness retainer clip was at the infant's chest level and there was approximately one finger of space between the harness straps and the infant's chest. The infant seat was then snapped into the base. Lastly, the Jeep's driver indicated she had attended a child safety seat clinic.

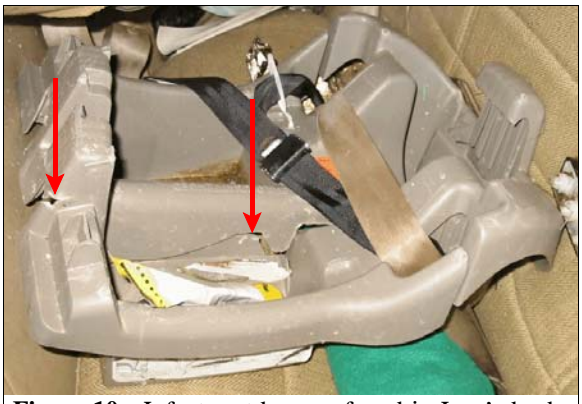


Figure 10: Infant seat base as found in Jeep's back center seat position, arrows show fractures in plastic

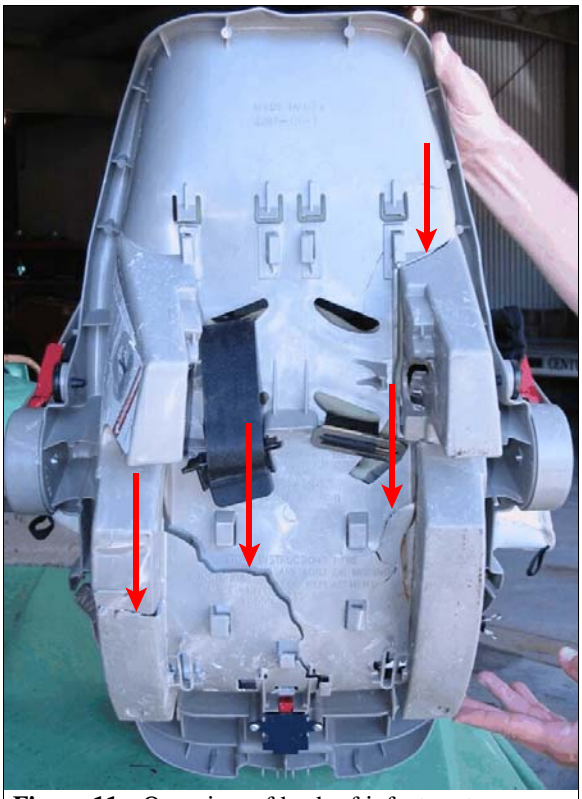


Figure 11: Overview of back of infant seat, arrows show cracks in plastic shell

The infant seat and base were constructed of a one piece plastic shell. The infant seat was equipped with a carrying handle, quilted cover and 2.5 centimeters (1 inch) thick foam pad. It was designed for use by children who weigh between 2.3 and 10 kilograms (5 and 22 pounds) and whose height is 74 centimeters (29 inches) or less.

Inspection of the infant seat and base revealed evidence that they had been heavily loaded during the crash. The back and bottom of the plastic shell were broken (**Figure 11**) and the base was fractured in several places (**Figure 10**). In addition, there were signs of stress to the plastic in the form of light colored striations throughout the infant seat and the base. The base was twisted to the right and bent forward slightly. The damaged condition of the infant seat and base indicated that they were heavily loaded, probably as the infant seat and base were compressed between the front right passenger's seat back and the rear seat back as the front right passenger seat was displaced rearward during the front impact (**Figures 10**, **12** and **13**). In addition, the Jeep's back center lap belt and the infant seat had loaded against the base. It is also possible that the unrestrained back left passenger had impacted the infant seat during the crash. Lastly, the back center passenger had loaded the harness straps and back of the infant seat. As a result of the loading, both the infant seat and base

had been severely flexed, deformed and cracked in this high severity crash. Based on information from the investigating sheriff's deputy, the infant seat was found still attached to the base following the crash.

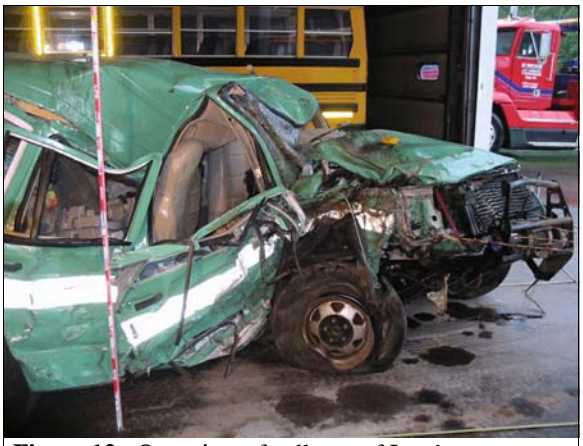


Figure 12: Overview of collapse of Jeep's passenger compartment and rearward displacement of front right passenger seat

Figure 13: View from left showing Jeep's front right seat back pressed against back seat cushion and intrusion of roof into back right and back center seat positions

CASE VEHICLE BACK CENTER PASSENGER KINEMATICS

Prior to the crash, the Jeep Cherokee's back center passenger [5-week-old, male; 53 centimeters and 5 kilograms (21 inches, 11 pounds)] was seated in a reclined position in his rear-facing infant seat. His feet and hands were within the infant seat. The forward/rearward position of the Jeep's seat was not adjustable.

Based on the vehicle and child safety seat inspections, discussions with the investigating sheriff's deputy and an interview with the Jeep's driver (mother of this passenger), the back center passenger was restrained in his infant seat by the three-point harness. The infant seat was snapped into the base, which was secured with the Jeep's two-point lap belt.

The Jeep's front impact with the Chevrolet caused the back center passenger to continue forward opposite the Jeep's 0 degree direction of principal force as the Jeep decelerated. The child loaded the harness straps and the back of the infant seat. The child sustained multiple rib fractures, a fracture of the right clavicle, bilateral lung contusions and a lacerated liver due to loading of the harness straps. In addition, the passenger probably contacted his head on the intruding roof (**Figure 13**) causing multiple skull fractures and brain injuries. The passenger remained restrained in the infant seat as the Jeep rotated clockwise and rolled over onto its top. At final rest, the passenger remained restrained in his infant seat and was suspended upside down. A passer-by removed the child from his infant seat.

CASE VEHICLE BACK CENTER PASSENGER INJURIES

The child was transported by ambulance to a local hospital and then airlifted to a trauma center. He died of his injuries and was pronounced dead 4 hours and 17 minutes following the crash. The child's injuries and injury mechanisms are shown in the table below.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
	Nonanatomic brain injury with loss of consciousness, unresponsive, pupils fixed and dilated, GCS=3	not coded	Roof {intruded}	Probable	Hospitalization records
1	Brainstem compression {bilateral transtentorial herniation}	critical 140202.5,8	Roof {intruded}	Probable	Hospitalization records
2	Hemorrhage, extra-axial, over left frontal convexity, not further specified	severe 140629.4,2	Roof {intruded}	Probable	Hospitalization records
3 4	Brain swelling, massive, diffuse bihemispheric with loss of gray-white junction, absence of basal cisterns[1], ventricles slit-like	critical 140666.5,1 140666.5,2	Roof {intruded}	Probable	Hospitalization records
5 6	Hemorrhage, intraventricular, in occipital horns of both lateral ventricles and blood in 3rd and 4th ventricles	severe 140678.4,1 140678.4,2	Roof {intruded}	Probable	Hospitalization records
7 8	Hemorrhage, subarachnoid, extensive, throughout basilar cisterns[1] and anterior temporal tips	serious 140684.3,1 140684.3,2	Roof {intruded}	Probable	Hospitalization records
9	Contusions lungs {pulmonary}, bilaterally, severe, not further specified	severe 441410.4,3	Child safety seat harness straps	Probable	Hospitalization records
10	Contusion {hematoma} mediastinal {pleura}	moderate 441804.2,4	Child safety seat harness straps	Probable	Hospitalization records
11	Laceration liver, grade V, not further specified	critical 541828.5,1	Child safety seat harness straps	Probable	Hospitalization records
12	Fracture, diastatic, right calvarium along coronal suture with 6 mm widening, extending posteriorly and superiorly to vertex with displacement	moderate 150402.2,1	Roof {intruded}	Probable	Emergency room records

[1] The following terms are} defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
cistern (sis′tern): a closed space serving as a reservoir for fluid; see also *cisterna*.
basal c.: cisterna interpeduncularis.
cisterna (sis-ter′na) **pl.** ***cister′nae***: a cistern -- a closed space serving as a reservoir for lymph or other body fluid, especially one of the enlarged subarachnoid spaces containing cerebrospinal fluid.
c. interpeduncula′ris: interpeduncular cistern -- a dilatation of the subarachnoid space between the cerebral peduncles; called also *basal cistern*.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
13	Fracture left calvarium extending superiorly along mastoid portion of temporal bone and through temporal bone superiorly to vertex with comminution and mild depression	serious 150404.3,2	Roof {intruded}	Probable	Emergency room records
14	Fracture, comminuted, open with cerebrospinal fluid leak, in occiput involving squamosal portion of left temporal bone, right side of clivus[2], right occipital condyle, and extending into infrasellar portions of sphenoid bodies	severe 150206.4,8	Roof {intruded}	Probable	Hospitalization records
15	Fracture, non-displaced, mid right clavicle	moderate 752200.2,1	Child safety seat harness straps	Probable	Hospitalization records
16	Fracture ribs: 1st rib bilaterally and right 6th, 7th, and 8th, not further specified	serious 450230.3,3	Child safety seat harness straps	Probable	Emergency room records
17	Contusion {subgaleal hematoma} over vertex and on bilateral temporal regions, not further specified	minor 190402.1,1	Roof {intruded}	Probable	Emergency room records
18		minor 190402.1,2	Child safety seat's left side surface	Probable	Emergency room records

CASE VEHICLE DRIVER KINEMATICS

The Jeep's driver [43-year-old, female; 152 centimeters and 61 kilograms (60 inches, 134 pounds)] was seated in an upright position with both hands on the steering wheel at the 3 and 9 o'clock positions, her back was against the seat back and her left foot on the floor. Based on a witness statement, she was not applying the brakes; however, the position of her left and right foot is not known. The driver's seat track was adjusted to near its forward-most position and her seat back was upright. The steering column was adjusted to its center position. The driver was not wearing glasses or contact lenses at the time of the crash.

---

[2] The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
clivus (klī′vas) [L. "slope"]: a bony surface in the posterior cranial fossa, sloping superiorly from the foramen magnum to the dorsum sellae, the inferior part being formed by a portion of the basilar part of the occipital bone © *ossis occipitalis*) and the superior part by a surface of the body of the sphenoid bone © *ossis sphenoidalis*).
c. os′sis occipita′lis: the lower part of the clivus, formed by the basilar portion of the occipital bone; called also *basilar c.* or *c. basilaris*, and *basilar groove of occipital bone*.
c. os′sis sphenoida′lis: the upper part of the clivus, formed by a surface of the body of the sphenoid bone; called also *basilar groove of sphenoid bone*.

Based on the vehicle inspection, the Jeep's driver was restrained by her lap-and-shoulder safety belt system. Friction burns were found on the sliding latch plate and the safety belt had been completely cut out of the vehicle by rescue personnel during the extrication of the driver.

The driver made no pre-crash braking avoidance maneuver and her pre-impact body position did not change significantly prior to impact. The Jeep's impact with the Chevrolet caused the driver to continue forward opposite the Jeep's 0 degree direction of principal force as the Jeep decelerated. The driver loaded her safety belt system and her face and chest impacted the deployed air bag. The driver rode down the air bag and her chest loaded and deformed the top left portion of the steering wheel causing a lung contusion. The driver rebounded back into her seat and probably moved to the left and up against the left front door as the Jeep rotated clockwise post-impact and began to roll over driver side leading. The driver moved toward the roof within her safety belt as the Jeep rolled over onto its top. The driver probably impacted her head on the left roof side rail causing a subarachnoid hemorrhage and non-anatomic brain injury. The driver remained restrained in her seat with her head against the roof and left roof side rail as the Jeep came to final rest on its roof. She was reported as entrapped on the sheriff department's crash report. Rescue personnel removed the left front door, cut the steering wheel and cut the driver's safety belt in order to remove her from the Jeep.

CASE VEHICLE DRIVER INJURIES

The sheriff department's crash report indicated that the driver sustained A (incapacitating) injuries and was transported by ambulance to a hospital. The driver was hospitalized for 7 days. The driver reported that she received follow-up treatment from a chiropractor. The table below shows the driver's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
	Nonanatomic brain injury without loss of consciousness, but lethargic/obtundent on initial examination; GCS=12, 14	not coded	Roof, left front side rail {intruded}	Probable	Hospitalization records
1 2	Hemorrhage, subarachnoid, scattered within parietal sulci[3] near vertex, right greater than left	serious 140684.3,1 140684.3,2	Roof, left front side rail {intruded}	Probable	Hospitalization records
3	Contusion lung {pulmonary}, not further specified	serious 441402.3,9	Steering wheel hub and/or spokes and rim	Possible	Hospitalization records

[3] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
fissure (fish′ar): any cleft or groove, normal or otherwise; especially a deep fold in the cerebral cortex which involves the entire thickness of the brain wall. Compare *sulcus*.
sulcus (sul′kas) pl. ***sul′ci (sul′si)***: a groove, trench, or furrow; a general term for such a depression, especially one of those on the surface of the brain, separating the gyri. Compare *fissure*.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
4	Contusion renal, not further specified	moderate 541610.2,9	Unknown contact mechanism	Unknown	Emergency room records
5	Abrasion right cornea with swelling, hypersensitivity, ptosis[4], and blurred vision related to contact	minor 240602.1,1	Air bag, driver's	Probable	Hospitalization records
6	Contusion right eye with scleral edema	minor 297402.1,1	Air bag, driver's	Probable	EMS treatment record
7	Abrasion right face, not further specified	minor 290202.1,1	Air bag, driver's	Probable	Emergency room records
8	Abrasion chest wall, not further specified	minor 490202.1,4	Torso portion of safety belt system	Certain	Emergency room records
9	Contusion {hematoma} across left chest, not further specified	minor 490402.1,2	Torso portion of safety belt system	Certain	Hospitalization records
10	Abrasion abdomen, not further specified	minor 590202.1,8	Lap portion of safety belt system	Certain	Emergency room records
11	Contusion down to right abdomen and across abdomen	minor 590402.1,0	Lap portion of safety belt system	Certain	Emergency room records
12	Contusion, ecchymosis right anterior upper arm	minor 790402.1,1	Air bag, driver's	Probable	Emergency room records
13	Abrasions, small, on arms bilaterally, not further specified	minor 790202.1,3	Air bag, driver's	Probable	EMS treatment record
14	Contusion {ecchymosis} right lateral upper thigh, not further specified	minor 890402.1,1	Steering wheel rim	Possible	Emergency room records
15	Laceration right lateral upper thigh, not further specified	minor 890600.1,1	Steering wheel rim	Possible	Emergency room records
16	Contusions {ecchymoses} anterior lower legs, not further specified	minor 890402.1,3	Left lower instrument panel and/or knee bolster	Probable	Emergency room records

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

The Jeep's front right passenger [55-year-old, white, (non-Hispanic) male; 180 centimeters and 109 kilograms (71 inches, 240 pounds)] was seated in an upright position with his back against the seat back, his feet on the floor and his hands in his lap. The front right passenger's seat track

[4] The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
***ptosis (to'sis)* [Gr pt oo sis fall]**: 1. *prolapse*. 2. drooping of the upper eyelid from paralysis of the third nerve or from sympathetic innervation; called also *blepharoptosis*.

was adjusted to its rear-most position and his seat back was slightly reclined. The front right passenger was wearing glasses at the time of the crash.

Based on the vehicle inspection, the Jeep's front right passenger was not restrained by his lap-and-shoulder safety belt system. Inspection of the safety belt assembly showed evidence of historical usage, but no evidence of loading.

The Jeep's driver made no pre-crash braking avoidance maneuver and therefore the front right passenger's pre-impact body position did not change significantly just prior to impact. The Jeep's front impact with the Chevrolet caused the unrestrained passenger to continue forward opposite the Jeep's 0 degree direction of principal force as the Jeep decelerated. The front right passenger's chest and arms impacted the intruding instrument panel, his knees impacted the intruding knee bolster and his face impacted the intruding windshield. As the Jeep rotated clockwise, the passenger moved to his left and his head probably contacted the intruded roof. As the Jeep rolled over, driver side leading, the passenger moved toward the roof and his head and body contacted it. The front right passenger was partially ejected through the right front window during the rollover and came to rest on the interior roof over the front right passenger seat with the upper half of his body extending out of the right front window. He was removed from the vehicle by rescue personnel.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The sheriff department's crash report indicated that the front right passenger sustained fatal injuries. This contractor was unable to obtain injury information on this passenger because the hospital refused cooperation.

CASE VEHICLE BACK LEFT PASSENGER KINEMATICS

The Jeep's back left passenger [29-year-old, female; 147 centimeters and 48 kilograms (58 inches, 105 pounds)] was seated in an upright position with her back against the seat back and her feet on the floor. The back left passenger's seat track and seat back were not adjustable. The passenger was not wearing glasses or contact lenses at the time of the crash.

Based on the vehicle inspection, the Jeep's back left passenger was not restrained by the lap-and-shoulder safety belt system. Inspection of the safety belt assembly showed signs of historical usage, but no evidence of loading or usage in this crash.

The Jeep's driver made no pre-crash braking avoidance maneuver and therefore the back left passenger's pre-impact body position did not change significantly just prior to impact. The Jeep's front impact with the Chevrolet caused the unrestrained passenger to continue forward opposite the Jeep's 0 degree direction of principal force as the Jeep decelerated. She impacted and deformed the driver's seat back forward causing lacerations to her liver, spleen, and kidneys, an open fracture to her left radius and an injury to her inferior vena cava. The passenger rode up the seat back and impacted her head on the roof leaving a transfer of hair on the roof and causing multiple brain injuries. The passenger rebounded back into her seat as the Jeep rotated clockwise

post-impact. She contacted the intruded roof structure behind the front right passenger's seat as well as the front right passenger's seat back as the vehicle rolled over, driver side leading. In addition, it is probable that she impacted the back center passenger's infant seat. The Jeep rolled over in a ditch with the rear portion of the Jeep landing in the bottom of the ditch and the front portion of the vehicle on the side of the ditch. As a result, the back left passenger was thrown toward the back left as the vehicle came to rest on its roof. She came to rest with her head on the roof over the cargo area near the left roof side rail, as evidenced by a large blood deposit on the roof in this location.

CASE VEHICLE BACK LEFT PASSENGER INJURIES

The sheriff department's crash report indicated the back left passenger was transported from the scene by ambulance to a hospital and was admitted for treatment of her injuries. The back left passenger's medical records indicated that she died three days following the crash. The table below shows the back left passenger's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
	Nonanatomic brain injury with coma, unresponsive to stimulation, flaccid, pupils dilated and unresponsive, no corneal, gag, or cold chloric responses, brain death	not coded	Roof {intruded}	Certain	Hospitalization records
1	Hematoma, subdural, small left frontal high convexity; grew to large left frontal lobe and left temporal lobe	critical 140656.5,2	Roof, left front side rail {intruded}	Probable	Hospitalization records
2	Brain swelling with slight mass effect grew to 4-8 mm (0.2-0.3 in) midline shift left-to-right, with effacement of brain tissue; hydrocephalus developed	critical 140666.5,2	Roof {intruded}	Certain	Hospitalization records
3 4	Intraventricular hemorrhage, extending into frontal horns and involving all ventricular system	severe 140678.4,1 140678.4,2	Roof {intruded}	Certain	Hospitalization records
5	Brainstem compression {tonsillar herniation} resulting from brain swelling	critical 140202.5,8	Roof {intruded}	Certain	Hospitalization records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
6	Laceration liver, grade V, with significant arterial extravasation[5], requiring hepatic embolization[5]	critical 541828.5,1	Seat back, driver's	Probable	Hospitalization records
7	Injury inferior vena cava, not further specified	serious 521299.3,7	Seat back, driver's	Probable	Hospitalization records
8	Laceration spleen, not further specified	moderate 544220.2,2	Seat back, driver's	Probable	Hospitalization records
9 10	Lacerations kidneys, bilaterally, not further specified	moderate 541620.2,1 541620.2,2	Seat back, driver's	Probable	Hospitalization records
11	Contusion {hematoma}, large, liver, not further specified	serious 541814.3,1	Seat back, driver's	Probable	Hospitalization records
12	Fracture, compression, L_1, not further specified	moderate 650632.2,8	Seat cushion, back left passenger's	Possible	Hospitalization records
13	Fracture clavicle, not further specified	moderate 752200.2,9	Head restraint, driver's seat	Possible	Hospitalization records
14	Fracture, open, left radius, not further specified	serious 752804.3,2	Seat back, driver's	Probable	Hospitalization records
15	Fracture left ulna, not further specified	moderate 753202.2,2	Seat back, driver's	Probable	Hospitalization records
16	Abrasion right scalp, not further specified	minor 190202.1,1	Roof {intruded}	Probable	Hospitalization records
17	Contusion right chest, not further specified	minor 490402.1,1	Seat back, driver's	Probable	Emergency room records
18	Abrasions bilateral shoulders, not further specified	minor 790202.1,3	Seat back, driver's	Probable	Emergency room records
19	Contusions bilateral shoulders, not further specified	minor 790402.1,3	Seat back, driver's	Probable	Emergency room records
20	Contusion left hand, not further specified	minor 790402.1,2	Left side interior surface rearward of left "B"-pillar	Possible	Emergency room records
21	Laceration {puncture wound}, 1 cm (0.4 in) left hand, not further specified	minor 790602.1,2	Noncontact injury: flying glass, unknown source	Possible	Emergency room records

[5] The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
embolization (em"be-li-za'shen): 1. the process or condition of becoming an ***embolus***. 2. therapeutic introduction of a substance into a vessel in order to occlude it; called also *embolotherapy*.
extravasation (ek-strav"e-sa'shen): 1. a discharge or escape, as of blood, from a vessel into the tissues. 2. the process of being extravasated. 3. blood or other substance which has been extravasated.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
22	Contusion {bruised} and swelling right hand, not further specified	minor 790402.1,1	Floor, center console	Probable	Hospitalization records
23	Abrasion right lateral lower leg, not further specified	minor 890202.1,1	Floor, center console	Possible	Emergency room records
24	Contusions {bruises} on lower legs, not further specified	minor 890402.1,3	Seat back, driver's	Probable	Emergency room records
25	Abrasion right ankle, not further specified	minor 890202.1,1	Seat back, driver's	Probable	Emergency room records

OTHER VEHICLE

The 1997 Chevrolet C1500 was a rear wheel drive, extended cab pickup truck (VIN: 2GCEC19M4V1------) equipped with a 5.0L, V8 engine and automatic transmission with overdrive. The Chevrolet was also equipped with driver and front right passenger air bags and four wheel, anti-lock brakes.

Exterior Damage: The Chevrolet's impact with the Jeep involved its front plane. The front bumper, bumper fascia, hood, grille, radiator, both turn signal and headlamp assemblies, and both fenders were directly damaged and crushed rearward. The direct damage length was determined to be 171 centimeters (67.3 inches). The crush measurements were taken at the bumper level. The residual maximum crush was measured as 144 centimeters (56.7 inches) occurring at C_6 (**Figure 12**). The table below shows the Chevrolet's front crush profile.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	171	144	126	35	46	83	120	139	144	0	0
in		67.3	56.7	49.6	13.8	18.1	32.7	47.2	54.7	56.7	0.0	0.0

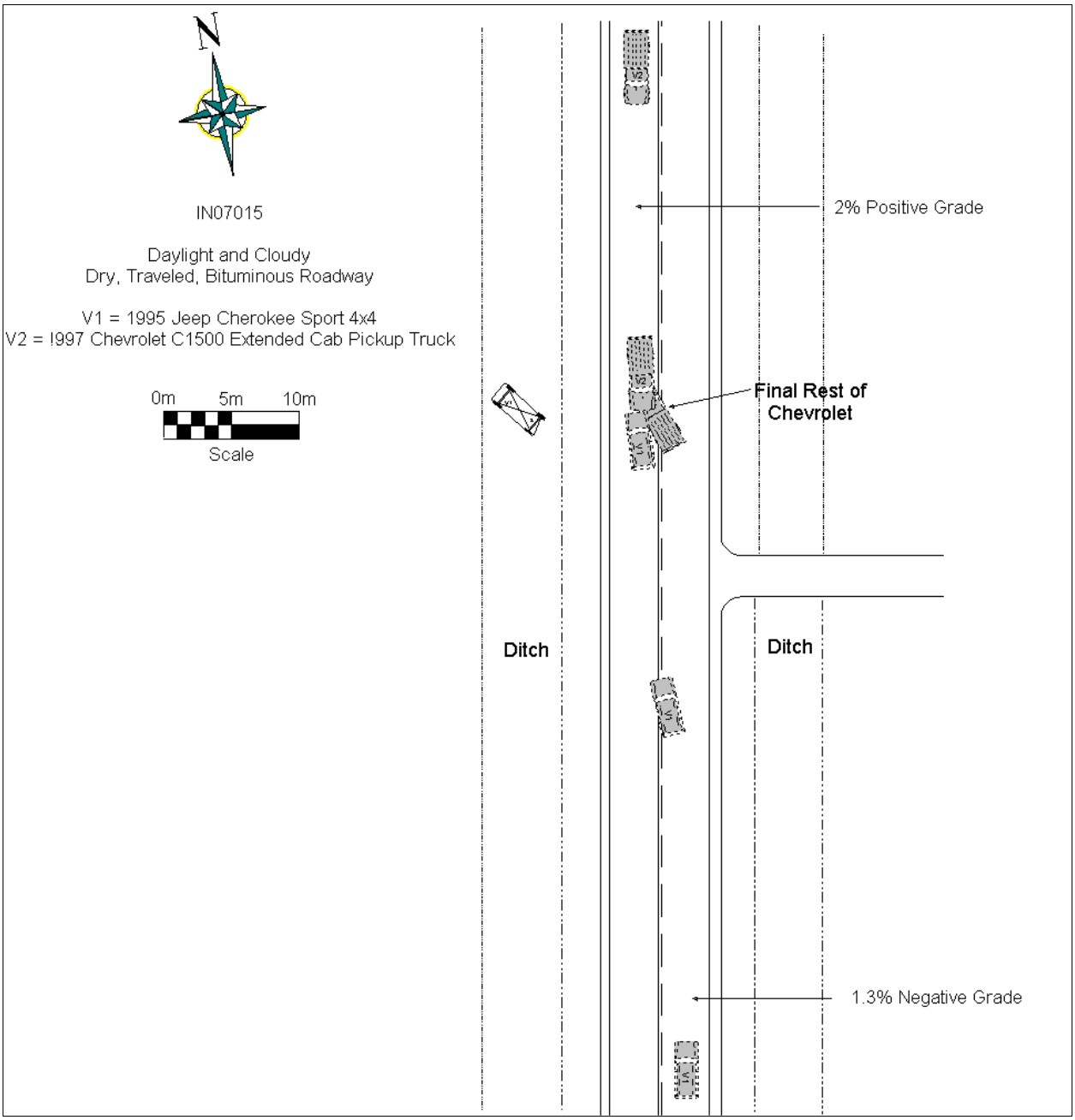
The Chevrolet's right side wheelbase was reduced 73 centimeters (28.7 inches) while the left side wheelbase was extended 11 centimeters (4.3 inches). Induced damage involved the hood, roof, right front door, right A-pillar, right B-pillar, right side of the cab, left front door and the left fender. In addition, the hood was displaced into the windshield.

The Chevrolet's recommended tire size was P235/75R15, and the Chevrolet was equipped with tires of this size. The Chevrolet's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	234	34	241	35	6	7	No	Yes	No
RF	241	35	241	35	6	7	Cut tread and sidewall	Yes	Yes
LR	Flat	Flat	241	35	4	5	None	No	No
RR	241	35	241	35	3	4	None	No	No

Damage Classification: Based on the vehicle inspection, the CDC for the Chevrolet was determined to be: **12-FDEW-5** (**0** degrees). Based on experience and the crush to both vehicles, this contractor estimated the crash severity to be in a range of 72 to 89 km.p.h. (45 to 55 m.p.h.). The Chevrolet was towed from the crash scene due to damage.

Chevrolet's Occupant: According to the sheriff's department crash report, the Chevrolet's driver [18-year-old, (unknown race and ethnic origin) male] was not restrained by the lap-and-shoulder safety belt system. The sheriff department's crash report indicated the driver sustained an A (incapacitating) injury and was transported by ambulance to a hospital.


N
IN07015
Daylight and Cloudy
Dry, Traveled, Bituminous Roadway
V1 = 1995 Jeep Cherokee Sport 4x4
V2 = I997 Chevrolet C1500 Extended Cab Pickup Truck
0m 5m 10m
Scale
Ditch
Ditch
2% Positive Grade
Final Rest of Chevrolet
1.3% Negative Grade