TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

VERIDIAN CASE NO. CA02-003

VEHICLE - 1989 GMC JIMMY

LOCATION - STATE OF OKLAHOMA

CRASH DATE - JANUARY 2002

Contract No. DTNH22-01-C-17002

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. *Abstract*

This on-site investigation focused on the performance of a rear-facing child safety seat (CSS) that was installed with a detachable base in the rear left position of a 1989 GMC Jimmy. The Jimmy was occupied by an 18-year-old restrained male driver, a 16-year-old female front right passenger, and a 4-month-old female who was restrained in the rear-facing infant CSS on the rear left position. The Jimmy was involved in a sideswipe collision with a 2000 Chevrolet Tahoe while both vehicles were executing a passing maneuver. The initial contact to the Jimmy resulted in a counterclockwise (CCW) rotation and left roadside departure which initiated a ten-quarter-turn tripped rollover with the right side leading. The Jimmy struck a utility pole after the tenth quarter turn while upside down with the left side area and came to rest on its roof adjacent to the pole. The restrained front seated occupants initiated lateral trajectories and loaded the manual restraints. The 4-month-old infant also initiated a lateral trajectory and loaded the harness system of the CSS which resulted in bilateral pulmonary contusions, left shoulder contusion, left abdominal abrasion, and a left thigh contusion. The severity of the rollover resulted in cerebral shear injury due to the infant's head motion. During the rollover, the infant's loading to the harness system caused the left side harness webbing to disengage from the adjustment slide and completely slide out of the harness slot. The infant was ejected from the CSS and from the vehicle through the left rear side window. Based on the lack of contact evidence in the vehicle and distance of the infant's final rest position relative to the vehicle, it appears the infant's trajectory out of the vehicle was unobstructed. She sustained multiple facial abrasions and lacerations, palpable skull fractures, and critical closed head injuries as a result of the ejection and impact with the ground. The driver struck the left side door frame and sustained multiple left scalp lacerations and avulsions. His left arm was partially ejected which resulted in a dislocated left elbow. He was transported by ambulance to a local hospital, transferred to a regional trauma center, and admitted. The front right passenger sustained a right fifth rib fracture, a right shoulder dislocation, a right clavicle fracture, a left lateral tibial plateau comminuted fracture, a left fibular head fracture, and seat belt-related abrasions as a result of contact with interior components and loading to the manual restraint. She was transported by helicopter to a regional trauma center and admitted. The infant was found on the roadside approximately 16 m (51') from the vehicle. She was transported by ambulance to a local hospital, transferred to a regional children's hospital, and expired five hours following the crash. The driver of the Tahoe was not injured and refused medical treatment at the scene.

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BACKGROUND

This on-site investigation focused on the performance of a rear-facing child safety seat (CSS) that was installed with a detachable base in the rear left position of a 1989 GMC Jimmy. The Jimmy was occupied by an 18-year-old restrained male driver, a 16-year-old female front right passenger, and a 4-month-old female who was restrained in the rear-facing infant CSS on the rear left position. The Jimmy was involved in a sideswipe collision with a 2000 Chevrolet Tahoe while both vehicles were executing a passing maneuver. The initial contact to the Jimmy resulted in a counterclockwise (CCW) rotation and left roadside departure which initiated a ten-quarter-turn tripped rollover with the right side leading. The Jimmy struck a utility pole after the tenth quarter turn while upside down with the left side area and came to rest on its roof adjacent to the pole **(Figure 1)**. The restrained front seated occupants initiated lateral trajectories and loaded the manual restraints. The 4-month-old infant also initiated a lateral trajectory and loaded the harness system of the CSS which resulted in bilateral pulmonary contusions, left shoulder contusion, left abdominal abrasion, and a left thigh contusion. The severity of the rollover resulted in cerebral shear injury due to the infant's head motion. During the rollover, the infant's loading to the harness system caused the left side harness webbing to disengage from the adjustment slide and completely pull out of the harness slot. The infant was ejected from the CSS and from the vehicle through the left rear side window. Based on the lack of contact evidence in the vehicle and distance of the infant's final rest position relative to the vehicle, it appears the infant's trajectory out of the vehicle was unobstructed. She sustained multiple facial abrasions and lacerations, palpable skull fractures, and critical closed head injuries as a result of the ejection and impact with the ground. The driver struck the left side door frame and sustained multiple left scalp lacerations and avulsions. His left arm was partially ejected which resulted in a dislocated left elbow. He was transported by ambulance to a local hospital, transferred to a regional trauma center, and admitted. The front right passenger sustained a right fifth rib fracture, a right shoulder dislocation, a right clavicle fracture, a left lateral tibial plateau comminuted fracture, a left fibular head fracture, and seat belt-related abrasions as a result of contact with interior components and loading to the manual restraint. She was transported by helicopter to a regional trauma center and admitted. The infant was found on the roadside approximately 16 m (51') from the vehicle. She was transported by ambulance to a local hospital, transferred to a regional children's hospital, and expired five hours following the crash. The driver of the Tahoe was not injured and refused medical treatment at the scene.

Figure 1. On-scene view of GMC Jimmy at final rest

This crash was found through a local newspaper by an instructor at the Transportation Safety Institute and the notification was forwarded to the Veridian SCI team on January 14, 2002. An on-site effort was assigned to the Veridian SCI team on Tuesday January 29, 2002. The field activities were initiated on February 5, 2002.

SUMMARY

Crash Site

This two-vehicle crash occurred on a two-lane undivided state roadway during the daylight hours of January 2002. The crash site was north of a four-leg intersection of the state roadway and a local dirt road. At the time of the crash, the asphalt road surface was dry and the weather was clear. The north/south roadway consisted of two asphalt travel lanes with paved shoulders separated by a dashed yellow centerline. The roadside environment consisted of grassy roadsides with negative slopes and fields. A wire fence with wood posts was located on the west roadside approximately 15 m (50') from the west road edge, and a wood fence was located on the east roadside approximately 15 m (50') from the east road edge. Utility poles were present on each roadside. Stop signs controlled east/west traffic entering the intersection. The scene schematic is included as **Figure 20**.

Pre-Crash

The 18-year-old driver of the GMC Jimmy was operating the vehicle southbound on the state roadway **(Figure 2)** at a driver-reported speed of approximately 100 km/h (60 mph). The 38-year-old female driver of the Chevrolet Tahoe was operating her vehicle southbound behind the Jimmy. The driver of the Jimmy stated that a slow-moving truck with a load of hay was traveling ahead of the Jimmy. As the Jimmy and Tahoe slowed behind the non-contact vehicle, the driver of the Tahoe initiated a passing maneuver around the Jimmy and the non-contact vehicle. The driver of the Jimmy did not detect the Tahoe overtaking his vehicle, and also initiated a passing maneuver around the non-contact vehicle. The driver of the Tahoe recognized the Jimmy encroaching onto the northbound lane and steered left in an attempt to avoid the collision. The driver of the Tahoe overcorrected right and braked as the vehicle traveled toward the left roadside and contacted the Jimmy while both vehicles were in the northbound lane.

Figure 2. Southbound approach to the crash site

Crash

The right front aspect of the Tahoe contacted the left rear corner of the Jimmy in a sideswipe configuration. Although the Tahoe was overtaking the Jimmy, the Jimmy was the dominant vehicle as it attempted the passing maneuver. The direction of force was in the 4 o'clock sector for the Tahoe and in the 10 o'clock sector for the Jimmy. The initial impact resulted in minor damage to both vehicles. The left aspect of the Jimmy's rear bumper appeared to snag on the front right corner of the Tahoe. The Jimmy initiated a CCW rotation on the northbound lane and departed the left roadside in a CCW yaw. The Jimmy traveled onto the west roadside and initiated a rollover with the right side leading **(Figure 3)**. The Jimmy rolled ten-quarter turns over an approximate distance of 45 m (150') in a southeast direction on the roadside. Numerous gouge marks were present on the soft roadside in the vehicle's trajectory. After the tenth quarter turn, the Jimmy was upside-down and struck a utility pole with the left front door area. The direction of force was non-horizontal (00) and the rollover event resulted in moderate damage to the Jimmy. The Jimmy came to rest upside down against the pole **(Figure 4)**.

Figure 3. Southbound rollover trajectory for the Jimmy showing final rest position

Figure 4. View of utility pole and final rest of the Jimmy

The Tahoe initiated a CW rotation and traveled back across the southbound lane in a CW yaw. The Tahoe traveled in a southeast direction an approximate distance of 55 m (180') on the southbound lane, and departed the right roadside. Furrows that measured approximately 10 m (30') in length from the left wheels were present along the negative slope of the roadside **(Figure 5)**. The furrowing of the left wheels tripped a three-quarter-turn rollover with the left side leading. The Tahoe came to rest adjacent to the furrows on the right side. The rollover resulted in moderate damage to the Tahoe.

Figure 5. Right road departure and furrows from the Tahoe

The data from the Tahoe's Event Data Recorder (EDR) was downloaded by the SCI investigator during the vehicle inspection. The EDR recorded a Near Deployment Event for the Tahoe which was attributed to the Tahoe's rollover. The data summary indicated the speed of the Tahoe five seconds prior to the near-event to have been 93 km/h (58 mph) and the speed one second before the near-event to have been 11 km/h (7 mph). Throughout the entire five seconds before the near-event, the throttle was at zero percent, and the brakes were fully applied. The EDR data summary is included as **Figure 21**.

Post-Crash

It was not known how the driver of the Tahoe exited the vehicle. She was not injured and refused medical treatment at the scene. The front seated occupants of the Jimmy were pinned in the vehicle. During the rollover, both occupants stated that they lost consciousness, and regained consciousness shortly after the vehicle came to rest on its roof. One of the passers-by that stopped to assist was a nurse. She immediately surveyed the overturned Jimmy and was advised by the front seated occupants that they were traveling with an infant in the rear seat. The passer-by could not determine if the infant was still restrained in the CSS, and attempted to remove the CSS from the vehicle. She stated that the CSS was installed with the vehicle's 3-point lap and shoulder belt and would not move. A second passer-by used a utility knife to cut the shoulder belt and the lap belt to remove the CSS. At that time, it was determined that the infant was no longer in the vehicle, and the passers-by began to search for the infant along the roadside. The infant was located face-down on the southeast corner of the intersection approximately 16 m (51') from the vehicle **(Figure 6)**. The first passer-by stabilized the posterior aspect of the infant and picked her up to expose her anterior aspect. She maintained stabilization of the infant until the ambulance arrived, and accompanied the infant to the hospital. The infant was transported to a regional trauma center where she expired five hours following the crash. The front-seated occupants of the Jimmy were removed by rescue personnel. Rescue personnel could not access the occupants through the right front door, and removed the left front door from the vehicle to remove them. The steering column was cut by rescue personnel, and it reportedly took 45 minutes to remove the occupants. The driver was transported by ambulance to a local hospital and transferred to a regional trauma center and admitted. The front right passenger was transported by helicopter to a regional trauma center and admitted.

Figure 6. View showing final rest position of the ejected infant relative to the Jimmy

VEHICLE DATA - 1989 GMC Jimmy

The 1989 GMC Jimmy was identified by the Vehicle Identification Number (VIN): 1GKCT18Z1K8 (production sequence omitted). The vehicle was a two-door, 4 x 4 sport utility vehicle equipped with a 4.3 liter, V6 engine, four-speed automatic transmission, power steering, power door locks, power windows, front disc, and rear drum brakes. The Jimmy was equipped with P235/75R15 tires that exhibited 3.2 mm (4/32) of tread depth. The driver stated that the right front door handle was inoperable pre-crash and the door could not be opened from outside of the vehicle. The vehicle was reported to have had over 402,235 km (250,000 miles) at the time of the crash.

The seating in the GMC Jimmy was configured with front bucket seats with integral head restraints and a rear two-person bench seat with a folding back. Both front bucket seats were covered with after-market seat covers at the time of the vehicle inspection.

Cargo in the vehicle was located in the back of the Jimmy behind the bench seat. The cargo was not restrained and included a tow chain, tire iron, vehicle jack, tool box, a bag of clothes, and miscellaneous packages.

VEHICLE DAMAGE

Exterior Damage - *1989 GMC Jimmy*

The initial sideswipe impact with the Tahoe resulted in minor damage on the left rear side aspect of the Jimmy. Although the rear bumper was deformed forward from rollover damage, the left corner of the rear bumper was torn rearward from snagging the Tahoe's right front corner. Longitudinal abrasions were also noted on the left rear quarter panel and 5 cm (2") of lateral crush was noted on the quarter panel forward of the bumper from this contact **(Figure 7)**. The Collision Deformation Classification (CDC) for the initial impact with the Tahoe was 10-LBES-1.

Figure 7. Initial contact damage

The 1989 GMC Jimmy sustained moderate damage as a result of the rollover event **(Figure 8)**. The front headlights and grille were separated from the vehicle and the front bumper was displaced. The hood was buckled and displaced. Both front fenders were deformed. The roof sustained severe crush at the right B-pillar and both C-pillars due to the rollover, and the roof rack was fractured and separated. The maximum left roof side rail crush was located 15 cm (6") forward of the B-pillar, and measured 10.2 cm (4.0") vertically. The left roof side rail was buckled upward 58 cm (23") aft of the leading edge of the left rear window 8.9 cm (3.5"). The maximum roof crush measured 41.9 cm (16.5"). The left and right A-pillars, B-pillars, and C-pillars were displaced from the rollover. The lateral and rearward displacement of the right A-pillar contributed to the upward bowing of the windshield header at the centerline and the windshield header was crushed vertically on the right side. The left B-pillar was crushed inward and the right B-pillar was bowed outward at the belt line. The left C-pillar was displaced forward and nearly compressed against the bottom aspect of the left rear window **(Figure 9)**. The right C-pillar was displaced laterally and forward. The backlight header was crushed downward with the most severe crush on the rear left corner. The right front door was deformed and bowed outward. It appears it may have been displaced by hydraulic spreaders during rescue attempts. The right rear quarter panel was deformed from contact with the ground. The rear tail gate and rear hatch were separated from the vehicle. Both front tires were deflated and debeaded. Lateral abrasions from the rollover were

Figure 8. View of rollover damage

Figure 9. Damage to rear aspect of roof and left C-pillar

present on the right roof side rail and the right side aspect of the Jimmy exhibited a large amount of dirt below the belt line and minor amounts of grass and dirt in the exterior trim. The CDC for the rollover event was 00-TDDO-4.

The subsequent utility pole impact resulted in moderate left front door area damage to the Jimmy. **(Figure 10)**. The left front door was removed from the vehicle by rescue personnel, and exhibited direct contact damage from the pole impact. The direct damage on the left front door was located 5 cm (2") forward of the rear aspect of the door, and extended forward 28 cm (11") in length. The maximum crush on the door panel measured 18 cm (7"). The left sill also sustained direct damage as a result of the pole impact. The damage along the left sill was located 3 cm (1") forward of the B-pillar and extended forward 28 cm (11") in length. The combined direct and induced damage along the left side from the pole impact began 27 cm (11") forward of the rear edge of the left front fender and extended rearward 198 cm (78") to 69 cm (27") aft of the left B-pillar at the mid-door level. Six crush measurements were taken along the left sill and were as follows: C1 = 0, C2 = 8 cm (3"), C3 = 13 cm (5"), C4 = 25 cm (10"), C5 = 11 cm (4"), C6 = 0. The maximum crush on the left sill was located 20 cm (8") forward of the left B-pillar and measured 30 cm (12"). The CDC for the utility pole impact was 00-LPEN-3.

Figure 10. Left side damage from pole impact

Interior Damage - *1989 GMC Jimmy*

Interior damage to the 1989 GMC was severe and attributed to compartment intrusion. The windshield was completely separated and all of the glazing was disintegrated from impact forces. The most severe roof intrusion was at the front right aspect where the roof was crushed vertically against the front right seat back **(Figure 11)**. The intrusions were as follows:

Figure 11. View through windshield showing intrusions

Position	Component	Intruded	Direction
11	Left roof side rail	10.2 cm (4.0")	Vertical
11	Roof	25.4 cm (10.0")	Vertical
13	Right roof side rail	41.9 cm (16.5")	Vertical

Position	Component	Intruded	Direction
13	Roof	41.9 cm (16.5")	Vertical
13	Right roof side rail	24.1 cm (9.5")	Lateral
21	Roof	32.4 cm (12.8")	Vertical
21	Left side interior panel	11.4 cm (4.5")	Lateral
21	Left B-pillar	15.2 cm (6.0")	Lateral
23	Right roof side rail	19.1 cm (7.5")	Vertical
Rear cargo area	Backlight header	32.4 cm (12.8")	Vertical

The entire instrument panel was separated from the vehicle. The glove box and center console were also separated. Both front bucket seats were displaced to the right and the left front seat back was deformed in a slightly CCW direction. The steering wheel was cut by rescue personnel. The knee bolster was displaced from occupant contact. A large amount of body fluid was noted on the head liner at the left B-pillar. The interior panel of the separated left front door was fractured from occupant contact.

The rear bench seat cushion was buckled laterally in at the center aspect due to the passenger compartment intrusion. Two vertical abrasions and two diagonal lacerations were noted on the interior trim panel of the left B-pillar approximately 33 cm (13") below the left roof side rail.

Exterior Damage - ***2000 Chevrolet Tahoe***

The initial sideswipe contact with the GMC Jimmy resulted in minor right front side damage to the 2000 Chevrolet Tahoe **(Figure 12)**. The direct contact damage began at the right front corner on the bumper and extended 23 cm (9") rearward. The combined direct and induced damage began at the front right bumper corner and extended rearward 40 cm (16"). The maximum lateral crush was located 23 cm (9") aft of the right front corner and measured 5 cm (2"). Longitudinal abrasions were present on the right front bumper corner from the direct contact. The CDC for the initial contact with the GMC Jimmy was 04-RFES-1.

Figure 12. View of damaged 2000 Chevrolet Tahoe

The Chevrolet Tahoe sustained moderate damage as a result of the rollover. The front bumper was slightly displaced to the left. Black plastic transfers were noted on the left front door and top rear aspect of the left front fender from the displacement and separation of the left side mirror. The right side mirror was also separated. Diagonal abrasions were present on the left roof side rail along the entire length of the vehicle.

Both left side doors were displaced slightly from the rollover. Dirt and grass were deposited in the left side window and door trim pieces. The roof sustained vertical crush and the roof rack was fractured on the right side and displaced. The maximum roof crush was located along the centerline and 84 cm (33") rearward of the windshield header and measured 3 cm (1"). The maximum crush on the right roof side rail was located 25 cm (10") rear of the right A-pillar and measured 5 cm (2"). The windshield was completely separated at the windshield header and displaced inward. The CDC for the rollover was 00-TDDO-2.

MANUAL RESTRAINT SYSTEM - 1989 GMC Jimmy

The 1989 GMC Jimmy was equipped with manual 3-point lap and shoulder belts with sewn latch plates and emergency locking retractors for the driver and front right passenger positions. Each front restraint was configured with a fixed D-ring. The driver's seat belt had been cut by rescue personnel. The driver's retractor was located on the floor area on the inboard aspect the left B-pillar, and was operational. The length of the webbing in the retractor measured 130 cm (51") from the severed edge. Body fluid was present on the driver's webbing 32 cm (13") from the severed edge. The front right passenger's manual restraint was restricted in the used position. The lap portion of the webbing was cupped forward from occupant loading and the shoulder belt webbing exhibited some stretching and was gathered in the forward aspect of the D-ring. Both frontal D-rings exhibited abrasions as a result of occupant loading to the restraints.

Figure 13. Cut rear left manual restraint

The rear bench seat was equipped with manual 3-point lap and shoulder belts with locking latch plates for both positions. The rear left seat belt webbing had been cut in two places in an attempt to remove the child safety seat from the vehicle **(Figure 13)**. At the time of the vehicle inspection, the rear left retractor was restricted in the used position and the cut webbing was still through the latch plate which was engaged in the buckle. The length of the webbing that was restricted in the retractor measured 51 cm (20"). Based on the position of the locking latch plate, the remaining shoulder belt webbing measured 84 cm (33") in length and the remaining lap belt webbing measured 47 cm (19") in length. The fixed D-ring for the rear left manual restraint was displaced rearward and outward from the roof deformation. Creases were noted in the webbing from the installation of the CSS, but there was minimal loading on the webbing as a result of the crash.

The rear right manual 3-point lap and shoulder belt was found restricted in the used position even though there was no occupant seated in that position.

CHILD SAFETY SEAT

A Cosco Turnabout infant child safety seat **(Figure 14)** with a detachable base was installed in the rear left seat of the GMC Jimmy. The model number was 02 758 TCD and the date of manufacture was June 7, 2000. There were no NHTSA recalls associated with this seat. The seat was received new by the parents as a gift approximately four months prior to the crash and the parents stated that they had read the owner's manual and used it as a guide during the initial installation. They mentioned that the owner's manual was difficult to follow, as they had no prior CSS experience. At the time of inspection, the owner's manual was not with the CSS, and the locking clip was stowed on the pivoting kick stand on the lower front aspect of the CSS. The infant seat was designed to be used with or without the detachable base and for infants who weighed 10 kg (22 lb) or less and measured 6 cm (26") or less. The infant seat was occupied by a 4-month-old female that weighed 4.8 kg (10.5 lb) and measured 63.5 cm (25.0") in length. The infant was within the manufacturer's recommended height and weight limits outlined in the instruction manual for use of the rear-facing infant seat. The infant CSS was configured with a single-loop 3-point harness system. The shell was configured with three sets of harness slots, however, the fabric cover and styrofoam padding were configured with two sets of harness slots. At the time of the inspection, the right harness strap was threaded through the bottom slot and the left harness strap was pulled forward and completely out of the bottom left slot. The latch plate was engaged in the buckle.

Figure 14. Cosco infant CSS

The infant CSS exhibited signs of wear and damage associated with the crash. The detachable base sustained abrasions on the forward aspect and the left side longitudinal plastic guide on the forward aspect of the base was deformed 0.6 cm (0.3") to the left. The inboard edges of the belt path sustained minor abrasions from the vehicle's manual restraint webbing.

The infant CSS also sustained damage as a result of the crash. A moderate amount of dust/dirt was noted on the bottom aspect of the seat. The carrying handle exhibited moderate stress points that measured 8 cm (3") in length on the outboard aspects which appeared to have resulted from vertical loading to the handle, which was in the upright position at the time of the crash. Both outboard aspects of the carrying handle showed multiple scuffs and scrapes.

Scrapes were present on the left rear aspect of the plastic shell, aft of the carrying handle. The inboard aspect of the left lower harness slot showed signs of stress and minor abrasions from the loading and subsequent pull-out of the harness webbing. The left harness webbing was completely removed from the left slot. The right harness was threaded through the right harness slot and the harness adjustment slide was attached to the end of the right harness webbing on the rear aspect of the CSS. The left harness exhibited a 30 cm (12") longitudinal crease in the center of the webbing. Diagonal plastic transfers were also present on outboard aspect of the webbing 27 cm (10") above the location of the harness retainer clip and 5 cm (2") forward of the end of the webbing **(Figure 15)**. The plastic transfers appeared to have resulted from staggered loading to the harness system from the infant during the rollover. The right harness strap also exhibited a longitudinal crease on the center aspect 30 cm (12") above the latch plate. Distinct creases were present on the webbing from the harness retainer clip spaced 3 cm (1") apart and located 22 cm (9") above the latch plate. The harness webbing was gathered in the plastic latch plate slot, and the plastic latch plate housing showed stress marks in the plastic around the perimeter. The latch plate showed heavy abrasions which indicated frequent usage.

Figure 15. View of plastic transfers on harness webbing

The harness was routed through the harness slots and the end of the left harness strap was routed through the adjustment slide that was attached to the end of the right harness strap. Based on the manufacturer's instructions, the end of the harness webbing should be re-threaded back through the adjustment slide to lock the harness straps **(Figure 16)**. During the interview with the parents, the CSS was re-configured as it was prior to the crash. The harness was threaded through the adjustment slide once, and subsequently tied in a knot over both sides of the harness webbing adjacent to the adjustment slide **(Figure 17)**. It was not re-threaded back through the adjustment slide. The left harness strap was threaded backwards through the harness retainer clip, and the right harness strap was routed under the locking tab on the retainer clip **(Figure 18)**. The parents stated that the left harness strap was threaded in that position when it was removed from the box prior to use.

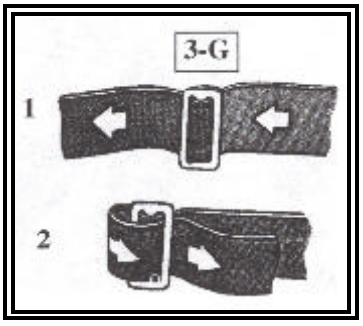


Figure 16. View of correct routing of the harness webbing through the adjustment slide

Figure 17. View of harness straps through the adjustment slide

Figure 18. View of harness retainer clip position

The rear-facing infant CSS was installed with the detachable base in the rear left position of the GMC Jimmy **(Figure 19)** with the manual 3-point lap and shoulder belt with a locking latch plate. There were no objects placed under the CSS base, and the carrying handle was in the upright position. The seat belt was routed through the belt path on the rear aspect of the base. The parents stated that the owner's manual for the GMC Jimmy was consulted, but did not offer any instructions as to how to install a CSS. The parents stated that the seat was installed tightly in the vehicle so that it would not move side-to-side, and it was checked by the parents prior to the crash. The parents also stated that the infant was restrained tightly in the CSS and the space between the harness and the child was no more than one finger width. The parents also mentioned that they regularly restrained the child in the CSS and placed blankets over the harness system, to limit the amount of space between the harness and the infant.

Figure 19. View of rear left position in GMC Jimmy

OCCUPANT DEMOGRAPHICS - 1989 GMC Jimmy

Driver

Age/Sex:	18-year-old male
Height:	183 cm (72")
Weight:	107 kg (235 lb)
Seat Track Position:	Between mid-track and full rear
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection, interview
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local hospital, transferred to a regional trauma center and admitted

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
10 cm (4") complex laceration of the right parietal area of the scalp	Moderate (190604.2,1)	Interior dome light
5 cm (2") deep laceration on the top of the scalp to the right of the midline	Minor (190602.1,1)	Interior dome light

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
6.0 cm (2") intermediate laceration of the left parietal area	Minor (190602.1,2)	Left front door frame, left B-pillar
Multiple complex, intermediate, and simple lacerations of the left ear	Minor (290602.1,2)	Left front door frame, left B-pillar
Multiple lacerations of the left face	Minor (290602.1,2)	Left front door frame, left B-pillar
Multiple lacerations of the left forehead	Minor (290602.1,7)	Left front door frame, left B-pillar
1 cm (.5") complex avulsion of the left posterior facial area	Minor (290802.1,2)	Left front door frame, left B-pillar
3 cm (1") complex avulsion of the left posterior auricular area	Minor (290802.1,2)	Left front door frame, left B-pillar
6 cm (2") complex avulsion of the left posterior auricular area	Minor (290802.1,2)	Left front door frame, left B-pillar
4 cm (2") complex avulsion of the left posterior helix of the ear	Minor (290802.1,2)	Left front door frame, left B-pillar
3 cm (1") avulsion of the left posterior auricular area	Minor (290802.1,2)	Left front door frame, left B-pillar
Minor abrasions on the right deltoid area	Minor (490202.1,1)	Loading against the shoulder belt webbing
Minor contusions on the right deltoid area	Minor (490402.1,1)	Loading against the shoulder belt webbing
Contusion extending from the left lateral neck across the chest	Minor (490402.1,2)	Loading against the shoulder belt webbing
Posterior left elbow dislocation	Minor (750630.1,2)	Partial ejection and contact with the utility pole

Injury source: Emergency room records, discharge summary

Driver Kinematics

The 18-year-old driver of the GMC Jimmy was seated in an upright posture with the seat track adjusted to between the mid-track and full-rear positions. His right hand was placed at the 12 o'clock position and his left hand at the 7 o'clock position on the steering wheel rim. He was restrained by the manual 3-point lap and shoulder belt.

The driver probably remained in position during the initial contact between the Jimmy and the Tahoe. As the Jimmy rotated CCW, the driver initiated a lateral trajectory to the left. He was redirected in the vehicle as the Jimmy rolled over and loaded the manual restraint, which mitigated substantial movement in the vehicle. It was not clear if there was any pay-out in the manual restraint during the rollover that allowed additional movement in the vehicle. During the rollover event, the driver's head struck the interior dome light which resulted in a 10 cm (4") complex laceration of the right parietal area of the scalp and a 5 cm (2") deep laceration on the top of the scalp to the right of the midline. As he was redirected laterally, the left aspect of his head struck the left front door frame and B-pillar area which resulted in multiple avulsions, complex, intermediate, and simple lacerations of the left ear, left forehead, left face, and left parietal area.

After the Jimmy completed the second complete turn, it rolled onto its roof and impacted a utility pole with the left front door area. The driver was redirected to the left and stated that his left arm was partially ejected through the left front door window opening as the vehicle impacted the utility pole. He reported that his arm was between the exterior door and the utility pole at impact. He sustained a posterior left elbow dislocation from that event. The knee bolster was deformed from probable occupant contact, although, there were no reported injuries associated with a knee strike.

The driver stated that he lost consciousness at the beginning of the rollover. He stated that he regained consciousness after the vehicle came to rest and was suspended upside down by the seat belt, and pinned under the steering wheel. Rescue personnel removed the steering wheel and the driver was removed through the left front door. He was transported by ambulance to a local hospital and transferred to a regional trauma center and admitted for one day and released.

Front Right Passenger

Age/Sex:	16-year-old female
Height:	157 cm (62")
Weight:	77 kg (170 lb)
Seat Track Position:	Full-rear
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection, interview
Eyewear:	None
Type of Medical Treatment:	Transported by helicopter to a regional trauma center and admitted

Front Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Fracture of posterior aspect of right fifth rib with pneumothorax	Serious (450214.3,1)	Loading against shoulder belt webbing
Left lateral tibial plateau comminuted Type II fracture	Serious (853408.3,2)	Loading against the lower right instrument panel
Right shoulder dislocation	Moderate (751030.2,1)	Loading against shoulder belt webbing
Left fibular head fracture	Moderate (851606.2,2)	Loading against the lower right instrument panel
Superficial abrasion on right ear	Minor (290202.1,1)	Contact with the right aspect of the intruded roof
Abrasion, right aspect of forehead	Minor (290202.1,7)	Contact with the right aspect of the intruded roof
Abrasion, right flank (abdomen)	Minor (590202.1,1)	Loading against lap belt webbing
Right distal clavicle fracture	Moderate (752200.2,1)	Loading against shoulder belt webbing
Abrasion, right shoulder	Minor (790202.1.1)	Loading against shoulder belt webbing
Abrasion, dorsal right hand	Minor (790202.1.1)	Right interior door surface
Abrasion, left anterosuperior iliac spine and left flank area	Minor (890202.1,2)	Loading against lap belt webbing

Injury source: Emergency room records, discharge summary

Front Right Passenger Kinematics

The 16-year-old female front right passenger was seated in an upright posture with the seat track adjusted to the full-rear position. She was restrained by the manual 3-point lap and shoulder belt. She probably maintained her position during the initial contact between the Jimmy and the Tahoe, and initiated a lateral trajectory to the left as the Jimmy entered the CCW yaw. She was redirected as the Jimmy rolled over and loaded the manual restraint, which mitigated substantial movement in the vehicle. It was not clear if there was any pay-out in the manual restraint during the rollover that allowed additional movement in the vehicle. She contacted the lower instrument panel with her left knee which resulted in a left lateral tibial

plateau comminuted Type II fracture and a left fibular head fracture. The loading to the shoulder belt and contact to the right interior door surface resulted in a fracture of posterior aspect of right fifth rib with pneumothorax, a right distal clavicle fracture, a right shoulder dislocation, and a right shoulder abrasion. She also loaded the lap belt portion of the restraint which caused a right abdominal abrasion and an abrasion on the left anterosuperior iliac spine and left flank area. Intrusion of the right aspect of the roof allowed her head to contact the interior aspect of the vertically displaced roof which resulted in superficial abrasion on right ear and an abrasion on the right aspect of forehead.

As the vehicle impacted the utility pole, she was redirected to the left. She came to rest upside down suspended from the seat belt. She stated that she had lost consciousness during the rollover and regained consciousness after the vehicle came to rest on its roof. She also said that the center console had separated and was on her lap. She stated that she unbuckled the manual restraint and was removed from the vehicle by rescue personnel through the left front door. She was transported by helicopter to a regional trauma center and admitted for nine days and released.

Rear Left Passenger

Age/Sex:	4-month-old female
Height:	64 cm (25")
Weight:	4.8 kg (10.5 lb)
Seat Track Position:	Fixed
Restraint Use:	Rear-facing infant CSS
Usage Source:	Vehicle inspection, CSS inspection
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local hospital, transferred to a regional children's hospital, and expired five hours following the crash

Rear Left Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Transtentorial herniation completely obliterating the basilar cisterns, third and fourth ventricles and sulci	Critical (140202.5,8)	Ejection from vehicle and impact with ground

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Brain stem injury, basilar cisterns, sulci, third and fourth ventricles were completely effaced, subarachnoid hemorrhage was noted throughout the basilar cisterns and sulci diffusely and globally	Critical (140210.5,8)	Ejection from vehicle and impact with ground
Cerebral shear injury as well as near complete loss of gray-white differentiation	Critical (140628.5,9)	Head motion as a result of the high-speed rollover
Pneumocephalus within the suprasellar cistern and anterior fossa	Serious (140682.3,9)	Ejection from vehicle and impact with ground
Linear transverse fracture that extended vertically from the vertex of the cranium to the right aspect of the posterior parietal, initially lateral to the lambdoid suture and became diastatic, the most medial and posterior aspect was depressed anteriorly approximately 4 mm (0.2")	Serious (150404.3,1)	Ejection from vehicle and impact with ground
Minimal diastasis of the left coronal suture, a large piece of cortical bone was lifted in a cephalad direction approximately 1 cm (0.5")	Serious (150404.3,2)	Ejection from vehicle and impact with ground
Multiple complex facial abrasions	Minor (190202.1,0)	Ejection from vehicle and impact with ground
Multiple complex facial lacerations	Minor (290600.1,0)	Ejection from vehicle and impact with ground
Right parietal scalp abrasion	Minor (190202.1,1)	Ejection from vehicle and impact with ground

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Pulmonary contusion of the lower lobes, bilaterally, worse on the right	Severe (441410.4,3)	Loading against the harness straps
Left anterior leg contusion	Minor (890402.1,2)	Loading against left harness strap
Left posterior back contusion	Minor (690402.1,2)	Rebound into CSS during rollover
Left abdominal abrasion	Minor (590202.1,2)	Loading against left harness strap
Left upper chest contusion	Minor (490402.1,2)	Loading against left harness strap

Injury source: Emergency room records, discharge summary, Medical Examiner's report

Rear Left Passenger Kinematics

The 4-month-old female rear left passenger was restrained in a Cosco rear-facing infant CSS that was installed with the vehicle's manual 3-point lap and shoulder belt system. The infant was restrained in the CSS's harness system with the harness retainer clip placed at the level of her armpits. Prior to impact, the infant was asleep in the CSS, and was not leaning to either side.

At the initial impact with the Tahoe, the infant probably maintained her position in the CSS. The parents were advised by medical personnel that the infant sustained a fatal brain stem injury from this initial event. As the Jimmy initiated the CCW yaw, the infant was redirected to the left. As the Jimmy rolled over, the infant continued the lateral trajectory to the left and loaded the harness system. Due to the severity of the rollover event, the infant sustained cerebral shear injury as well as near complete loss of gray-white differentiation as a result of head motion. The harness system, tied in a knot, became loose as the vehicle rolled over. As the infant continued to load the harness system, the knot completely unraveled and allowed the left harness strap to pull out completely from the harness slot. The left harness was threaded backwards through the harness retainer clip, and the right harness strap was routed under the locking tab on the retainer clip **(See Figure 18)**. The configuration of the harness retainer clip may have contributed to the loading on the left strap, as it was not secured in by the locking tab and may have allowed the right strap to disengage from the retainer clip. The infant sustained a pulmonary contusion of the lower lobes, bilaterally, worse on the right, left shoulder contusion, left abdominal abrasion, and a left thigh contusion from loading to the CSS harness system.

The infant was ejected from the CSS and from the vehicle through the left rear side window opening during the final quarter turn as the Jimmy struck the utility pole. She was found approximately 16 m (51') south of the final rest position of the vehicle. Based on the lack of contact evidence in the vehicle and distance of the infant's final rest position relative to the vehicle, it appears the infant's trajectory out of the vehicle was unobstructed. As a result of the ejection and impact with the ground, she sustained a transtentorial herniation completely obliterating the basilar cisterns, third and fourth ventricles and sulci, a brain stem injury with the basilar cisterns, sulci, third and fourth ventricles completely effaced, subarachnoid hemorrhage was noted throughout the basilar cisterns and sulci diffusely and globally, pneumocephalus within the suprasellar cistern and anterior fossa, a linear transverse fracture that extended vertically from the vertex of the cranium to the right aspect of the posterior parietal, initially lateral to the lambdoid suture and became diastatic, with the most medial and posterior aspect depressed anteriorly approximately 4 mm (0.2"). She also sustained minimal diastasis of the left coronal suture, a large piece of cortical bone was lifted in a cephalad direction approximately 1 cm (0.5"), multiple complex facial abrasions, multiple complex facial lacerations, and a right parietal scalp abrasion as a result of the ejection and ground impact. She was transported by ambulance to a local hospital, transferred to a regional children's hospital, and expired five hours following the crash.

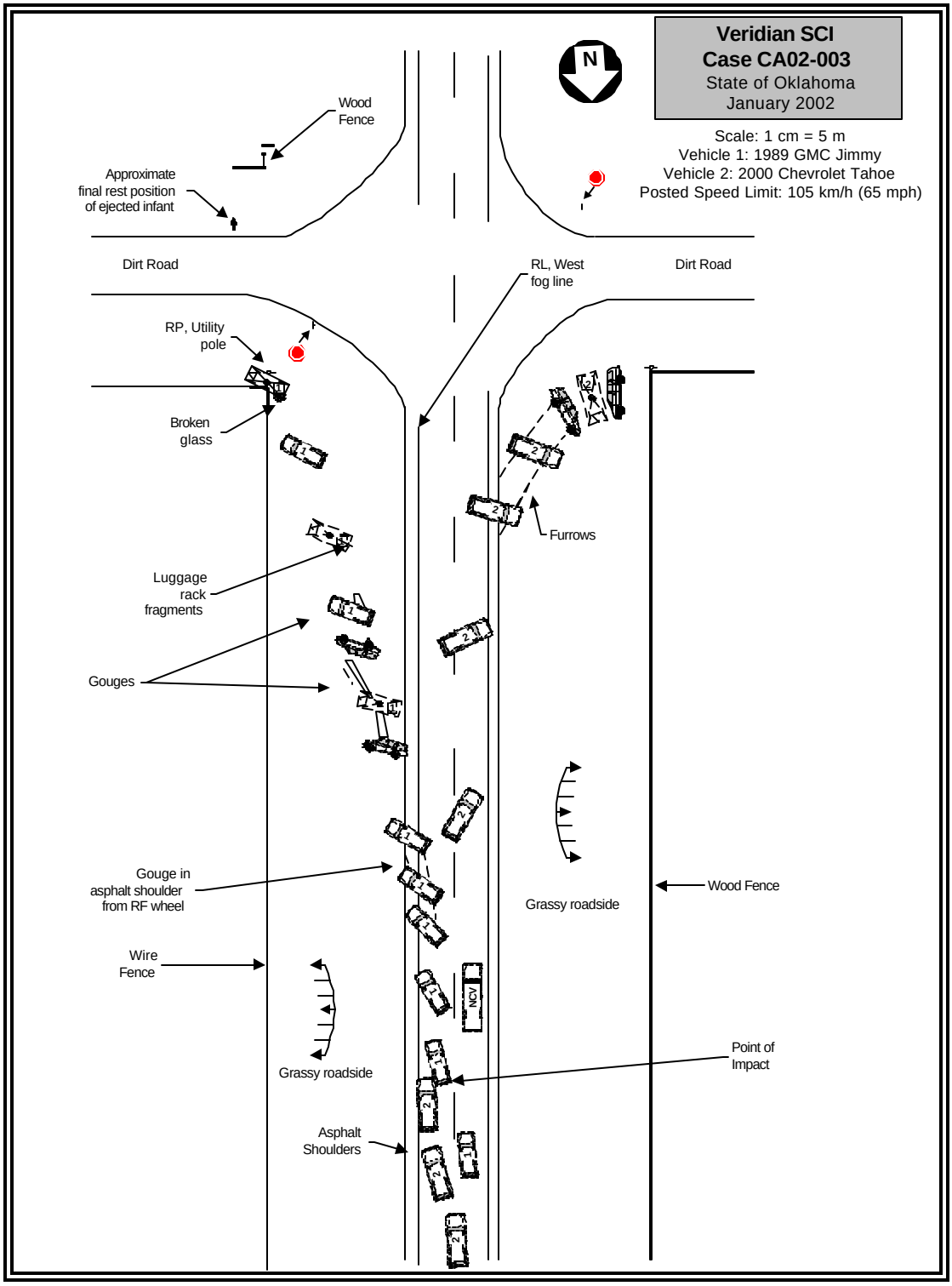
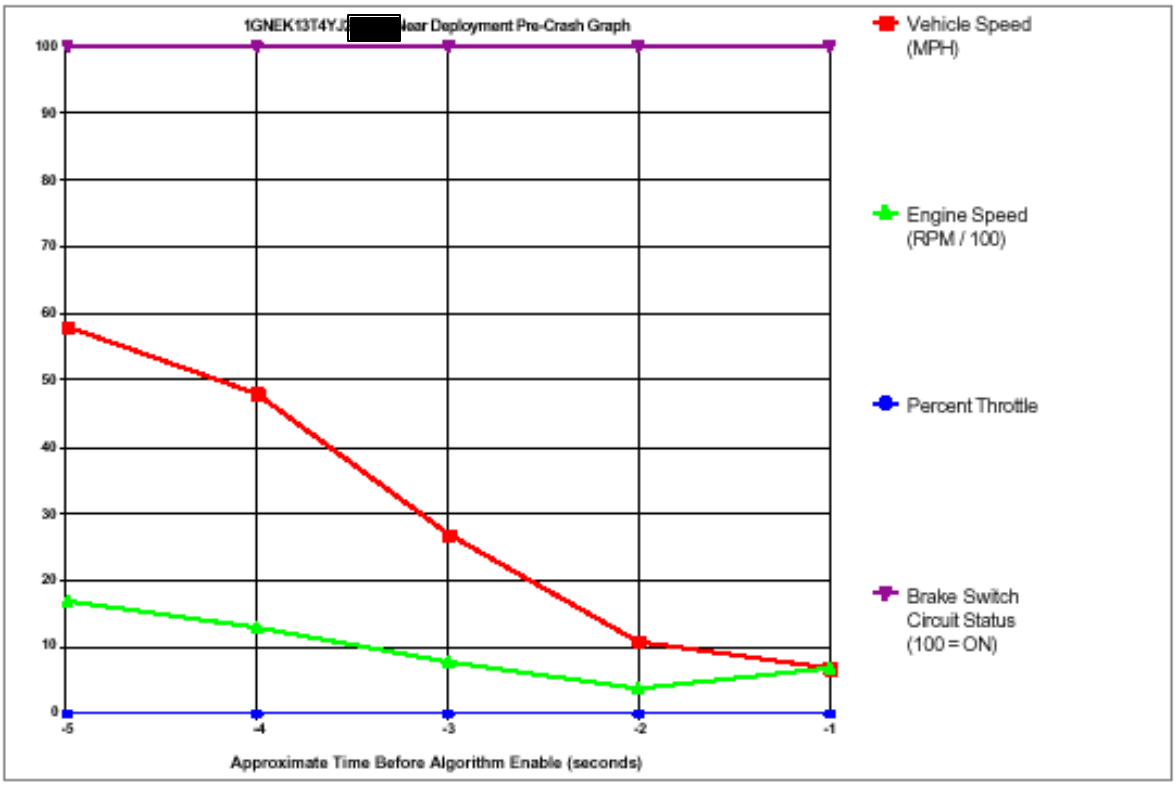


Figure 20. Scene schematic

System Status At Near Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Near Deployment	5106



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	58	1664	0	ON
-4	48	1344	0	ON
-3	27	832	0	ON
-2	11	448	0	ON
-1	7	704	0	ON

Figure 21. EDR summary report for the Chevrolet Tahoe