TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

Veridian Engineering
Buffalo, NY 14225

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

VERIDIAN CASE NO. CA01-023

VEHICLE - 1997 DODGE CARAVAN

LOCATION - STATE OF NEW JERSEY

CRASH DATE - FEBRUARY 2001

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

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 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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* CA01-023	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* Veridian On-site Child Safety Seat Crash Investigation Vehicle: 1997 Dodge Caravan Location: State of New Jersey		5. *Report Date*: October 2001 6. *Performing Organization Code*	
7. *Author(s)* Crash Data Research Center		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Sciences Crash Data Research Center Veridian Engineering P.O. Box 400 Buffalo, New York 14225		10. *Work Unit No.* C01115.0341.(0000-0009) 11. *Contract or Grant No.* DTNH22-94-D-07058	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. *Type of Report and Period Covered* Technical Report Crash Date: February 2001 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site investigation of a front-to-rear collision with a secondary impact. Occupant-to-occupant interaction between the driver and the child passenger restrained in a child safety seat resulted in the death of the 3-year-old child passenger.			
16. *Abstract* This on-site investigation focused on the crash severity, the installation and performance of three child safety seats, and the injury mechanisms for the child passengers of a 1997 Dodge Caravan SE. The Caravan was struck in the back aspect by a 1985 Chevrolet C-30 tow truck and sustained a secondary impact to the right front side area by a 1993 Ford Taurus. The Caravan was occupied by two adult front seat passengers and three children positioned in child safety seats. The 31-year-old male driver initiated a rearward trajectory in response to the rear impact. His loading force against the seat back support deflected the seat back in a rearward direction. The 3-year-old child seated in the booster seat with an integral harness initially moved rearward and rebounded in a forward direction. He loaded the child safety seat back which resulted in a left shoulder contusion and abrasion. His head continued in a forward direction and struck the rear aspect of the driver's head as the driver moved rearward, deflecting the seat back rearward. The child sustained a compound depressed skull fracture in the right frontal region, extensive cerebral contusions and lacerations, diffuse brain swelling, subdural and subarachnoid hemorrhages, as a result of the occupant-to-occupant interaction. He also sustained a laceration and contusion of the liver, and a lung contusion from the lateral loading to the harness straps. He sustained right scalp contusions and multiple facial lacerations as a result of contact with the right side surface of the booster seat and the plastic seat belt positioner. The driver sustained a 12 suture laceration on the occipital region of his scalp. The child was transported by ambulance to a regional trauma center where he expired three days after the crash. The remaining occupants of the Caravan sustained minor injuries and were transported by ambulance to a regional trauma center where they were treated and released.			
17. *Key Words* Child Safety Seat Child Fatality		18. *Distribution Statement* General Public	
19. *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 19	22. *Price*

TABLE OF CONTENTS

VERIDIAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
SCI SUMMARY TECHNICAL REPORT
VERIDIAN CASE NO. CA01-023
LOCATION: STATE OF NEW JERSEY
VEHICLE: 1997 DODGE CARAVAN
CRASH DATE: FEBRUARY 2001

BACKGROUND

This on-site investigation focused on the crash severity, the installation and performance of three child safety seats, and the injury mechanisms for the child passengers of a 1997 Dodge Caravan SE **(Figure 1)**. The Caravan was struck in the back aspect by a 1985 Chevrolet C-30 tow truck and sustained a secondary impact to the right front side area by a 1993 Ford Taurus. The Caravan was occupied by two adult front seat passengers and three children positioned in child safety seats. A 3-year old male was seated on the second seat left position, an 18-month old male was seated on the second seat center position, and a 5-year old male was seated on the third seat left position.

Figure 1. Damaged 1997 Dodge Caravan SE

The 31-year-old male driver initiated a rearward trajectory in response to the rear impact. His loading force against the seat back support deflected the seat back in a rearward direction. The 3-year-old child seated in the booster seat with an integral harness initially moved rearward and rebounded in a forward direction. He loaded the child safety seat back which resulted in a left shoulder contusion and abrasion. His head continued in a forward direction and struck the rear aspect of the driver's head as the driver moved rearward, deflecting the seat back rearward. The child sustained a compound depressed skull fracture in the right frontal region, extensive cerebral contusions and lacerations, diffuse brain swelling, subdural and subarachnoid hemorrhages, as a result of the occupant-to-occupant interaction. He also sustained a laceration and contusion of the liver, and a lung contusion from the lateral loading to the harness straps. He sustained right scalp contusions and multiple facial lacerations as a result of contact with the right side surface of the booster seat and the plastic seat belt positioner. The driver sustained a 12 suture laceration on the occipital region of his scalp. The child was transported by ambulance to a regional trauma center where he expired three days after the crash. The remaining occupants of the Caravan sustained minor injuries and were transported by ambulance to a regional trauma center where they were treated and released.

This crash occurred in a non-sampled jurisdiction within the geographical boundaries of a NASS PSU during the month of February 2001. The investigating officer notified the NASS Team Leader of the crash, and the Team Leader immediately forwarded the notification to the Veridian Special Crash Investigations Team. The Team Leader performed a preliminary inspection of the vehicles to verify child safety seat usage and crash severity. The notification was forwarded to NHTSA and an on-site investigation was assigned on February 20, 2001 with the field activities completed on February 22, 2001.

SUMMARY

Crash Site

This crash occurred during the daylight hours of February 2001 on a two-lane state roadway at a driveway entrance. At the time of the crash, the weather was clear. The asphalt roadway surface was wet from rainfall that had occurred earlier in the day. The east/west roadway consisted of two travel lanes that were straight with level grades and bordered by asphalt shoulders. The north shoulder measured 3.1 m (10.2') in width and the south shoulder measured 2.7 m (8.9') in width. The travel lanes were separated by a broken yellow passing line for eastbound traffic and a solid yellow no-passing line for westbound traffic. The posted speed limit was 80.5 km/h (50.0 mph). A concrete driveway for a church parking lot was located on the north roadside and measured 7.7 m (25.3') in width. The driveway was bordered by 15.3 cm (6.0") curbs that followed the contour of the driveway corners. The concrete curb continued in an east direction along the north roadside to a second driveway and continued 4.4 m (14.4') in a westbound direction, from the respective driveway corners. The north roadside environment consisted of landscaped grassy areas with moderately dense trees. The south roadside environment included a raised dirt area, densely populated trees, and utility poles.

Pre-Crash

The driver of the 1997 Dodge Caravan had stopped the vehicle in the eastbound lane **(Figure 2)** and was waiting for westbound traffic to clear prior to initiating a left turn onto the church driveway. The driver of the 1985 Chevrolet tow truck was operating the vehicle in an easterly direction behind the Dodge Caravan. The driver of the tow truck stated that he was aware of the van traveling ahead of his vehicle, and that he was distracted by an uninvolved vehicle traveling in the westbound lane. He did not realize the van had stopped in the travel lane. When the driver of the tow truck detected the stopped Caravan, he shifted the manual transmission from third to second gear, applied the brakes in full lockup, and steered right in an attempt to avoid the collision. The combination of braking, steer input, and the wet roadway surface caused the Chevrolet tow truck to initiate a slight clockwise (CW) yaw prior to the impact. The investigating officer documented approximately 13.1 m (43.0') of pre-impact skid marks from the Chevrolet tow truck, however, the marks were not visible at the time of the SCI scene documentation. The driver of the Caravan did not detect the approaching tow truck and did not attempt any avoidance maneuvers. The driver of the 1993 Ford Taurus was operating the vehicle in the westbound travel lane approaching the church driveway and did not anticipate the collision between the Dodge Caravan and the Chevrolet tow truck. The driver of the Taurus did not attempt any avoidance maneuvers until after the initial impact between the Caravan and the tow truck.

Figure 2. Eastbound view for the stopped Dodge Caravan and approach view for the Chevrolet tow truck

Crash

The front left and center areas of the Chevrolet tow truck impacted the back center and right aspect of the Dodge Caravan. The direction of force was in the 6 o'clock sector for the Caravan and in the 12 o'clock sector for the tow truck. The damage algorithm of the WinSMASH program computed total velocity changes of 43.0 km/h (26.7 mph) for the Dodge Caravan and of 21.0 km/h (13.0 mph) for the Chevrolet tow truck based on the respective crush profiles. The Caravan's longitudinal component was 42.3 km/h (26.3 mph) and the latitudinal component was 7.5 km/h (4.6 mph). The Chevrolet tow truck's longitudinal component was -20.7 km/h (-12.9 mph), and the latitudinal component was -3.6 km/h (-2.3 mph). The impact deflected the Caravan forward and to the left approximately 10.0 m (33.0') onto the westbound lane in a counterclockwise (CCW) rotation. The Chevrolet tow truck was deflected slightly to the right and continued to skid in a forward direction onto the south shoulder. The tow truck traveled approximately 23.5 m (77.0') in an east direction from impact to final rest. The Chevrolet tow truck came to rest facing east and straddling the edge of the paved shoulder.

The driver of the 1993 Ford Taurus recognized the collision between the Caravan and the Chevrolet tow truck, and detected the Caravan encroaching into the westbound lane from the initial impact force. The driver of the westbound Taurus attempted to avoid the collision with the Caravan by applying the brakes in full lockup and steering right. The front left area of the Taurus impacted the right front side area of the Caravan. The direction of force was in the 11 o'clock sector for the Taurus and in the 2 o'clock sector for the Caravan. The impact was sufficient to deploy the frontal air bag system in the Taurus. The damage algorithm of the WinSMASH program computed total velocity changes of 17.0 km/h (10.6 mph) for the Taurus and 14.0 km/h (8.7 mph) for the Caravan based on the respective crush profiles. The longitudinal component for the Taurus was -14.7 km/h (-9.1 mph) and the latitudinal component was 8.5 km/h (5.3 mph). The longitudinal component for the Caravan was -9.0 km/h (-5.6 mph) and the latitudinal component was -10.7 km/h (-6.7 mph). The Taurus was deflected slightly to the right and initiated a CCW yaw as it continued in a westerly direction on the north shoulder. The Taurus traveled approximately 23.5 m (77') from impact to final rest. The Ford Taurus came to rest facing west and straddling the fog line on the westbound lane. The Caravan rotated CCW approximately 330 degrees in the westbound lane and came to rest facing northeast.

Post-Crash

The driver of the Chevrolet tow truck exited the vehicle under his own power. Witness statements indicate that he was using a cellular phone when he exited the vehicle, but it was not known if the cellular phone was in use prior to the crash. He was treated by EMS personnel at the scene and refused additional medical treatment. The driver of the Ford Taurus exited the vehicle under her own power and was transported by ambulance to a local hospital where she was treated and released. The driver of the Dodge Caravan exited the vehicle under his own power and attempted to remove the injured children. The 3-year-old male child was removed by a witness to the crash, and was found by responding officers lying on the concrete church driveway. He was treated at the scene by first responders and transported by ambulance to a regional trauma center, accompanied by the driver of the Caravan. A police officer removed an 18-month old from the vehicle in a child safety seat, and subsequently removed the child from the child safety seat. The front

right adult passenger exited the vehicle under her own power and remained with the 18-month-old child. The 5-year-old child was removed from the vehicle and was taken into the church. The front right adult passenger, 18-month-old, and 5-year-old were transported by ambulance to a regional trauma center. All of the Caravan occupants were treated and released except the 3-year-old child. The 3-year-old expired three days following the crash.

VEHICLE DATA -*1997 Dodge Caravan*

The 1997 Dodge Caravan SE was identified by the Vehicle Identification Number (VIN): 2B4GP45R8VR (production sequence omitted). The vehicle was a 5-door minivan configured with left side and right side sliding doors and a rear lift gate. It was equipped with a 3.3 liter, 6 cylinder engine, a 4-speed automatic transmission, cruise control, power brakes with anti-lock, and power steering. The Caravan was also configured with 215/G5R15 tires. The Caravan was equipped with a digital odometer and the vehicle's milage was unknown. The Caravan had a tilt steering wheel and the knee bolster was a rigid plastic type.

The Caravan was configured with front bucket seats with integral head restraints, a removable second row two-person bench seat, and a removable third row three-person bench seat. Both front bucket seats were equipped with armrests on the inboard aspects. Both bench seats were equipped with adjustable head restraints and armrests for the outboard positions. The left outboard head restraints were in the full down positions and the right outboard head restraints were slightly raised.

VEHICLE DAMAGE

Exterior Damage - *1997 Dodge Caravan SE*

The 1997 Dodge Caravan sustained severe rear damage **(Figure 3)** as a result of the impact with the 1985 Chevrolet tow truck. The direct damage along the rear lift gate started 12.1 cm (4.8") left of center and extended 85.1 cm (33.5") to the right rear corner. The combined direct and induced damage involved the entire rear width of the Caravan and measured 144.2 cm (56.8"). The height of the direct damage extended upward approximately 20 cm (8") above the bottom aspect of the backlight frame, evidenced by red paint transfers and moderate abrasions on the right D-pillar. The maximum crush at the bottom aspect of the rear lift gate measured 54.3 cm (21.4") at the rear right corner. The crush on the right aspect of the lift gate caused the bottom left aspect of the lift gate to pull away from the lift gate frame. The rear bumper fascia was completely separated from the vehicle and the bumper beam was crushed forward on the right side. The maximum crush on the rear bumper beam measured 53.8 cm (21.2") at the rear right corner. The lower aspect of the right D-pillar was crushed forward and the right rear quarter panel was crushed and buckled outward over the right rear wheel. The quarter panel sheet metal was crushed against the right rear tire which caused the right rear wheel to be restricted. The right rear wheel rim was deformed from the impact and subsequent vehicle rotation and the tire was deflated. The leading edge of the right rear quarter panel was also deformed at the right C-pillar. The right rear side window frame was deformed and induced buckling was noted on the roof side rail at

Figure 3. Rear damage to the 1997 Dodge Caravan

the right C-pillar. The right brake light assembly was displaced from the Caravan and was suspended by the wiring harness. The Collision Deformation Classification (CDC) for the rear impact to the Caravan was 06-BZEW-4. Six crush measurements spaced 28.8 cm (11.4") apart were recorded along the rear bumper beam and were as follows: C1 = 1.0 cm (0.4"), C2 = 11.4 cm (4.5"), C3 = 20.6 cm (8.1"), C4 = 32.4 cm (12.8"), C5 = 41.9 cm (16.5"), C6 = 53.8 cm (21.2"). An additional set of crush measurements was taken at the same C locations at the lower aspect of the rear lift gate frame, which were consistent with the measurements recorded on the bumper beam.

Figure 4. View of right front side damage to the Caravan

The 1997 Dodge Caravan also sustained moderate damage as a result of the secondary impact with the 1993 Ford Taurus. The damage was concentrated on the right front side area forward of the right A-pillar **(Figure 4)**. The direct damage began 151.8 cm (59.8") forward of the rear edge of the right front door at the belt line and extended forward 67.9 cm (26.8") to the right front bumper corner. The combined direct and induced damage began at the right A-pillar and extended 113.7 cm (44.8") to the right front bumper corner along the side trim area. The right front fender was crushed laterally and exhibited white paint transfers and abrasions from direct contact with the Ford Taurus. The rear edge of the fender was pulled forward slightly from the lateral displacement. The hood was displaced vertically from induced damage. The front bumper fascia was fractured and separated at the right front corner. The front right aspects of the bumper beam and radiator support were crushed laterally and rearward from the impact force. The grille assembly was displaced and the front right head lamp assembly was fractured and separated. The front left head lamp assembly was also separated from induced damage. The right front wheel was slightly displaced from direct contact and the wheel cover was partially separated. The right front wheel was restricted but the tire was not deflated. The damaged right front wheel had a significantly greater right steer angle than the left front wheel at the time of inspection. The CDC for the secondary impact with the Ford Taurus was 02-RFEW-3. Six crush measurements were recorded along the right front side trim level and were as follows: C1 = 2.5 cm (1.0"), C2 = 2.5 cm (1.0"), C3 = 15.5 cm (6.1"), C4 = 27.7 cm (10.9"), C5 = 23.2 cm (9.1"), C6 = 0.0 cm.

The right side sliding door sustained damage from rescue efforts. The top aspect of the window frame of the sliding door was pulled outward from the roof side rail in an attempt to gain access to the rear seating positions.

Interior Damage - *1997 Dodge Caravan SE*

Interior damage to the 1997 Dodge Caravan was moderate and attributed to compartment intrusion and front seat back deflection. Integrity was lost from the backlight glazing which disintegrated as a result of the rear impact. The tinted tempered glazing on both sliding side doors and in the right side rear window was disintegrated, although it was not known if it was due to impact forces or rescue efforts.

The front seat backs intruded rearward into the second seat area. Both front seat tracks were adjusted to the full-rear positions and the total track travel measured 22.2 cm (8.8") for each seat. Both front seat backs were deflected rearward from occupant loading and rotated slightly inward **(Figure 5)**. The residual angle of the front left seat back from a horizontal of zero degrees was 48 degrees at the lumbar region and 45 degrees at the integral head restraint. The residual angle of the front right seat back from a horizontal of zero degrees was 35 degrees at the lumbar region and 46 degrees at the integral head restraint. The dynamic deflection of both front seat backs intruded farther into the second seat occupants' space. The driver's seat back contacted the child seated in the booster seat in the left second seat position. At the time of the vehicle inspection, the space between the front left seat back and the leading edge of the booster seat was 7.0 cm (2.8") and 5.7 cm (2.3") on the left and right sides, respectively. Both outboard front seat back brackets were constructed of a flat stock bracket welded to an extra "U" channel. The reinforced outboard brackets measured 4.1 cm (1.6") fore and aft, and 1.3 cm (0.5") in width **(Figure 6)**. The inboard brackets consisted of a flat stock bracket with a radius on the edges and measured 4.1 cm (1.6") fore and aft, and 0.6 cm (0.3") in width **(Figure 7)**.

The rear lift gate intruded into the rear cargo area. The maximum lift gate intrusion measured 60.0 cm (23.6"), at 12.7 cm (5.0") right of center. Intrusion into the rear cargo area resulted from penetration of the front aspect of the Chevrolet tow truck. The maximum longitudinal intrusion measured 46 cm (18.1") on the right side of the cargo area. The hood of the Chevrolet tow truck contacted the third seat back which caused the seat back to intrude longitudinally into the third seat area. The maximum intrusion measured 11.4 cm (4.5") on the right side of the seat back and 5.7 cm (2.3") at the center of the seat back. The top aspect of the third seat back exhibited numerous red paint transfers and two moderate fabric lacerations as a result of the direct contact with the tow truck's hood **(Figure 8)**.

Figure 5. Front seat back deflection

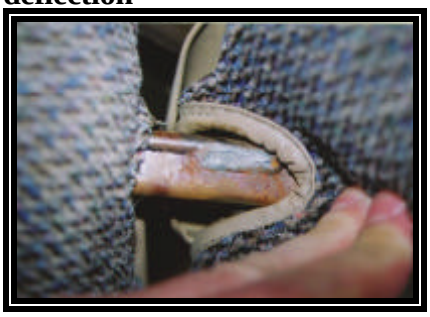

Figure 6. Outboard front seat back bracket

Figure 7. Inboard front seat back bracket

Figure 8. Paint transfers and fabric lacerations on third seat back

Exterior Damage - ***1985 Chevrolet C-30 Tow Truck***

The 1985 Chevrolet tow truck was a one-ton, 4 x 2, C-30 Chassis cab with a tow body. The vehicle was configured with a regular cab, dual rear wheels, and an aftermarket steel plate front bumper. The bumper was located 24.8 cm (9.3") forward of the lower radiator support. The bumper extended 80.0 cm (31.5") laterally from the center line in both directions. The corners of the bumper were angled rearward, starting 24.1 cm (9.5") inboard of the edge. The edge was positioned 11.4 cm (4.5") aft of the face of the steel bumper. The odometer read 136,962 km (85,107 miles) at the time of the vehicle inspection.

Figure 9. Frontal damage to 1985 Chevrolet tow truck

The Chevrolet tow truck sustained moderate frontal damage **(Figure 9)** as a result of the impact with the Dodge Caravan. The direct damage on the hood face began 16.5 cm (6.5") left of the centerline and extended 64.1 cm (25.3") to the left edge. The direct damage on the bumper began 9.8 cm (3.9") right of the centerline and extended 116.2 cm (45.8") to the left corner. The combined direct and induced damage involved the entire frontal plane of the vehicle and measured 193.0 cm (76.0"). The maximum crush measured 47.6 cm (18.8") at the lower radiator support and was located 27.9 cm (11.0") left of center. The left half of the bumper was crushed rearward against the left front wheel. The left front wheel was restricted as a result of the bumper crush and rearward displacement against the rear aspect of the left front fender. The grille and both head lamp assemblies were fractured and displaced. The upper and lower radiator supports were crushed rearward. The hood was buckled and exhibited significant abrasions and missing paint fragments on the left and center aspects. The left front fender was crushed and buckled rearward and outward. A portion of fabric from the third seat of the Dodge Caravan was stuck on the sheet metal of the left front fender. Tinted glazing fragments were scattered along the lower radiator support and surrounding components from the Caravan's backlight. The entire front axle was displaced CCW as a result of the left side impact. The left wheelbase was shortened by 12.1 cm (4.8") and the right wheelbase was extended 12.1 cm (4.8"). The CDC for the frontal impact to the Chevrolet tow truck was 12-FYEW-2. Six crush measurements were taken along the lower radiator support and were as follows: C1 = 36.8 cm (14.5"), C2 = 38.7 cm (15.3"), C3 = 45.1 cm (17.8"), C4 = 27.6 cm (10.9"), C5 = 12.7 cm (5.0"), C6 = 4.1 cm (1.6").

Exterior Damage - ***1993 Ford Taurus***

The 1993 Ford Taurus sustained moderate damage **(Figure 10)** as a result of the frontal impact with the Dodge Caravan. The direct damage began 20.3 cm (8.0") left of center on the bumper fascia, and extended to the front left corner. The combined direct and induced damage involved the entire frontal width of the vehicle and measured 116.2 cm (45.8"). The maximum crush was located 6.4 cm (2.5") inboard of the front left bumper corner and measured 31.1 cm (12.3") on the upper radiator support. The

Figure 10. Frontal damage to 1993 Ford Taurus

Taurus was equipped with Energy Absorbing Devices (EAD's) on the outboard aspects of the bumper. The left EAD was 43.1 cm (17.0") to the left of the center of the bumper fascia. The residual depth of stroke on the left EAD was 4.4 cm (1.8"). The right EAD did not exhibit any rearward displacement. The bumper fascia was fractured and partially separated 34.0 cm (13.1") to the right of center and 25.0 cm (9.8") to the right of center. The fiberglass bumper beam was separated at the left EAD. The upper and lower radiator supports were crushed rearward on the left side. The left head lamp assembly was separated from the vehicle and the plastic grille fascia was fractured on the left side. The hood was displaced to the right and buckled downward on the front left corner. The left front fender was crushed rearward and the leading edge pulled inward. The left front wheel cover was abraded from contact with the Caravan. The left front wheel was displaced rearward which reduced the left wheelbase by 9.3 cm (3.7"). The CDC for the frontal impact to the Ford Taurus was 11-FLEW-1. Six crush measurements were taken along the upper radiator support and were as follows: C1 = 23.8 cm (9.4"), C2 = 21.0 cm (8.3"), C3 = 9.6 cm (3.8"), C4 = 4.5 cm (1.8"), C5 = 0.0 cm, C6 = 0.0 cm.

MANUAL RESTRAINT SYSTEM - ***1997 Dodge Caravan***

The front seat positions were equipped with manual continuous loop 3-point lap and shoulder belts with lightweight cinching latch plates and inertial lock/belt sensitive retractors. Both front adjustable D-rings were in the full down position and both latch plates exhibited routine wear marks consistent with frequent usage. There was no loading evidence on either front belt webbing.

The second and third seats were equipped with manual 3-point lap and shoulder belts for the outboard seat positions and manual lap belts for the center seat positions. The outboard lap and shoulder belts were configured with lightweight cinching latch plates and inertial lock/belt sensitive retractors. The second seat lap and shoulder belts were equipped with adjustable D-rings that were in the full down positions.

The manual 3-point lap and shoulder belt was used to secure the Century booster seat in the left position on the second seat. The manual restraint was routed through the rear aspect of the child safety seat per the manufacturer's instructions. The webbing exhibited one complete twist between the floor anchor and the D-ring. The webbing was found folded and gathered in the forward aspect of the D-ring from the forward loading of the child safety seat during the rebound after the initial impact and the subsequent lateral loading from the secondary impact **(Figure 11)**. Subtle blood spattering was noted on the D-ring. The manual 3-point lap and shoulder belt for the second seat center position exhibited signs of loading on the webbing from the convertible child safety seat.

Figure 11. D-ring for the second seat left position

The manual 3-point lap and shoulder belt was used with the Century belt-positioning booster to restrain the 5-year-old child on the third seat left position. At the time of the vehicle inspection, the manual restraint was found looped over the left side integral armrest on the booster seat. The webbing exhibited one

complete twist over a 30.5 cm (12.0") length between the lightweight cinching latch plate and the booster seat arm rest.

CHILD SAFETY SEAT ***(Second Row Left Position - 1997 Dodge Caravan)***

A Century Breverra Premiere seat was installed in the left position on the second seat of the Dodge Caravan. The model number was 4885DOM and the manufacture date was November 11, 1997. The seat could be used with the 5-point harness system for children that weighed between 13.6 kg (30.0 lb) and 18.1 kg (40.0 lb) and whose height was between 88.9 cm (35.0") and 109.2 cm (43.0"). For use as a belt-positioning booster with the vehicle's 3-point manual lap and shoulder belt, it was used by children that weighed between 13.6 kg (30.0 lb) and 27.2 kg (60.0 lb) and whose height was between 88.9 cm (35.0") and 127.0 cm (50.0"). A NHTSA recall notice was listed for this child safety seat as follows:

NHTSA Campaign ID Number:	99X-001
Recall Date:	January 18, 2000
Make/Model:	Century Breverra Premiere and Century Breverra Contour
Production Dates:	February 1995 - July 10, 1998

Defect: This is not a safety recall in accordance with Federal Regulation Part 573. However, it is deemed a product improvement campaign by the agency. The buckle for the harness system on these booster seats can crack or break. In the event of a vehicle crash, the child may not be properly restrained causing increased risk of personal injury.
Corrective Action: Owners are being asked to check the buckle at the top and down the side on their car seat and Century will replace the buckle if it is cracked.

The Century Breverra was found installed in the Caravan. The seat was secured with the manual 3-point lap and shoulder belt and lightweight cinching latch plate. Post-crash observations indicated that the lap portion of the manual 3-point belt was not tightened properly. Post-crash, the child seat freely moved 10.2 cm (4.0") laterally to the right and 12.7 cm (5.0") laterally to the left at the belt path. The child seat also freely moved forward 8.9 cm (3.4") at the top aspect and 10.8 cm (4.3") at the bottom aspect. Due to the rearward deflection of the driver's seat back, the distance between the leading edge of the child seat and the static driver's seat back was 7.0 cm (2.8") on the left side and 5.7 cm (2.3") on the right side. The distance between the top of the child seat and the driver's integral head restraint was 34.3 cm (13.5"), which placed the deflected front left seat back into the forward head excursion range of the child seated in the child seat **(Figure 12)**. The NHTSA 213 head excursion limit for forward facing child safety seats is 81.3 cm (32.0") without a tether strap.

Figure 12. View showing distance between the booster seat and the damaged driver's seat back

Figure 13. Damaged Century booster seat

Figure 14. Close up of twisted harnesses and shield with tongues

At the time of the vehicle inspection, the harness system in the Century Breverra had numerous twists in the webbing **(Figure 13)**. The right harness strap had two complete twists between the harness slots and the right shield with tongue. The entire left harness strap had repeated twists in the webbing through upper and lower harness slots, the left retainer clip, and the left shield with tongue **(Figure 14)**. The twists significantly reduced the width of the harness straps to a rope-like strap. The harness retainer clip was positioned at the full-down position adjacent to the shields with tongues. The buckle webbing had one complete twist. There were no cracks in the plastic buckle housing and the buckle was operational. A moderate amount of blood was on the inboard right aspect of the fabric cover. Blood was also observed on the right aspect of the fabric below the bottom harness slot, on the mid aspect of both harness straps, on the harness retainer clip, and on the rigid plastic shield with tongues.

The Century Breverra seat was occupied by a 3-year-old male child who weighed 17.6 kg (39.0 lb) and measured 96.5 cm (38") in height. The child was within the upper range of the manufacturer's recommended weight limits, outlined in the instruction manual for use of the seat with the 5-point harness system.

CHILD SAFETY SEAT ***(Second Row Center Position - 1997 Dodge Caravan)***

A Fisher-Price convertible child safety seat **(Figure 15)** with a plastic tray shield was installed in the center position on the second seat of the Dodge Caravan. The model number was 9104 and the manufacture date was January 5, 1995. There were no NHTSA recalls associated with this child safety seat. The seat was designed for forward-facing use by children that weighed between 9.1 kg (20.0 lb) and 18.1 kg (40.0 lb). The child safety seat had been removed from the vehicle with the child immediately after the crash

Figure 15. Fisher-Price convertible child safety seat

by a responding police officer. The seat had been installed in the vehicle in a forward-facing orientation. Upon inspection, the seat was found in the rear-facing recline position. The child safety seat was configured with two sets of slots for the harness straps; the bottom slots for rear-facing orientation and the top slots for forward-facing orientation. The harness straps were routed through the top slots of the child seat back, however, both harness straps were folded as they passed through the slots. Between the slots and the tray shield, the left harness strap had one complete twist and the right harness strap had one fold. At the time of inspection, the harness retainer clip was positioned at the lowest aspect of the right harness near the tray shield, and the left harness was not routed through the retainer clip. The buckle assembly beneath the tray shield was operational and was configured with a fixed latch plate with an automatic adjuster inertia lock. Scuff marks were noted on the leading edge of the bottom aspect of the plastic shell and on the bottom aspect of the frame. Blood was noted on the left aspect of the tray shield and fabric cover.

CHILD SAFETY SEAT ***(Third Row Left Position - 1997 Dodge Caravan)***

A Century Breverra Metro seat was located on the left third seat position of the Dodge Caravan. The model number was 44846CKM and the manufacture date was December 28, 1999. There were no NHTSA recalls associated with this seat. The seat was designed for use with the integral 5-point harness system for children who weighed 13.6 kg (30.0 lb) and 18.1 kg (40.0 lb) and up to 36.3 kg (80.0 lb) for use as a belt-positioning booster without the harness system.

Figure 16. Century belt-positioning booster seat

The Century Breverra Metro seat **(Figure 16)** was used as a belt positioning booster seat and was not secured with the vehicle's manual restraint. Even though the harness system was not used by the child seated in the seat, the harness system was still in place. The harness straps were routed through the top slots on the booster seat back. At the time of the vehicle inspection, the left harness had one complete twist between the upper harness slot and the left latch clip, and a second complete twist between the latch clip and the bottom left harness slot. The right harness strap had one complete twist through the right latch clip. The harness retainer clip was located on the harness straps 34.3 cm (13.5") below the top slots. There were no signs of abrasions or loading to the plastic belt positioner on the left side of the booster seat. Minor abrasions were noted on the bottom aspect of the plastic shell.

The 5-year-old seated in the booster seat weighed 19.5 kg (43.0 lb), which placed him out of the manufacturer's recommended range for use with the 5-point harness system. The child was restrained using the seat as a belt positioning booster in conjunction with the Caravan's manual 3-point lap and shoulder belt, which conformed with the child safety seat manufacturer's recommendations.

OCCUPANT DEMOGRAPHICS - *1997 Dodge Caravan*

Driver

Age/Sex:	31-year-old male
Height:	178 cm (70")
Weight:	77 kg (170 lb)
Seat Track Position:	Full rear
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	Vehicle inspection, driver, police report
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a regional trauma center where he was treated and released

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
3.0 cm (1.2") occipital scalp laceration	Minor (190602.1,6)	Occupant-to-occupant interaction (head-to-head contact) with the 3-year-old seated on the left position of the second seat

*Injury source: Emergency department record

Driver Kinematics

The 31-year-old male driver of the Dodge Caravan was seated in an upright posture with the seat track adjusted to the full rear position. He was restrained by the manual 3-point lap and shoulder belt. At impact with the Chevrolet tow truck, the driver initiated a rearward trajectory and loaded the front left seat back. As a result of the rearward loading, the seat back deflected rearward into the occupant space of the second seat. Due to the heavier construction of the outboard seat back bracket, the seat back also deflected slightly inward. As the seat back deflected rearward, the 3-year-old child in the child safety seat also initiated a rearward trajectory, however, his forward rebound was considerably faster than that of the driver. This placed the child forward in the second seat position as the driver was moving rearward. The driver's torso slid upward on the seat back as the seat back deflected rearward which allowed the rear aspect of his head to become exposed over the integral head restraint. The front left seat back collapsed against the leading edge of the second seat and the child safety seat. The driver's exposed head struck the front aspect of the 3-year-old's head as the driver moved rearward and the child rebounded forward. The driver sustained a 3.0 cm (1.2") laceration on the occipital region as a result of the occupant-to-occupant interaction. The secondary impact displaced the driver in the seat slightly, however, the driver's use of the manual restraint mitigated additional movement in the vehicle. The driver exited the vehicle under his own power and was transported by ambulance to a regional trauma center where he received 12 sutures for the head laceration, and was treated and released.

Front Right Passenger

Age/Sex:	30-year-old female
Height:	Not reported
Weight:	Not reported
Seat Track Position:	Full rear
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	Vehicle inspection, police report
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a regional trauma center where she was treated and released

Front Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Left parietal contusion	Minor (190402.1,2)	Possible occupant-to-occupant contact with the driver's right hand
Chest wall strain	Minor (442214.1,9)	Lateral loading of the shoulder belt

*Injury source: Emergency department record

Front Right Passenger Kinematics

The 30-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. At impact, she initiated a rearward trajectory and loaded the front right seat back. The loading to the seat back resulted in the rearward deflection of the seat back into the second seat occupant space. The seat back was also deflected slightly inward, consistent with the deflection of the front left seat back. The front right passenger was redirected to the right as a result of the secondary impact. She loaded the manual restraint and sustained a chest wall strain from the shoulder belt. She also sustained a left parietal contusion, possibly a result of occupant-to-occupant contact with the driver's right arm or hand, however, that contact could not be confirmed. When the Caravan came to final rest, the front right passenger reportedly removed the manual restraint and went into the rear of the Caravan to assist in the removal of the children. She exited the vehicle and was treated by rescue personnel at the scene. She was transported by ambulance to a regional trauma center where she was treated and released.

Second Seat Left Position Child Passenger

Age/Sex:	3-year-old male
Height:	97 cm (38")
Weight:	18 kg (39 lb)
Seat Track Position:	Fixed
Manual Restraint Use:	Century Breverra seat with integral 5-point harness
Usage Source:	Vehicle inspection, injury data, police report
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a regional trauma center where he expired three days following the crash

Second Seat Left Position Child Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Multiple punctate hemorrhages in the white matter in the right and left frontal lobes	Critical (140626.5,3)	Occupant-to-occupant contact with the rear aspect of the driver's head
Small subdural hemorrhage	Severe (140652.4,9)	Occupant-to-occupant contact with the rear aspect of the driver's head
Extensive lacerations of right frontal lobe	Severe (140688.4,1)	Occupant-to-occupant contact with the rear aspect of the driver's head
Diffuse brain swelling	Severe (140660.3,9)	Occupant-to-occupant contact with the rear aspect of the driver's head
Subarachnoid hemorrhage in both cerebral hemispheres	Serious (140684.3,1) (140684.3,2)	Occupant-to-occupant contact with the rear aspect of the driver's head
Linear fracture in the left middle cranial fossa involving the petrous part of the temporal lobe	Serious (150200.3,8)	Occupant-to-occupant contact with the rear aspect of the driver's head
Linear skull fracture involving the right frontal bone and extending to the right temporal bone transversely	Serious (150404.3,1)	Occupant-to-occupant contact with the rear aspect of the driver's head

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Lung contusion, NFS	Serious (441402.3,9)	Twisted/roped child safety seat harness straps
Liver laceration, NFS	Moderate (541820.2,1)	Twisted/roped child safety seat right harness strap/shield with tongue
Liver contusion	Moderate (541822.2,1)	Twisted/roped child safety seat right harness strap/shield with tongue
Right temporal scalp contusions	Minor (190402.1,1)	Right interior side aspect of the child safety seat/plastic seat belt positioner
Semi-circular 2.5 cm (1.0") laceration on the right forehead, 2.5 cm (1.0") above the eyebrow	Minor (290602.1,7)	Right interior side aspect of the child safety seat/plastic seat belt positioner
2.0 cm (0.8") laceration on the right upper eyebrow	Minor (290602.1,7)	Right interior side aspect of the child safety seat/plastic seat belt positioner
7.6 cm (3.0") transverse linear contusion on the upper back approximately 5.1 cm (2.0") below the base of the neck	Minor (690402.1,7)	Child safety seat back
Multiple linear abrasions on the left shoulder extending to the upper back	Minor (790202.1,2)	Child safety seat back
5.1 x 3.1 cm (2.0 x 1.5") left shoulder contusion	Minor (790402.1,2)	Child safety seat back

*Injury source: Emergency department record and autopsy

Second Seat Left Position Child Passenger Kinematics

The 3-year-old male child was restrained in a Century booster child safety seat with the integral 5-point harness system. The child safety seat was installed on the left position of the second bench seat directly behind the driver. The loose installation of the child seat allowed for considerable lateral and forward movement of the child safety seat at the belt path, which ultimately contributed the child's forward travel. Both harness straps were twisted/roped which reduced their width.

At impact, the 3-year-old initiated a rearward trajectory and loaded the child safety seat back. He sustained a 7.6 cm (3.0") transverse linear contusion on the upper back approximately 5.1 cm (2.0") below the base of the neck, multiple linear abrasions on the left shoulder extending to the upper back, and a 5.1 x 3.1 cm (2.0 x 1.5") left shoulder contusion. The child quickly rebounded forward as the driver moved rearward due to the deflection of the front left seat back. The forward excursion of the child's head, the forward movement of the child safety seat, and the intrusion of the driver's seat into the allowable head excursion zone allowed the exposed rear aspect of the driver's head to contact the front aspect of the child's head. The occupant-to-occupant interaction resulted in multiple punctate hemorrhages in the white matter in the right and left frontal lobes, a small subdural hemorrhage, extensive lacerations of right frontal lobe, diffuse brain swelling, subarachnoid hemorrhage in both cerebral hemispheres, a linear fracture in the left middle cranial fossa involving the petrous part of the temporal lobe, and a linear skull fracture involving the right frontal bone and extending to the right temporal bone transversely.

The 3-year-old was redirected to the right in response to the secondary impact, and loaded the right harness strap and plastic harness shield with tongue which resulted in a liver laceration and contusion. He also sustained a lung contusion from loading the twisted/roped harness straps. He struck the right side interior surface of the child safety seat and the rigid plastic belt positioner with the right aspect of his head. He sustained right temporal scalp contusions, a semi-circular 2.5 cm (1.0") laceration on the right forehead, 2.5 cm (1.0") above the eyebrow, and a 2.0 cm (0.8") laceration on the right upper eyebrow from that contact.

The unconscious 3-year-old was removed from the child safety seat and from the Dodge Caravan by a passer-by at the crash scene. The child was placed on the concrete driveway and treated by first responding police officers at the scene. He was subsequently transported by ambulance to a regional trauma center where he expired three days following the crash.

Second Seat Center Position Child Passenger

Age/Sex:	18-month-old male
Height:	Not reported
Weight:	Not reported
Seat Track Position:	Fixed
Manual Restraint Use:	Fisher-Price convertible child safety seat, forward facing
Usage Source:	Vehicle inspection, injury data, police report
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a regional trauma center where he was treated and released

Second Seat Center Position Child Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Abrasion on the right side of the face	Minor (290202.1,1)	Right interior side aspect of the child safety seat

*Injury source: Police crash report

Second Seat Center Position Child Passenger Kinematics

The 18-month-old male child passenger was restrained in a Fisher-Price convertible child safety seat positioned in a forward facing orientation on the center aspect of the second bench seat. The installation of the seat could not be evaluated since it was removed from the Caravan at the scene. At impact, the child initiated a rearward trajectory and loaded the child safety seat back. He rebounded forward and loaded the integral harness system and tray shield. He was redirected to the right due to the secondary impact. The right aspect of his face contacted the right interior side aspect of the child safety seat which resulted in an abrasion on the right side of this face. A first-responding police officer removed the child and the child safety seat from the Caravan. The 18-month-old was transported by ambulance to a regional trauma center, treated and released.

Third Seat Left Position Child Passenger

Age/Sex:	5-year-old male
Height:	Not reported
Weight:	20 kg (43 lb)
Seat Track Position:	Fixed
Manual Restraint Use:	Century Breverra Metro seat with an integral 5-point harness used in the belt-positioning mode
Usage Source:	Vehicle inspection, police report,
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a regional children's hospital and treated and released

Third Seat Left Position Child Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Lumbar strain	Minor (640678.1,8)	Lateral and rotational impact forces

*Injury source: Emergency department records

Third Seat Left Position Child Kinematics

The 5-year-old male child passenger was restrained by the vehicle's manual 3-point lap and shoulder belt in the Century belt-positioning booster seat. The harness system was still in place on the booster seat, although it was not used to restrain the child. The booster seat was positioned on the left aspect of the third bench seat. At impact, the child initiated a rearward trajectory and loaded the child safety seat back. He rebounded forward and loaded the manual restraint. He was redirected laterally to the right due to the secondary impact and post-impact rotation. He may have partially jackknifed over the lap belt and loaded the right side integral arm rest of the child safety seat. The impact and rotational forces resulted in a lumbar strain. The 5-year-old was removed from the vehicle and was taken into the church near the crash site. He was transported by ambulance to a regional trauma center, treated and released.

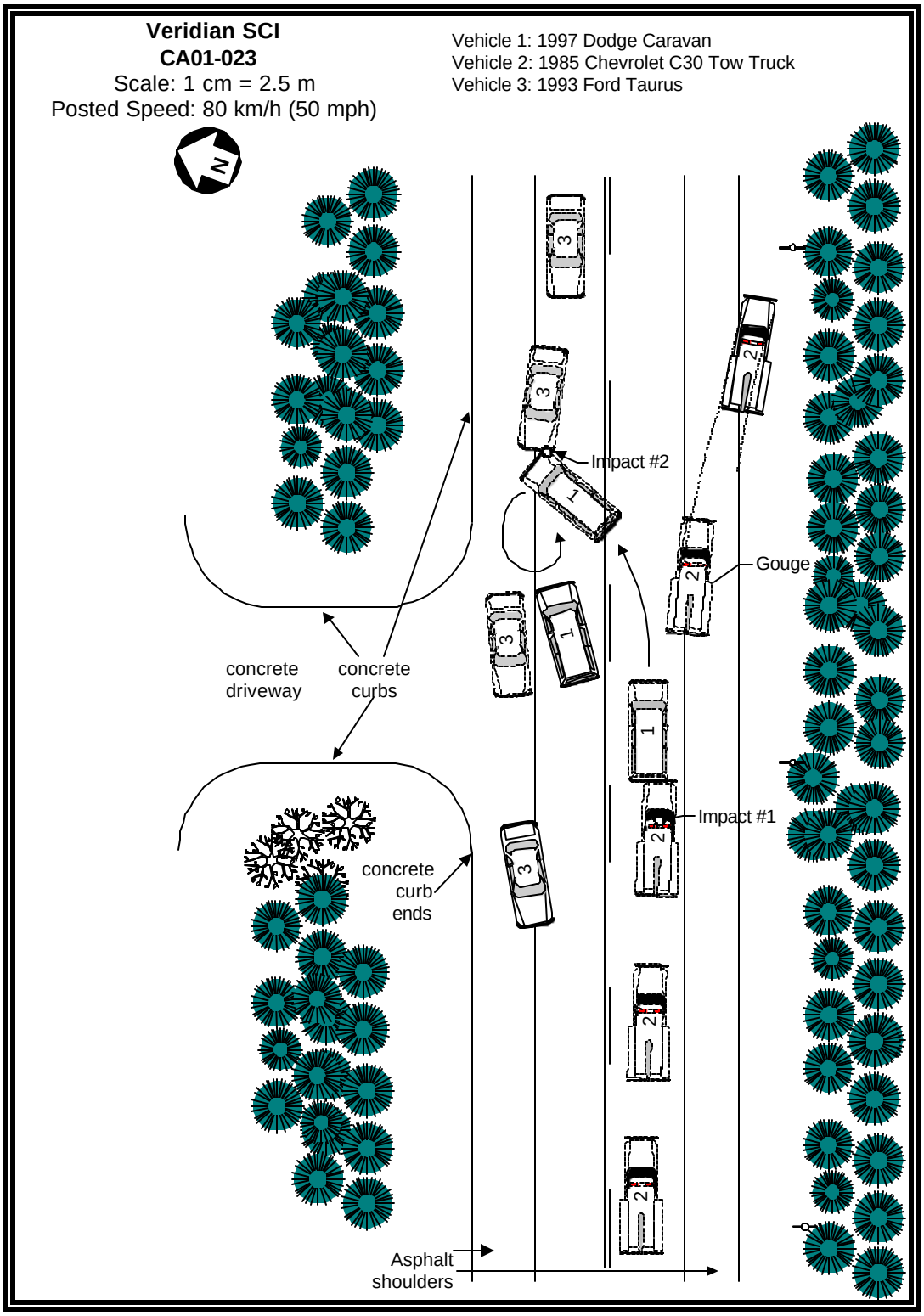

Figure 17. Scene schematic