

CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NO.: CA03-068

LOCATION: STATE OF NEW YORK

VEHICLE: 1999 DODGE GRAND CARAVAN

CRASH DATE: DECEMBER 2003

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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CALSPAN ON-SITE CHILD SAFETY SEAT INVESTIGATION
CASE NO.: CA03-068
LOCATION: STATE OF NEW YORK
VEHICLE: 1999 DODGE GRAND CARAVAN
CRASH DATE: DECEMBER 2003

BACKGROUND

This on-site investigative effort focused on the performance of the Belt Positioning Booster (BPB) seat, the forward-facing convertible Child Safety Seat (CSS), and the resulting injury mechanisms of the occupants of a 1999 Dodge Grand Caravan (**Figure 1**). The Grand Caravan was involved in a run-off-road crash during snow conditions. The Grand Caravan was occupied by a restrained 32-year-old female driver, a 10-month-old male restrained in the forward-facing CSS, and a 3-year-old female positioned in a BPB and restrained by the vehicle's safety belt. The driver lost control of the vehicle on a snow-covered roadway, initiated a clockwise (CW) yaw, and traveled into a roadside ditch. The Grand Caravan initiated a rapid CW rotation, and began to roll onto its left side. The Grand Caravan struck multiple trees with the left side aspect, which prevented the vehicle from rolling completely onto its left side. The impact resulted in significant lateral and vertical intrusions into the driver's position. The driver sustained a closed head injury, a left frontal scalp laceration, an abrasion and contusion to the left arm, and a Stage 1 splenic hematoma. She was transported by helicopter to a regional trauma center and admitted for treatment. Neither child sustained injury as a result of the crash and did not receive medical treatment.



Figure 1. Damaged 1999 Dodge Grand Caravan

The Calspan SCI team identified this crash. Cooperation was established with the driver of the Grand Caravan and the investigating police agency, and a copy of the Police Accident Report was obtained from the investigating agency. The notification was forwarded to the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) due to the use of the BPB and convertible CSS. An on-site investigation was assigned on December 17, 2003. The BPB and CSS were inspected during an in-person interview with the driver.

VEHICLE DATA – 1999 Dodge Grand Caravan

The 1999 Dodge Grand Caravan was identified by the Vehicle Identification Number (VIN): 2B4GP24G0XR (production sequence omitted). The Grand Caravan had been purchased used approximately one year prior to the crash. The vehicle was a four-door minivan that was equipped with a Flex Fuel 3.3 liter, V-6 engine, capable of operating on E85 (85 percent ethanol and 15 percent gasoline), unleaded gasoline, or any blend of the two. The vehicle was also equipped with a four-speed automatic transmission, power brakes, power steering, and a tilt steering wheel. The tilt steering wheel was jammed at the time of the vehicle inspection and

appeared to be in the full-down position. At the time of the vehicle inspection the odometer could not be read due to the lack of power to the vehicle. The manufacturer's recommended tire pressure was unknown, as the placard could not be accessed due to the jammed left front door. The specific tire data at the time of the inspection was as follows:

Position	Tire	Measured Pressure	Measured Tread	Damage
LF	Goodyear Model Unknown	155.1 kPa (22.5 PSI)	6.4 mm (8/32")	None
LR	Gillette Bear P205/75R14	168.9 kPa (24.5 PSI)	7.1 mm (9/32")	None
RF	Goodyear Integrity P205/75R14	210.3 kPa (30.5 PSI)	7.1 mm (9/32")	None
RR	Goodyear Conquest P205/75R14	165.5 kPa (24.0 PSI)	3.2 mm (4/32")	None

The Grand Caravan was configured with box-mounted bucket seats with integral head restraints for the driver and front right seat positions. The driver's seat was adjusted to a mid-track position at the time of the vehicle inspection. The second row was configured with a removable 2-person bench seat with adjustable head restraints. Both head restraints were positioned 7.6 cm (3.0") above the seat back. The third row was configured with a removable three-person bench seat with adjustable head restraints for the outboard positions that were adjusted to the full-down positions.

CRASH SITE

This single-vehicle crash occurred during the daylight hours of December 2003, in the state of New York. At the time of the crash, snow was falling and the asphalt roadway was snow-covered. The north/south two-lane roadway was configured with a broken yellow centerline for northbound traffic and a solid yellow centerline for southbound traffic. A single broken yellow centerline was present north of the crash site. The roadway exhibited a slight positive southbound grade. Asphalt shoulders bordered the roadway with earth drainage ditches paralleling the shoulders. The west roadside ditch was located 1.1 m (3.6') from the west road edge, and measured 1.5 m (4.9') in width and 76 cm (30") in depth. Wooded areas were located on each roadside and the west tree line began at the west aspect of the roadside ditch. The crash site was located at a cluster of small trees that measured 8 - 10 cm (3 - 4") in diameter. A tree that measured 20 cm (8") in diameter was also located at the crash site. The posted speed limit was 89 km/h (55 mph). The scene schematic is included as **Figure 10** of this narrative report.

CRASH SEQUENCE

Pre-Crash

The 32-year-old female driver was operating the vehicle in a southbound direction on the two-lane roadway during snow conditions (**Figure 2**). The roadway surface was slippery due to snow accumulation and had not been plowed or treated by road maintenance crews. The driver stated that she was attempting to maintain control of the vehicle by driving in existing tire tracks that were present in the lane from a previous vehicle. As she ascended the slight positive grade, she noted a dump truck approaching in the opposite lane. She attempted to steer slightly to the right to provide additional distance for the truck to pass. As the Grand Caravan traveled out of the tire tracks and into the deeper snow, the driver lost control of the vehicle. The Grand Caravan initiated a CW yaw, departed the right roadside, and entered the roadside ditch.



Figure 2. Southbound approach for the Grand Caravan

Crash

The front right bumper corner impacted the west outboard ditch bank. The initial impact was minor due to the snow accumulation on the roadside, and was not sufficient to deploy the frontal air bag system. The impact caused the Grand Caravan to rotate approximately 90 degrees in a rapid CW direction about the front right bumper corner, and the angle of the ditch bank caused the Grand Caravan to tip laterally, with the left side leading. The left front door area impacted a tree that measured 20 cm (8") in diameter. Due to the non-horizontal attitude of the vehicle, the direct contact and pocketing extended onto the roof. The impact resulted in severe left side/left roof damage and significant vertical passenger compartment intrusion. The left front fender struck a small tree that measured 8 cm (3") in diameter and additional multiple small trees were contacted which did not produce measurable vehicle damage. The Grand Caravan came to rest in a non-horizontal attitude with its left side engaged against the tree.



Figure 3. View of ditch and struck tree cluster

Post-Crash

The female driver sustained a positive loss of consciousness at the scene and her extrication from the vehicle took approximately 20 minutes. Both rear bench seats were removed to facilitate extrication of the driver. A passerby stopped at the crash site and removed both child passengers from the CSS's and from the vehicle. The 10-month-old and 3-year-old child passengers were not injured and did not receive medical treatment. The driver of the Grand Caravan was transported by helicopter to a regional trauma center and admitted for treatment. She was released two days after the crash.

VEHICLE DAMAGE

Exterior Damage – 1999 Dodge Grand Caravan

The 1999 Dodge Grand Caravan sustained minor front right damage as a result of the initial impact with the ditch. The front bumper fascia was fractured at the centerline and the right half of the fascia was separated from the vehicle at the time of inspection. The direct damage involved the entire width of the front bumper and measured 129.5 cm (51.0”) in width. The left aspects of the bumper fascia and bumper beam exhibited scuff marks. The grille was fractured and partially separated. The Collision Deformation Classification (CDC) for the initial impact with the ditch was 11-FDEW-1. Six crush measurements were documented along the front bumper beam and were as follows: C1 = 6.2 cm (2.4”), C2 = 5.1 cm (2.0”), C3 = 2.0 cm (0.8”), C4 = 1.7 cm (0.7”), C5 = 3.3 cm (1.3”), C6 = 5.1 cm (2.0”). Due to the yielding object, no Winsmash reconstruction could be completed.



Figure 4. Close up of frontal damage to the Grand Caravan



Figure 5. View of left side damage to the Grand Caravan



Figure 6. Close-up of direct damage from the tree

The Grand Caravan sustained severe left side and roof damage as a result of the left side impact with the tree (**Figures 5 and 6**). The direct contact damage began 36.2 cm (14.3”) aft of the left front axle and extended 34.3 cm (13.5”) rearward along the left side plane. The maximum crush was located 30.5 cm (12.0”) forward of the aft edge of the left front door and measured 48.3 cm (19.0”) at the mid-door level. The maximum lateral crush at the same longitudinal location on left roof side rail measured 56.5 cm (22.5”). The direct contact and crush extended vertically from the left sill to the roof side rail and extended laterally 119.4 cm (47.0”) from the left roof

side rail across the roof. Pocketing was present along the entire height of the left front door from direct engagement with the tree. The left A-pillar and left roof side rail were displaced laterally inward and crushed downward. The windshield header and roof were crushed downward and buckled. The lateral combined direct and induced damage began 19.1 cm (7.5”) forward of the left front axle and extended 238.8 cm (94.0”) rearward along the left side plane. The left front fender was deflected inward at the rear aspect, and the left rear sliding door was deflected inward at the forward aspect. Although the roof sustained direct contact damage and vertical displacement, the left side plane was the area of primary contact, which necessitated a CDC of 00-LPAN-5. Six crush measurements were documented along the left side at the mid-door level and were as follows: C1 = 0.0 cm, C2 = 2.9 cm (1.1”), C3 = 18.4 cm (7.3”), C4 = 25.4 cm (10.0”), C5 = 12.7 cm (5.0”), C6 = 0.0 cm. The non-horizontal impact was outside the scope of the Winsmash reconstruction program.

The secondary impact with the small diameter tree resulted in minor damage to the left front fender. The direct contact on the left fender began 73.7 cm (29.0”) forward of the leading edge of the left front door and measured 7.6 cm (3.0”) in width. The CDC for this impact was 00-LFEN-1. The lateral crush measured 1.3 cm (0.5”).

Minor deflection damage was located on the rear left corner above the taillight from rescue personnel attempting to open the rear hatch.

Interior Damage – 1999 Dodge Grand Caravan

Interior damage to the Dodge Grand Caravan was severe and attributed to passenger compartment intrusion (**Figure 7**) and occupant contact. The vertical intrusion of the left A-pillar compressed the top aspect of the steering wheel rim forward approximately 90 degrees. The distance between the driver’s seat cushion and the intruded roof and left roof side rail measured 30.5 cm (12.0”). Intruded components included the following: windshield header, roof, left roof side rail, left A-pillar, left B-pillar, left front door, and the left C-pillar. The extent of the intrusion of these components is documented in the table that follows.



Figure 7. View from right side showing intrusions into front and second row seat positions

Seating Position	Intruded Component	Magnitude	Direction
Front Left	Roof	59.7 cm. (23.5”)	Vertical
Front Left	Roof Side Rail	50.0 cm. (19.7”)	Vertical
Front Left	Windshield Header	25.9 cm. (10.2”)	Vertical
Front Left	A-Pillar	20.0 cm. (7.9”)	Vertical
Front Left	B-Pillar	14.9 cm. (5.9”)	Lateral
Front Left	Door Panel	13.0 cm. (5.1”)	Lateral

Seating Position	Intruded Component	Magnitude	Direction
Front Center	Roof	55.9 cm. (22")	Vertical
Front Center	Windshield Header	45.0 cm. (17.7")	Vertical
Front Right	Roof	31.0 cm. (12.2")	Vertical
Front Right	Windshield Header	5.1 cm. (2.0")	Vertical
Front Right	Instrument Panel	2.0 cm. (0.8")	Longitudinal
Second Left	Roof Side Rail	15.0 cm. (5.9")	Vertical
Second Left	Door Panel	14.0 cm. (5.5")	Vertical
Second Left	Roof	10.9 cm. (4.3")	Lateral
Second Left	C-Pillar	3.0 cm. (1.2")	Lateral
Second Right	Roof	2.0 cm. (0.8")	Vertical

Two makeup transfers were present on the left roof side rail that began 22.9 cm (9.0") and 12.7 cm (5.0") forward of the B-pillar centerline, and measured 19.1 cm (7.5") and 6.4 cm (2.5") in length, respectively. Each measured (2.0") in width. A body fluid transfer (blood) was present on the roof and was located 5.1 cm (2.0") aft of the B-pillar and 3.8 cm (1.5") inboard of the left roof side rail. Strands of hair were present on the driver's head restraint. The head restraint also exhibited a body fluid (blood) transfer on the outboard aspect that measured 2.5 cm (1.0") in width and 3.8 cm (1.5") in height.

MANUAL RESTRAINT SYSTEMS – 1999 DODGE GRAND CARAVAN

The 1999 Dodge Grand Caravan was configured with manual 3-point lap and shoulder belts for the driver and front right passenger seating positions. The driver's safety belt was configured with a sliding latch plate, Emergency Locking Retractor (ELR), and an adjustable D-ring that was located in the full-up position. The driver's belt was partially restricted at the time of the vehicle inspection, and although the webbing retracted, it would not extend. The bottom aspect of the webbing and anchor were captured between the left front door and the left side aspect of the driver's seat cushion. A 12.7 cm (5.0") long plastic transfer was present on the webbing at the stop button from probable engagement with the outboard aspect of the plastic seat cushion base. The plastic coated D-ring sustained abrasions from loading, and the plastic D-ring cover was partially separated.

The front right passenger's safety belt was configured with a cinching latch plate, an ELR, and an adjustable D-ring located 3.8 cm (1.5") below the full-up position.

The second row bench seat was configured with manual 3-point lap and shoulder belts for both positions. Each safety belt was configured with a cinching latch plate, an ELR, and a fixed D-ring. Corrugation from the loading of the CSS was present on the left side safety belt webbing that began 78.7 cm (31.0") above the anchor and measured 40.6 cm (16.0") in length up the webbing. Two semi-circular D-ring transfers that measured 2.5 cm (1.0") in height were present on the inboard aspect of the webbing 171.5 cm (67.5") above the anchor.

The right side safety belt webbing exhibited loading 74.9 cm (29.5”) above the lower anchor that extended upward 19.1 cm (7.5”). Minor cupping of the webbing began 106.7 cm (42.0”) above the anchor and extended 24.1 cm (9.5”) in length. One half-twist in the safety belt webbing was present between the latch plate and the D-ring. A second half-twist was present between the D-ring and the retractor. The plastic cover of the lower anchor was separated.

Manual 3-point lap and shoulder belts were present for the outboard seat positions of the third row bench seat. The third row bench seat was also configured with a center lap belt.

CHILD SAFETY SEAT – FISHER PRICE SAFE EMBRACE CONVERTIBLE CSS

The Fisher-Price convertible CSS (**Figure 8**) was identified by the Model Number: 79701. The date of manufacture was September 14, 2000. The CSS was configured with a five-point harness system, a two-piece harness retainer clip, and a tether. The seat was purchased new and was used daily to transport the 10-month-old child. The CSS was designed for rear-facing use for children between birth and one-year-old, and who weighed between 3 - 14 kg (6 - 30 lb). It was designed for forward-facing use for children one-year and older, and who weighed between 10 - 18 kg (22 - 40 lb). The harness slots were color-coded, such that the forward-facing harness slots were blue and the rear-facing harness slots were red. The convertible CSS was occupied by the 10-month-old male child. Although the child was not yet one-year-old at the time of the crash, the driver stated that the child’s pediatrician advised the parents that he felt the child’s neck control was adequate enough to be positioned in a forward-facing orientation.



Figure 1. Fisher-Price Safe Embrace Convertible CSS

The CSS was installed in a forward-facing orientation on the left aspect of the second row bench seat with the manual 3-point lap and shoulder belt. The tether was not used to install the CSS and the kickstand was down in the forward-facing position. The driver stated that she put her knee into the CSS, buckled the safety belt, pulled the slack out of the safety belt, and routed the shoulder belt through the positioning clip located on the outboard aspect of the CSS. She described the installation as “tight.” The shoulder harnesses were routed through the second set of rear-facing slots versus the reinforced top forward-facing slots, which was inconsistent with the manufacturer’s recommendations. At the time of the CSS inspection, the harness retainer clip was positioned 6.4 cm (2.5”) below the harness slots on the harness webbing. The total length of the harness webbing between each upper and lower harness slot measured 36.2 cm (14.5”), and the adjustment tab webbing was extended 50.8 cm (20.0”).

The convertible CSS sustained minor two small circular stress marks on the right side aspect.

CHILD SAFETY SEAT – FISHER PRICE SAFE EMBRACE BPB

The Fisher-Price Safe Embrace high-back BPB (**Figure 9**) was identified by the Model Number: 79752. The 3-year-old female occupied it during the crash. The date of manufacture was October 27, 1999. The BPB was configured with an adjustable shoulder belt positioner on each upper outboard aspect. Each positioner traveled a total vertical distance of 14.0 cm (5.5”), and both were located in the full-down position at the time of the BPB inspection. Two horizontal red lines were present on the seat back of the BPB, which indicated the manufacturer’s recommended minimum and maximum shoulder height. Specific height requirements were not specified on the BPB label. The driver stated that at the time of the crash, the vehicle’s shoulder belt was positioned over the shoulder and crossed the center of the child’s chest, and the lap belt was snug across the child’s hips.



Figure 2. Fisher-Price Safe Embrace BPB

Both plastic shoulder belt positioners exhibited stress marks. A stress mark was present on the top interior aspect of the right positioner from probable loading from the shoulder belt. A light stress mark was also present on the bottom aspect. The left positioner exhibited two minor stress marks on the top aspect that were most likely not a result of this crash. There was no additional damage to the BPB.

REDESIGNED FRONTAL AIR BAG SYSTEM - 1999 DODGE GRAND CARAVAN

The 1999 Dodge Grand Caravan was equipped with redesigned frontal air bags for the driver and front right passenger positions. The driver’s air bag was housed in the center of the steering wheel and the front right passenger’s air bag was configured with a mid-mount module located on the right instrument panel. The redesigned frontal air bag system did not deploy in this crash.

OCCUPANT DEMOGRAPHICS – 1999 DODGE GRAND CARAVAN

Driver

Age/Sex:	32-year-old female
Height:	168 cm (66”)
Weight:	77 kg (170 lb)
Seat Track Position:	Between mid-track and full-forward
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection, interview
Eyewear:	Prescription contact lenses
Type of Medical Treatment:	Transported by helicopter to a regional trauma center and admitted for two days.

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Closed head injury, positive loss of consciousness at scene, positive amnesia, GCS of 14 on admission	Moderate (160610.2,0)	Intruding left roof side rail
Splenic hematoma, Stage I	Moderate (544212.2,2)	Intruding left front door armrest
Left frontal scalp abrasion	Minor (190202.1,5)	Intruding left roof side rail
Small 2 cm (1”) laceration over left frontal parietal region at the hairline	Minor (190602.1,5)	Intruding left roof side rail
Left lateral upper arm abrasion	Minor (790202.1,2)	Intruding left roof side rail
Left lateral upper arm contusion	Minor (790402.1,2)	Intruding left roof side rail

Injury source: Hospital records

Driver Kinematics

The 32-year-old female driver of the Grand Caravan was seated in an upright posture with the seat track adjusted to a mid-track position. At impact with the ditch, she initiated a forward trajectory and loaded the manual restraint. She rebounded rearward and was redirected to the left as the Grand Caravan initiated a rapid CW rotation. She continued her lateral trajectory as the Grand Caravan began to tip onto its left side. At impact with the tree, she continued her lateral motion to the left and loaded the safety belt. There was no evidence of direct occupant contact with the tree, and given the tree's area of contact at the A-pillar, direct occupant contact was unlikely. Her head struck the left roof side rail that intruded in a lateral direction, which resulted in a closed head injury, positive loss of consciousness at the scene, and positive amnesia. Contact with the laterally intruding left roof side rail also resulted in a left upper arm abrasion and contusion. Her left torso contacted the intruded left front door and armrest, which resulted in a Stage I splenic hematoma. The severe vertical and lateral intrusion resulted in contact with the left roof side rail, which caused a left frontal scalp abrasion and a small 2 cm (1”) laceration over left frontal parietal region at the hairline. The driver came to rest against the intruded driver's door as a result of the angled final rest position against the tree. Due to the orientation of the Grand Caravan, rescue personnel removed the female driver from the vehicle approximately 20 minutes after the crash. She was transported by helicopter to a regional trauma center where she was admitted for two days and released.

Rear Left Passenger

Age/Sex: 10-month-old male
Height: 61 cm (24")
Weight: 10 kg (22 lb)
Seat Track Position: Fixed
Manual Restraint Use: Forward-facing Fisher-Price convertible CSS with 5-point harness
Usage Source: Vehicle inspection, CSS inspection, interview with parent
Eyewear: None
Type of Medical Treatment: Did not sustain injury and did not receive medical treatment

Rear Left Passenger Kinematics

The 10-month-old male passenger was restrained in a forward-facing Fisher-Price convertible CSS with a 5-point harness that was installed on the left aspect of the second row bench seat. At the time of the crash, he was wearing a bulky winter coat and jeans. The driver stated the he was asleep prior to the crash, and woke up as the vehicle entered the ditch. At impact with the ditch, the child initiated a forward trajectory and loaded the CSS harness system. The CSS loaded the vehicle's safety belt. The child was redirected to the left as the Grand Caravan began to rotate CW. He continued the lateral trajectory as the Grand Caravan began to tip onto its left side, and struck the tree. The CSS loaded the vehicle's safety belt due to its lateral trajectory, and the child loaded the CSS's harness system as he moved to the left. The child probably contacted the left side padded shell of the CSS and rebounded slightly to the right. Due to the angled orientation of the Grand Caravan at final rest, the child came to rest against the left side of the CSS. The child remained in the CSS and was alert and crying post-crash. A witness to the crash removed the 10-month-old child from the CSS and from the vehicle. The child did not sustain injury and did not receive medical treatment.

Rear Right Passenger

Age/Sex: 3-year-old female
Height: 91 cm (36")
Weight: 15 kg (32 lb)
Seat Track Position: Fixed
Manual Restraint Use: Vehicle's manual 3-point lap and shoulder belt
Usage Source: Vehicle inspection, interview with parent
Eyewear: None
Type of Medical Treatment: Did not sustain injury and did not receive medical treatment

Rear Right Passenger Kinematics

The 3-year-old female child was seated in the Fisher-Price Safe Embrace BPB that was positioned on the right aspect of the second row bench seat. She was restrained by the manual 3-point lap and shoulder belt. At impact with the ditch, the child initiated a forward trajectory and loaded the vehicle's safety belt. The child was redirected to the left as the Grand Caravan began to rotate CW. She continued the lateral trajectory as the Grand Caravan began to tip onto its left side, and struck the tree. She continued her lateral trajectory and loaded the vehicle's safety belt. Her head most likely contacted the left side aspect of the BPB seat back. She rebounded slightly to the right and came to rest in the BPB. Due to the angled orientation of the Grand Caravan at

final rest, the child came to rest against the left side of the BPB. The female child was alert and crying post-crash, and witness to the crash removed her from the vehicle. The child did not sustain injury and did not receive medical treatment.

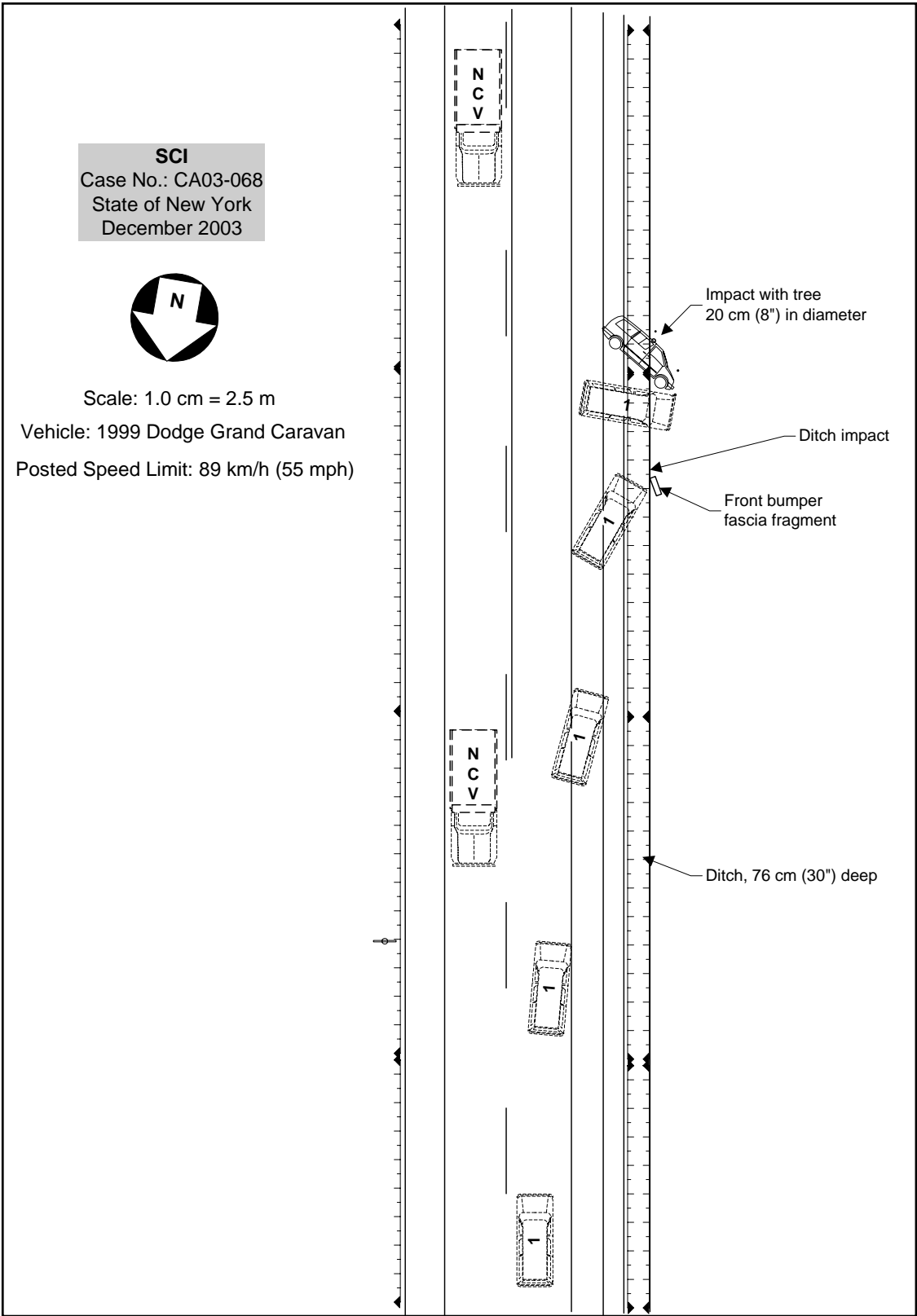


Figure 10. Scene schematic