

CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION

CASE NO.: CA05-059

VEHICLE: 2002 DODGE GRAND CARAVAN

LOCATION: MASSACHUSETTS

DATE OF CRASH: NOVEMBER 2005

Contract No. DTNH22-01-C-17002

Prepared for:

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

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

<p>1. Report No. CA05-059</p>	<p>2. Government Accession No.</p>	<p>3. Recipient's Catalog No.</p>	
<p>4. Title and Subtitle Calspan On-Site Child Safety Seat Crash Investigation Vehicle: 2002 Dodge Grand Caravan Location: State of Massachusetts</p>		<p>5. Report Date: July 2006</p>	
		<p>6. Performing Organization Code</p>	
<p>7. Author(s) Crash Data Research Center</p>		<p>8. Performing Organization Report No.</p>	
<p>9. Performing Organization Name and Address Crash Data Research Center Calspan Corporation P.O. Box 400 Buffalo, New York 14225</p>		<p>10. Work Unit No. C00410.0000.0328</p>	
		<p>11. Contract or Grant No. DTNH22-01-C-17002</p>	
<p>12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590</p>		<p>13. Type of Report and Period Covered Technical Report Crash Date: November 2005</p>	
		<p>14. Sponsoring Agency Code</p>	
<p>15. Supplementary Note This on-site investigative effort focused on the performance of a child safety seat and the resulting injuries of a 3-year-old male passenger of a 2002 Dodge Grand Caravan.</p>			
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<p>17. Key Words Child Safety Seat 3-year-old male second row right occupant</p>		<p>18. Distribution Statement General Public</p>	
<p>19. Security Classif. (of this report) Unclassified</p>	<p>20. Security Classif. (of this page) Unclassified</p>	<p>21. No. of Pages 12</p>	<p>22. Price</p>

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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
CASE NO.: CA05-059
VEHICLE: 2002 DODGE GRAND CARAVAN
LOCATION: MASSACHUSETTS
DATE OF CRASH: NOVEMBER 2005

BACKGROUND

This on-site investigative effort focused on the performance of a child safety seat and the resulting injuries of a 3-year-old male passenger of a 2002 Dodge Grand Caravan (**Figure 1**). The child safety seat was removed from the vehicle on the day of the SCI inspection prior to the arrival of the SCI investigator. Numerous attempts were made to obtain the child safety seat for inspection without success. Therefore, the child safety seat was not inspected for this on-site investigative effort. The Dodge was involved in a run-off-road collision with a wood utility pole. The vehicle was equipped with dual-stage frontal air bags for the driver and front right positions and buckle mounted safety belt pretensioners for the front positions. The Dodge was occupied by a restrained 34-year-old female driver, a restrained 7-year-old male second row left passenger, and a 3-year-old male second row right passenger who was restrained in a backless booster seat. The 34-year-old female driver of the Dodge relinquished control of the vehicle and departed the left roadside. Consequently, the front of the vehicle struck a wood utility pole. As a result of the collision, the frontal air bag system deployed and the front left safety belt buckle pretensioner fired. The driver sustained severe injuries and was transported to a local hospital where she was hospitalized for twenty days. The 7-year-old male rear left passenger sustained minor severity injuries and was transported to a local hospital where he was treated and released. The 3-year-old male sustained moderate severity injuries and was transported to a local hospital where he was hospitalized for two days.



Figure 1. 2002 Dodge Grand Caravan subject vehicle.

This crash was identified by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) through an Internet news article. The CID forwarded the news article to the Calspan Special Crash Investigations (SCI) team due to the presence of the CSS in the 2002 Dodge Caravan. The Dodge and the child safety seat were located at local tow facility and cooperation was established to inspect the vehicle and the CSS. An on-site investigation was assigned to the Calspan SCI team on November 8, 2005. The vehicle inspection and CSS inspection were scheduled for November 9, 2005. The child safety seat was removed from the vehicle on the day of the SCI inspection prior to the arrival of the SCI investigator. Numerous attempts were made

to obtain the child safety seat for inspection without success. Therefore, the child safety seat was not inspected for this on-site investigative effort.

SUMMARY

Crash Site

This run-off road crash occurred on the south roadside of a two-lane east/west road in a residential area. The travel lanes were 6 meters (19.7 feet) in width and delineated by double yellow centerlines. A positive grade of 2 percent terminated 114.7 meters (373.3 feet) east of the crash site. A right curve began 20.2 meters (66.3 feet) west of the crash site. Dirt and grass bordered the north road edge and a low concrete curb bordered the south road edge. Adjacent to the curb was a sidewalk that contained several wooden utility poles placed between the curb and the sidewalk. There was no posted speed limit within the vicinity of the crash site; therefore, it defaults to the state speed limit of 89 km/h (55 mph). The scene schematic is included as **Figure 10** of this report.

Vehicle Data

2002 Dodge Grand Caravan

The subject vehicle in this crash was a 2002 Dodge Grand Caravan. The Dodge was identified by Vehicle Identification Number (VIN) 1B4GP44372 (production number deleted). The odometer reading at the time of the SCI inspection was unknown due to the expended vehicle battery. The Dodge was equipped with a 3.3-liter, six-cylinder engine linked to a four-speed automatic transmission with a steering column mounted transmission shifter. The service brakes were front disc and rear drum with anti-lock. The vehicle was equipped with OEM steel wheel with plastic wheel covers. The tires on the Dodge were Bridgestone Weather Force tires size, P215/70R15. The manufacturer recommended front and rear tire pressure was unknown. The specific tire data at the time of the SCI inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Damage
Left Front	0 kPa	6 mm (8/32")	None
Left Rear	200 kPa (29 PSI)	8 mm (10/32")	None
Right Front	193 kPa (28 PSI)	6 mm (7/32")	None
Right Rear	207 kPa (30 PSI)	7 mm (9/32")	None

The interior of the Caravan was configured with cloth surfaced front bucket seats with integrated head restraints. The second row was configured with a left side wide two-passenger bench seat with height adjustable head restraints. The second row head restraints were not with the vehicle at the time of the SCI inspection. The third row was configured with a three-passenger bench seat with height adjustable head restraints for the outboard seats. The third row head restraints were adjusted 9 cm (3.5") above the seat backs at the time of the SCI investigation.

Crash Sequence

Pre-Crash

The 34-year-old female driver was operating the Caravan westbound on the two-lane roadway at a police reported high rate of speed (**Figure 2**). The driver had successfully negotiated the left curve and began traveling on the straight segment of the roadway. As she continued to travel in a westerly direction, the driver applied a left steering input resulting in a lane departure to the left. The Dodge traversed the eastbound lane traveling in a southwesterly direction approaching the south road side. As the vehicle neared the curb, the driver applied a right steering input and a possible brake application resulting in a clockwise rotation of the vehicle of approximately ten degrees. This steering maneuver resulted in a 9 meter (29.5 feet) left front tire scuff and a 3.7 meter (12.1 feet) left rear tire scuff, which began on the eastbound lane and extended onto the south curb (**Figure 3**). The Dodge overrode the curb and began a northwesterly trajectory exposing the left front corner of the vehicle.



Figure 2. Westbound pre-crash travel for the Dodge.



Figure 3. Pre-impact tire scuff marks.

Crash

The front left corner of the Dodge impacted a 43 cm (17") diameter wood utility pole (**Figure 4**) that was located 0.7 meters (2.3 feet) south of the curb. The resultant direction of force for this impact was 12 o'clock. The impact occurred outside the left frame rail of the Caravan. As the corner of the bumper beam crushed rearward, the left front fender, tire, wheel axle and suspension components, cowl, A-pillar, and windshield header engaged the pole. The WINSMASH damage algorithm was used to calculate a delta-V for this impact. The total delta-V was 32 km/h (19.9 mph) with longitudinal and lateral components of -32 km/h (-19.6 mph) and 6 km/h (3.5 mph), respectively. The delta-V



Figure 4. Struck 43 cm (17.0") diameter utility pole.

data was not representative of the damage to the vehicle due to the impact location occurring outboard of the left frame rail. The resultant crush to the cowl and windshield header was outside the scope of the WINSMASH program, and was not used in the calculation of the delta-V. The Dodge came to rest against the pole facing a westerly direction.

Post-Crash

Police and Emergency Medical Services (EMS) personnel responded to the crash site. The fire department pried open the left front door to facilitate the extrication of the driver. The driver sustained severe injuries and was transported to a local hospital where she was hospitalized for twenty days. The 7-year-old male rear left passenger sustained minor severity injuries and was transported to a local hospital where he was treated and released. The 3-year-old male sustained moderate severity injuries and was transported to a local hospital where he was hospitalized for two days. The Caravan was towed due to the disabling damage to a tow yard where it was held for this SCI inspection.

Vehicle Damage

Exterior

The 2002 Dodge Grand Caravan sustained severe frontal damage as a result of the impact with the wood utility pole. The impact location was outboard of the left frame which allowed the vehicle to continue forward engaging the left front fender, tire/wheel and suspension components, cowl and windshield header locations. The resultant crush was documented at the front bumper beam, cowl, and windshield header to capture the extent of damage to the Dodge. **Figures 5 and 6** are an overall view of the residual damage and maximum crush.



Figure 5. Overall view of the residual damage.



Figure 6. Lateral view of the maximum crush.

The maximum crush at the left corner of the bumper beam was 49 cm (19.3”), and 100 cm (39.3”) and 26 cm (10.2”) at the cowl and windshield header, respectively.

The direct contact damage measured 36 cm (14”) and began 43 cm (17”) left of the vehicle’s centerline and extended to the left bumper corner. The residual crush was measured along the full width of the deformed bumper beam (Field L) of 109 cm (42.9”). Six equidistant crush measurements were documented at this level and were as follows:

C1 = 49 cm (19.3"), C2 = 32 cm (12.6"), C3 = 24 cm (9.4"), C4 = 16 cm (6.3"), C5 = 7 cm (2.8"), C6 = 0 cm.

A second crush profile was documented at the level of the cowl. The crush at the cowl was measured along the full width (Field L) of 147 cm (58"). The six crush measurements at this level and were as follows: C1 = 100 cm (39.3"), C2 = 72 cm (28.3"), C3 = 40 cm (15.7"), C4 = 26 cm (10.2"), C5 = 6 cm (2.4"), C6 = 1 cm (0.4").

The windshield header deformation was measured across the full width of 117 cm (46"). The crush was as follows: C1 = 11 cm (4.3"), C2 = 26 cm (10.2"), C3 = 13 cm (5.1"), C4 = 8 cm (3.1"), C5 = 8 cm (3.1"), 0 cm. The Collision Deformation Classification (CDC) for this impact was 12-FLEE-7.

The damage components consisted of the bumper, hood, fender, left front tire/wheel and suspension, A-pillar, and the windshield header. The left front tire/wheel and suspension were separated from their respective mounted locations. Additionally, the left front door was jammed closed and was pried open by the local fire department. This damage included severe deformation to the left front door and minor damage to the left rear sliding door.

Interior

The interior of the Dodge sustained severe damage that was attributed to passenger compartment intrusion and occupant contact points (**Figure 7**). The driver's occupant contact points consisted of tears to the top of the left instrument panel from contact with her head/face. A make-up transfer was noted to the deployed front right air bag from possible contact from the driver's face. Occupant contact points could not be identified to the lower left instrument due to the severe deformation and intrusion. The occupant contact points from the rear left passenger consisted of yellow powder residue on the rear of the left front seat back. Although not considered an occupant contact point, body fluid was present on the leading edge of the rear left seat cushion. The second row right passenger contacted the rear of the right front seat back, which was evidenced by a yellow powder transfer and white colored fluid. The frame of the right front seat back could not be accessed; however, based on the 3-year-old's leg fractures it was probable that he contacted this component. Additionally, body fluid was also noted on the leading edge of the rear right seat cushion. **Figure 8** illustrates the occupant contact points to the rear of the front seat backs. The passenger compartment intrusions are identified in the following table:



Figure 7. Lateral view of the driver's area.



Figure 8. Occupant contact points to the rear of the front seat backs.

Seat Position	Intruded Component	Magnitude	Direction
Front Left	Toe pan	75 cm (29.5")	Longitudinal
Front Left	Instrument panel	111 cm (43.7")	Longitudinal
Front Left	Windshield header	31 cm (12.2")	Longitudinal
Front Left	Cowl	85 cm (33.5")	Longitudinal
Front center	Instrument panel	70 cm (27.6")	Longitudinal
Front center	Floor	59 cm (23.2")	Longitudinal
Front right	Floor	6 cm (2.4")	Longitudinal

Frontal Air Bag System

The Dodge was equipped with dual-stage frontal air bags for the driver and front right passenger positions. The system deployed as a result of the impact with the wood utility pole.

The driver's air bag was contained within the steering wheel hub. The steering wheel and air bag module were removed post-crash by rescue personnel and were not with the vehicle at the time of the SCI inspection.

The front right passenger air bag was a top-mount design, incorporated into the right instrument panel and was concealed by a single cover flap. There was no damage or contact evidence to the cover flap. The air bag measured 45 cm (17.7") in width and 86 cm (33.8") in height. The air bag was not tethered and was internally vented. The maximum rearward excursion of this air bag at the midpoint measured 57 cm (22.4"). A transfer that appeared to be make-up was located on the face of the air bag from 7-15 cm (2.8-5.9") inboard of the seam and above the lower peripheral seam. A black colored transfer was noted on the rear panel. This transfer did not appear to be an occupant contact point. Additionally, a 4 cm (1.6") tear was located on the air bag membrane. This tear began 17-21 cm (6.7-8.3") inboard of the left seam and 7-10 cm (2.8-3.9") below the bottom seam. Furthermore, several tears that ranged from 0-0.5 cm (0-0.2") were located on the rear panel of the air bag which probably resulted from contact with the fracture windshield or disintegrated side glazing.

Manual Safety Belt Systems

The 2002 Dodge Grand Caravan was equipped with three-point lap and shoulder belt systems for the six outboard seated positions. The driver's safety belt consisted of continuous loop webbing with a sliding latch plate, height adjustable D-ring, Emergency Locking Retractor (ELR), and a buckle pretensioner. The driver used the safety belt in the subject crash. There was no loading on the safety belt due to the severe intrusion of the frontal components, which reduced the forward motion of the driver. The second row safety belts consisted of continuous loop webbing with light weight locking latch plates, height adjustable D-rings that were in the full-down position at the time of the SCI inspection, and ELR's. The third row outboard safety consisted of the same mechanical

components as the second row without height adjustable D-rings. The third row center safety belt consisted of a fixed length lap belt with a locking latch plate.

The second row left safety belt was used by the 7-year-old male passenger. Minor loading abrasions to the D-ring supported belt usage by this passenger. The second row right safety belt was used by the 3-year-old male passenger that was seated in a backless booster seat. Belt usage was evidenced by the loading abrasions on the D-ring.

Child Safety Seat

The 3-year-old male passenger was restrained by the lap and shoulder belt system in the second row right position of the Dodge. He was seated in an unknown backless booster seat. The manufacturer of the safety seat was unknown. The child safety seat was removed from the vehicle on the day of the SCI inspection, prior to the arrival of the SCI investigator. Numerous attempts were made to obtain the child safety seat for inspection; however, these were unsuccessful. The tow yard operator observed the safety seat during its removal and described it to the SCI investigator as not having a backrest and resembling a telephone book. Due to this description, it was determined that this safety seat was a backless booster. **Figure 9** is of the seating locations for the child passengers.



Figure 9. Seating positions of the child passengers.

Occupant Demographics/Data

Driver Demographics

Age/Sex: 34 year old/Female
 Height: Unknown
 Weight: Unknown
 Seat Track Position: Unknown
 Eyewear: Unknown
 Manual Safety Belt Usage: Lap and shoulder belt
 Usage Source: Vehicle inspection
 Egress from Vehicle: Extricated through left front door
 Mode of Transport from Scene: Transported by ambulance to a hospital
 Type of Medical Treatment: Hospitalized for 20 days

Driver Injuries

Injury	Injury Severity AIS90/Update 98	Injury Source
Right eyelid laceration	Minor (297602.1,1)	Top of left instrument panel

Injury	Injury Severity AIS90/Update 98	Injury Source
Right eyelid abrasion	Minor (297202.1,1)	Top of left instrument panel
Right hip abrasion	Minor (890202.1,1)	Lower left instrument panel
Left elbow laceration into joint	Moderate (750640.2,2)	Left instrument panel
Bilateral frontal lobe hemorrhagic contusion	Serious (140620.3,3)	Top of left instrument panel
Left subarachnoid hemorrhage	Serious (140684.3,2)	Top of left instrument panel
Right subarachnoid hemorrhage	Serious (140684.3,1)	Top of left instrument panel
Right frontal and left subgaleal hemorrhage	Serious (190402.1,0)	Top of left instrument panel
Right second finger dorsal dislocation	Minor (750404.1,1)	Left instrument panel
Left anterior pneumothorax and a small left upper lobe pulmonary contusion	Serious (441406.3,2)	Steering wheel
Left femoral head fracture with left hip dislocation	Serious (851808.3,2)	Lower left instrument panel and knee bolster
Left tibia mid shaft fracture open 20 cm (7.9") highly comminuted, Grade III B	Serious (853422.3,2)	Lower left instrument panel and knee bolster
Right femoral mid shaft distal fracture, highly comminuted, open	Serious (851814.3,1)	Lower left instrument panel and knee bolster
Left intracordylar femur fracture	Serious (851804.3,2)	Lower left instrument panel and knee bolster
Left complete tear of quadriceps tendon from the patella	Moderate (840802.2,2)	Lower left instrument panel and knee bolster
Left open navicular fracture open (Grade II)	Moderate (852200.2,2)	Floor panel
Avulsion of the left heel pad from the calcaneus	Minor (890800.1,2)	Unknown
Left fibula mid shaft fracture mildly comminuted	Moderate (851606.2,2)	Lower left instrument panel and knee bolster
Left tibia plateau fracture	Moderate (853406.2,2)	Lower left instrument panel and knee bolster
Right proximal comminuted fibula fracture	Moderate (851605.2,1)	Lower left instrument panel and knee bolster
Left and right laceration to anterior distal thigh	Minor (890600.1,3)	Lower left instrument panel and knee bolster

Source – Medical records

Driver Kinematics

The 34-year old female driver of the 2002 Dodge Grand Caravan was presumed seated in an upright driving position and was restrained by the manual safety belt system.

At impact with the utility pole, the frontal air bag system deployed. The driver initiated a forward trajectory in response to the 12 o'clock direction of force. As vehicle crushed to maximum engagement the left instrument panel, toe pan, and steering wheel/column intruded into the driver's space limiting her motion and loading the belt system. The intruding instrument panel also moved vertically downward, resulting in no interaction between the driver's face and the air bag. The combination of her forward trajectory and intrusion allowed the driver to contact the steering wheel, upper and lower left instrument panel. Her contact and loading of the rearward displacing steering wheel/column resulted in the left anterior pneumothorax and a small left upper lobe pulmonary contusion.

The contact to the intruding upper instrument panel resulted in the right eyelid laceration, right eyelid abrasion, bilateral frontal lobe hemorrhagic contusion, left subarachnoid hemorrhage, right subarachnoid hemorrhage, and the right frontal and left subgaleal hemorrhages. The intruding lower instrument panel and knee bolster contact resulted in the left elbow laceration into joint, right second finger dorsal dislocation, left femoral head fracture with left hip dislocation, left tibia mid shaft fracture open 20 cm (7.9") highly comminuted, Grade III B, right femoral mid shaft distal fracture, highly comminuted open, left intracordylar femur fracture, left complete tear of quadriceps tendon from the patella, left open navicular fracture open (Grade II), left tibia mid shaft fracture mildly comminuted, left tibia plateau fracture, right proximal comminuted fibula fracture, left and right femur laceration anterior and distal thigh. Additionally, the driver sustained an avulsion of the left heel pad from the calcaneus, the injury source could not be identified for this injury.

The driver was extricated from the vehicle which was evidenced by the pry marks on the left front door area. She was transported to a local hospital where she was hospitalized for twenty days.

Rear Left Passenger

Age/Sex:	7-year-old/Male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Not adjustable
Eyewear:	Unknown
Restraint Use:	Lap and shoulder belt
Usage Source:	Vehicle inspection
Egress from Vehicle:	Unknown
Mode of Transport from Scene:	Transported by ambulance
Type of Medical Treatment:	Treated and released

Rear Left Passenger Injuries

Injury	Injury Severity (AIS 90, Update 98)	Injury Source
Unknown	Unknown	Unknown

Source: Hospital records

Rear Left Passenger Kinematics

The 7-year-old male rear left passenger was seated in a presumed upright posture and was restrained by the manual safety belt system. At impact, he initiated a forward trajectory in response to the crash forces. He loaded the manual belt system which arrested his forward motion. The driver's medical records indicated that the 7-year-old male sustained minor severity injuries. He was transported to a local hospital where he was treated and released. The medical records for this occupant were not available.

Rear Right Child Passenger

Age/Sex: 3-year-old/Male
Height: Unknown
Weight: Estimated by hospital 15 kg (33 lbs)
Seat Track Position: Not adjustable
Eyewear: Unknown
Restraint Use: Lap and shoulder belt with backless booster
Usage Source: Vehicle inspection
Egress from Vehicle: Unknown
Mode of Transport from Scene: Ambulance to hospital
Type of Medical Treatment: Hospitalized for two days

Rear Right Child Injuries

Injury	Injury Severity AIS90/Update 98	Injury Source
Right lower leg abrasion	Minor (890402.1,1)	Rear of front right seat back
Right tibia mid shaft fracture transverse non-displaced	Moderate (853420.2,1)	Rear of front right seat back
Right fibula mid shaft fracture transverse non-displaced	Moderate (851606.2,1)	Rear of front right seat back
Anterior neck abrasion 8 cm x 2 cm (3.1" x 0.8") with a mild laryngeal edema	Minor (390202.1,5)	Shoulder belt
Right shoulder abrasion	Minor (790202.1,1)	Shoulder belt
Right chest contusion	Minor (490202.1,1)	Shoulder belt
Right waist abrasion	Minor (590202.1,1)	Lap belt

Source – Medical Records

Rear Right Child Kinematics

The 3-year-old male child passenger was seated in a backless booster seat and was restrained by the vehicle's lap and shoulder belt system. At impact, the child responded to the frontal crash forces by initiating a forward trajectory. His legs contacted and loaded the rear of the seatback which resulted in the right lower leg abrasion, right tibia mid shaft fracture transverse non-displaced, and the right fibula mid shaft fracture transverse non-displaced. Additionally, he loaded the lap and shoulder belt system with his torso and hips. The anterior neck abrasion 8 cm x 2 cm (3.1" x 0.8") with a mild laryngeal edema, right shoulder abrasion, right chest contusion, and right waist abrasion resulted from this loading.

The 3-year-old male was transported to a local hospital where he was hospitalized for two days for treatment of his injuries.

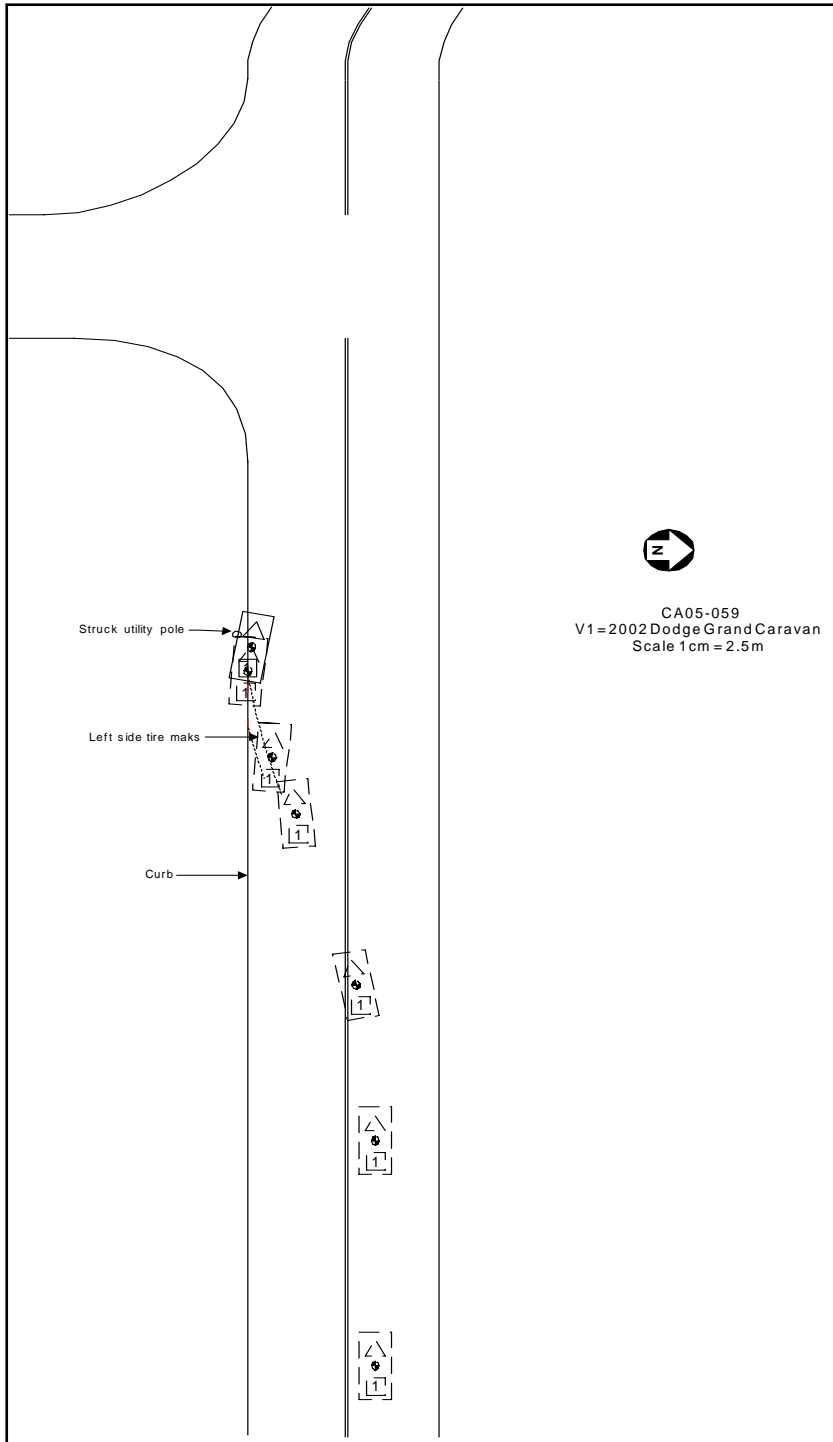


Figure 10: Scene Schematic