**CRASH DATA RESEARCH CENTER**
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Buffalo, NY 14225

# CALSPAN ON-SITE ROLLOVER CRASH INVESTIGATION
# SCI CASE NO: CA09065

## VEHICLE: 2007 DODGE CARAVAN
## LOCATION: PENNSYLVANIA
## DATE: AUGUST 2009

Contract No. DTNH22-07-C-00043

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.

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***BACKGROUND***

This investigation focused on the roadside departure fixed object/rollover crash of a 2007 Dodge Caravan. **Figure 1** is a front right oblique view of the Dodge. The Dodge was equipped with a Certified Advanced 208-Compliant (CAC) front air bag system and a driver knee air bag. It was not equipped with side impact air bags or Inflatable Curtain air bags. The crash occurred on the south road side of a 2-lane divided east/west state roadway located in a suburban setting. The Dodge was eastbound driven by a 48-year-old female. The police investigation determined the driver was distracted using her cellular telephone immediately prior to the crash. The Dodge drifted to the right where the right wheels struck and mounted the right curb. The vehicle continued forward on the roadside and struck a utility pole with the right aspect of its front plane. The force of the impact resulted in the deployment of the CAC driver air bag and the driver knee air bag. The offset impact initiated a clockwise (CW) rotation of the vehicle. The Dodge then tripped over the left right tire and rolled over 4-quarter turns coming to rest on its wheels straddling the curb. The driver sustained minor soft tissue injuries and was transported by ground ambulance to a local hospital where she was treated and released.

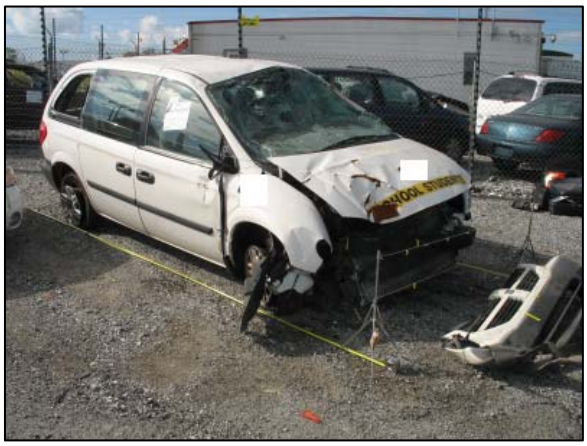

**Figure 1: Front right oblique view of the Dodge.**

The crash was identified through the weekly sampling of police reported crashes conducted by the General Estimates System (GES) of the National Automotive Sampling System (NASS). The Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) forwarded the police report to the Calspan Special Crash Investigations (SCI) team on September 18, 2009. Calspan SCI initiated follow-up investigation and established cooperation with the insurance company for the Dodge. The vehicle was considered a total loss and was available for inspection at an insurance salvage yard. Based on the availability of the vehicle and its interest in rollover crashes involving late model year vehicle, the NHTSA assigned an on-site investigation of the crash on September 25, 2009. The inspections of the vehicle and crash site took place October 1, 2009.

## *SUMMARY*

## *VEHICLE DATA*

### *2007 Dodge Caravan*

The 2007 Dodge Caravan was manufactured in April 2007 and identified by the Vehicle Identification Number (VIN): 1D4GP25B57B (production sequence deleted). The odometer reading at the time of the crash was 75,730 km (47,058 miles). The four-door, seven passenger minivan was configured on a 288 cm (113.4 in) wheelbase and had a Gross Vehicle Weight Rating of 2,449 kg (5,400 lb). The power train consisted of a 2.4-liter/I4 engine linked to a four-speed automatic transmission. The service brakes were a front disc/rear drum system with ABS. The seating configuration consisted of two manual bucket seats in the front row, a two-passenger bench seat in the second row, and a third row three-passenger bench seat. The manual restraint system consisted of 3-point lap and shoulder belts in the six outboard positions and a third row center lap belt. The front restraints utilized buckle pretensioners. The frontal air bag system consisted of Certified Advanced 208-Compliant (CAC) air bags for the driver and front right passenger and a driver knee air bag. The vehicle was not equipped with side impact air bags or Inflatable Curtain air bags. The Dodge was equipped with Goodyear Integrity P215/70R15 tires at all four positions. The tires were the proper size recommended by the manufacturer. The recommended cold tire pressure was 248 kPa (36 PSI). The specific measured tire data was as follows:

| Tire | Measured Pressure | Tread Depth | Restricted | Damage |
|---|---|---|---|---|
| LF | 207 kPa (30 PSI) | 6 mm (8/32) | No | None |
| LR | 221 kPa (32 PSI) | 6 mm (8/32) | No | Asphalt in rim bead |
| RF | Tire flat | 6 mm (8/32) | Yes | Sidewall cut, tire debeaded |
| RR | Tire flat | 6 mm (8/32) | No | Rim deformed, tire debeaded |

## *CRASH SITE*

This crash occurred during the daylight hours of August 2009. At the time of the crash, the environmental conditions were reported as clear and dry. The crash site consisted of a 2-lane divided east/west state roadway located in a suburban setting. **Figure 2** is an eastbound trajectory view approaching the point of impact. There was a negative 7 percent (-7%) grade along the Dodge's pre-crash trajectory. The grade at the point of impact and subsequent rollover measured negative 2 percent (-2%). The total width of the eastbound lanes measured 7.0 m (23.0 ft). The width of the south shoulder measured 3.0 m (9.8 ft). The shoulder was bordered by a 15 cm (6 in) barrier curb. A wooden utility pole located along the south roadside was identified in the police report as the

**Figure 2: Eastbound trajectory view 45 m (148 ft) from the point of impact.**

point of impact. The pole had recently been replaced as evidenced by the disturbed earth surrounding the pole. The posted speed limit was 64 km/h (40 mph).

## *CRASH SEQUENCE*

### *Pre-Crash*

The 48-year-old female was operating the Dodge eastbound in the outboard lane immediately prior to the crash. She was restrained by the vehicle's manual 3-point safety belt. The police investigation determined the driver was distracted by the use of her cellular telephone and allowed the vehicle to drift to the right. The vehicle departed the travel lane and traveled through the right shoulder on a southeast (SE) trajectory. **Figure 12**, located at the end of this report, is a schematic of the crash.

### *Crash*

The right front and right rear tires struck and mounted the south barrier curb (Events 1 and 2). A curb strike that measured 23 cm (9 in) long was identified during the SCI scene inspection. The curb impacts cut the sidewall of the right front tire and deformed the right rear wheel rim. The right rear tire subsequently debeaded. The Dodge continued along its SE trajectory a distance of 8 m (26.2 ft) and impacted a wooden utility pole with the right aspect of the front plane (Event 3). The safety belt pretensioner and the CAC driver air bag and knee air bag deployed as a result of the impact. **Figure 3** is a trajectory view of the curb strike and utility pole impact. The Barrier Equivalent Speed (BES) of the yielding object impact calculated by the Damage Algorithm of the WinSMASH program was 41.0 km/h (25.5 mph). The longitudinal and lateral components were -41.0 km/h (-25.5 mph) and 0, respectively.

**Figure 3: Trajectory view of the curb strike and utility pole impact.**

The force of the offset impact caused the vehicle to rotate clockwise (CW) around the pole. The rotation resulted in a weight shift to the left rear of the vehicle. The weight shift caused the left rear tire to roll under exposing the wheel rim to the pavement. The rim contacted the road as evidenced by 36 cm (14.0 in) abrasion to the bead edge with asphalt gathered into the rim bead. The rim contact tripped the wheel into a left side leading 4-quarter turn rollover (Event 4). A 1.8 m (6 ft) diameter area of fluid spill was located along the path of the rollover. The Dodge rolled uninterrupted approximately 15 m (49 ft) and came to rest on its wheels straddling the south curb.

### *Post-Crash*

The police and ambulance personnel responded to the crash. The driver exited the vehicle under her own power and was transported to a local hospital by ground ambulance. She was treated for minor soft tissue injuries and released approximately 3 hours post-crash. The Dodge sustained disabling damage and was towed. It was deemed a total loss by its insurer and transferred to a salvage facility where it inspected.

***2007 DODGE CARAVAN***

***Exterior Damage***

The Dodge sustained impact damage to the both right wheels/tires and to the front, sides and top planes as a result of the multiple-event crash sequence. The right front wheel impacted the curb (Event 1). The impact was evidenced by an 80 percent abrasion to the rim and sidewall damage to tire. The sidewall was cut resulting in an air-out and debeading of the tire. The Collision Deformation Classification of the event was 12FRWN3. The right rear wheel rim was deformed due to an impact to the curb (Event 2). The rim was deformed and abraded over 40 percent of its circumference. The tire was also debeaded. The CDC was 12FRWN9.


**Figure 4: Front view of the damage to the Dodge Caravan resultant to the utility pole**

**Figure 4** is a view of the frontal damage to the vehicle from its impact to the utility pole (Event 3). The direct contact damage began 18 cm (7.1 in) right of center and extended 50 cm (19.7 in) to the right corner. The impact resulted in crush to the fascia, bumper reinforcement bar, right front suspension components and structures of the right fender. The contact damage extended onto the hood 20 cm (8.0 in). The residual crush profile measured to bumper reinforcement was as follows: C1 = 1 cm (0.4 in), C2 = 8 cm (3.1 in), C3 = 18 cm (7.1 in), C4 = 28 cm (11.0 in), C5 = 38 cm (15.0 in), C6 = 34 cm (13.4 in). The maximum crush measured 40 cm (15.7 in) and was located 50 cm (19.5 in) right of center. The right wheelbase was reduced 12 cm (4.6 in). There was no change in the left wheelbase dimension. The windshield was fractured. The CDC was 12FZEW3.

The rollover damage (Event 4) consisted of minor body panel deformation and abrasion to the left, top and right planes. **Figure 5** is a right side view of the Dodge depicting a portion of the damage. The maximum vertical and lateral deformations of the rollover damage were located at the right A-pillar. The maximum vertical deformation measured 6 cm (2.5 in). The maximum lateral deformation measured 3 cm (1.0 in). The glazing of the left second window and the left and right third windows disintegrated during the rollover. All the doors remained closed during the crash sequence and were operational post-crash. The CDC was 00TDDO3.

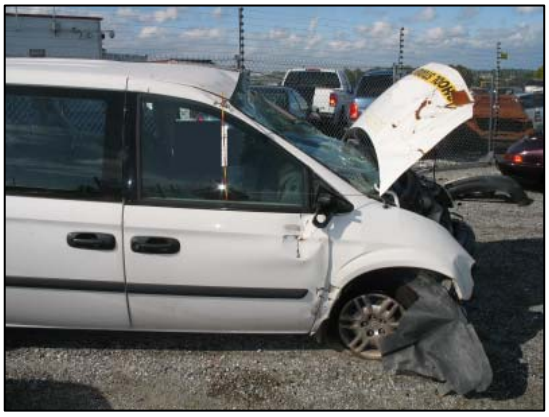

**Figure 5: View of the rollover damage to the forward right plane.**

***Interior Damage***

The interior damage to the Dodge was limited to minor intrusion in the front right seat position, the deployment of the air bags and minor driver contacts to the knee bolster. The right toe pan

intruded 4 cm (1.6 in) longitudinally as a result of the utility pole impact. The right A-pillar intruded 2 cm (0.8 in) laterally as a result of the rollover.

The manual driver seat was located in a full-rear track position as the time of the SCI inspection. It could not be verified if this was the at-crash track position. The total seat track travel measured 22 cm (8.8 in). The seat back angle measured 15 degrees aft of vertical. The adjustable head restraint was in the full-down position. The horizontal distance from the driver air bag module to the seat back measured 65 cm (25.5 in). This distance was measured 41 cm (16.0 in) above the seat bight.

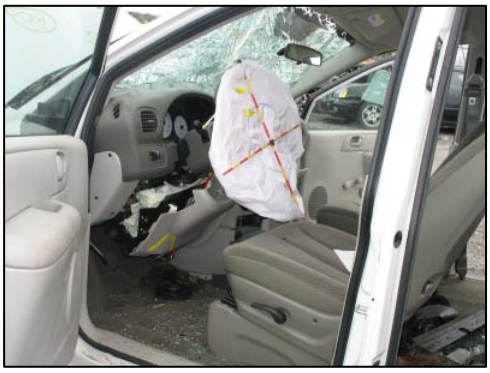

**Figure 6: View of the driver interior.**

The 4-spoke steering wheel rim was mounted on a fixed column. There was no rim deformation. Examination of the steering column shear capsules revealed 6 mm (0.25 in) of column displacement as a result of driver loading.

The rigid knee bolster panel exhibited two scuffs from contact with the driver's lower extremities (**Figure 7**). A 13 cm x 3 cm (5 in x 1 in) scuffed area was located 11 cm (4.5 in) right of the steering column and 53 cm (21.0 in) above the floor. This contact was attributed to the right lower extremity. A 5 cm x 3 cm (2 in x 1 in) scuff was located 14 cm (5.5 in) left of the steering column. This scuff was located 41 cm (16.0 in) above the floor and was attributed to the left lower extremity contact.

**Figure 7: View of the knee bolster contacts.**

***Manual Restraint System***

The driver restraint in the 2007 Dodge Caravan consisted of continuous loop webbing, a sliding latch plate, an adjustable D-ring, and an Emergency Locking Retractor (ELR) located in the base of the B-pillar. The D-ring was in the full-down position. The inboard buckle stalk was attached to the seat track and was equipped with a pretensioner. The pretensioner actuated as a result of the crash. The height of the driver's buckle stalk was reduced 5.6 cm (2.2 in) as compared to the (uncompressed) buckle stalk in the front right position. The driver's webbing was stowed on the retractor at initial inspection. The webbing was extended and examined. A 4 cm (1.6 in) abrasion was observed as a result of frictional contact with the D-ring. It was located 188 cm to 193 cm (74.2 in to 75.8 in) above the outboard anchor. The D-ring was abraded across its full width. A 2 cm (0.8 in) abrasion to the webbing was identified at the latch plate. This abrasion was located 106 cm (41.8 in) above the floor anchor. Examination of the latch plate revealed indicators of historical use and a friction abrasion as a result of the webbing loading. All the evidence identified during the course of the SCI inspection indicated the driver was restrained at the time of the crash.

***Air Bag Systems***

The 2007 Dodge Caravan was equipped with CAC frontal air bags for the driver and front right passenger. The vehicle's manufacturer certified that the frontal air bags were compliant to the advanced air bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No: 208. The driver air bag module was located in the center hub of the steering wheel rim and the air bag had deployed as a result of the pole impact (**Figure 8**). The driver air bag module had a single semi-circular flap that was hinged along its top aspect. The width and height of the cover flap measured 20 cm (7.9 in) and 12 cm (4.8 in), respectively. There was no contact evidence or damage to the cover flap. The diameter of the deployed driver air bag measured 66 cm (26 in) in its deflated state. It was tethered by two internal straps sewn to the face of the bag and was vented by two 2 cm (0.8 in) diameter ports. An 8 cm x 5 cm (3 in x 2 in) abrasion was noted on the face of the air bag. It was locate in the 12 o'clock sector, 16 cm (6.3 in) above and 6 cm (2.5 in) left of the center of the bag. The 5 to 7 o'clock sectors of the air bag were soiled from exposure to the elements.

**Figure 8: View of the deployed driver air**

The front right air bag module was located in the mid-aspect of the right instrument panel. The deployment of this air bag was suppressed due to the unoccupied status of the front right seat.

**Figures 9 – 11** are views of the knee air bag located in the lower aspect of the left instrument panel. The driver knee air bag was attached between to the fixed structure of the lower instrument panel and the vinyl bolster panel. At deployment, the bolster separated from the instrument panel and expanded toward the driver as the knee air bag inflated. The rearward excursion of the panel measured 13 cm (5 in). The air bag was rectangular and measured 42 cm x 24 cm (16.5 in x 9.5 in), width by height. There was no direct contact between the knee air bag and the driver. The driver's lower extremities contacted the bolster panel as evidenced by the identified contacts.

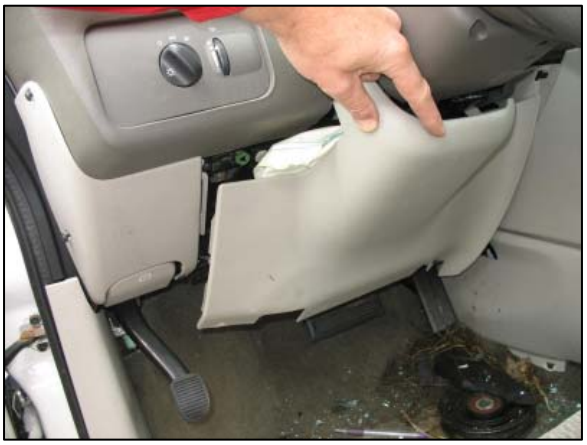

**Figure 9: View of the reconstructed position of the knee bolster prior to the deployment of the knee air bag.**

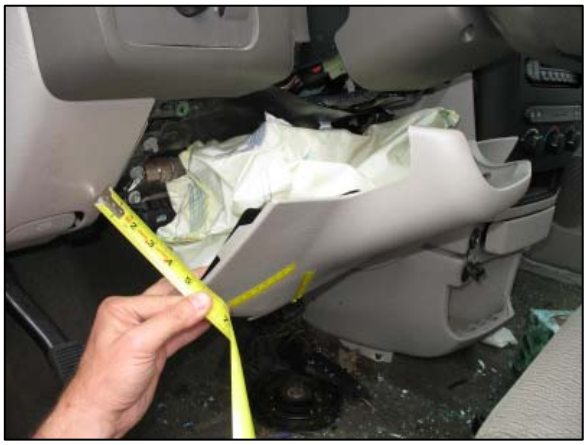

**Figure 10: View of the deployed knee air bag depicting the rearward excursion of the bolster panel.**

**Figure 11: Overhead view of the knee air bag assembly removed from the vehicle.**

***DRIVER DEMOGRAPHICS***

| | Driver |
|---|---|
| Age / Sex: | 48-year-old/Female |
| Height: | Unknown |
| Weight: | Unknown |
| Seat Track Position: | Unknown |
| Restraint Use: | 3-point lap and shoulder |
| Usage Source: | SCI inspection |
| Medical Treatment: | Treated and released |

***DRIVER INJURIES***

| Injury | Injury Severity (AIS 90/Update 98) | Injury Source |
|---|---|---|
| Left upper chest abrasion | Minor (490202.1,2) | Safety belt loading |
| Bilateral anterior lower extremity hematomas | Minor (890402.1,3) | Knee bolster |
| Right hand small hematoma over the dorsal aspect | Minor (790402.1,1) | Mid-instrument panel (possible) |

Source: Emergency Department Records

***DRIVER KINEMATICS***

The 48-year-old female was operating the Dodge eastbound in the outboard travel lane. She was restrained by the vehicle's manual 3-point restraint and was seated in an unknown seat track position. She was distracted by the use of her cellular telephone and allowed the vehicle to drift to the right.

The right side tires impacted and overrode the south curb. The impacts had a negligible effect on the driver's movement within the vehicle. The vehicle continued along its errant trajectory and the impacted the utility pole with the front plane. The force of the impact locked the safety belt

system and actuated the pretensioner. The CAC driver air bag and the knee bolster air bag deployed. The driver initiated a forward trajectory in response to the 12 o'clock direction of the impact force and loaded the locked safety belt system. The driver's chest was abraded by the safety belt loading. The forward movement of the driver in concert with the rearward motion of the bolster panel (due to the inflation of the knee air bag) resulted in the contact of her lower extremities to the bolster panel. The driver's lower extremities sustained soft tissue contusions as a result of the contact.

The Dodge rotated clockwise, tripped and rolled over. The driver continued to load the safety belt and deployed air bag systems during the rollover event. She came to rest within the driver seat. She exited and vehicle and was subsequently transported by ground ambulance to the Emergency Department of a local hospital. The driver was treated and released on the day of the crash.

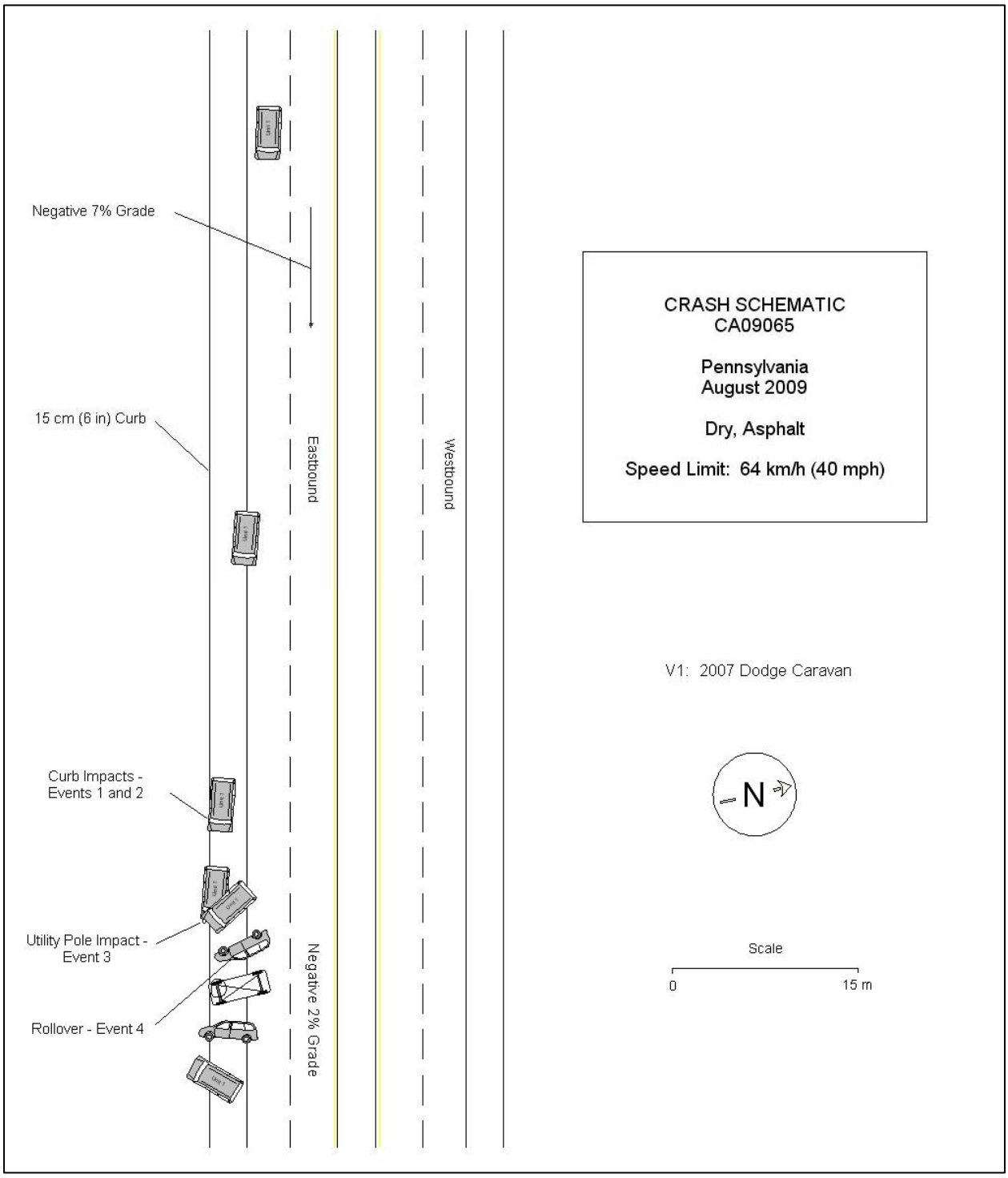


**Figure 12: Crash Schematic.**