

CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION

CALSPAN CASE NO: CA03-038

VEHICLE: 1994 CHEVROLET CAVALIER

LOCATION: OHIO

CRASH DATE: JUNE 2003

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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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<p>16. Abstract This on-site investigative effort focused on the performance of two child safety seats that were installed in a 1994 Chevrolet Cavalier and were occupied by an 11-month-old male and a 2-year-old male. The Chevrolet was involved in a severe head-on collision with a 1993 Ford F-250 pick-up truck. The Cavalier deflected off-road and subsequently rolled over two-quarter turns. The Chevrolet was not equipped with frontal air bags; however, it was equipped with door mounted 3-point automatic lap and shoulder belts in the front seating positions. The Chevrolet was occupied by a restrained 26-year-old male driver, 25-year-old female restrained right front passenger, and two child passengers that were restrained in child safety seats. As a result of the crash, the female front right passenger and the 11-month-old male rear left passenger were fatally injured. The driver and the 2-year-old male rear right passenger sustained police reported serious injuries and were transported to a local hospital for treatment.</p>			
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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
CASE NO.: CA03-038
VEHICLE: 1994 CHEVROLET CAVALIER
LOCATION: OHIO
CRASH DATE: JUNE 2003

BACKGROUND

This on-site investigative effort focused on the performance of two child safety seats that were installed in a 1994 Chevrolet Cavalier (**Figure 1**) and were occupied by an 11-month-old male and a 2-year-old male. The Chevrolet was involved in a severe head-on collision with a 1993 Ford F-250 pick-up truck. The Cavalier deflected off-road and subsequently rolled over two-quarter turns. The Chevrolet was not equipped with frontal air bags; however, it was equipped with door mounted 3-point automatic lap and shoulder belts in the front seating positions. The Chevrolet was



Figure 1. Subject vehicle 1994 Chevrolet Cavalier.

occupied by a restrained 26-year-old male driver, 25-year-old female restrained right front passenger, and two child passengers that were restrained in child safety seats. As a result of the crash, the female front right passenger and the 11-month-old male rear left passenger were fatally injured. The driver and the 2-year-old male rear right passenger sustained police reported serious injuries and were transported to a local hospital for treatment.

The Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) notified the Calspan Special Crash Investigation (SCI) team of this crash on Monday, June 30 following an Internet news search of potential crashes of interest. The Calspan SCI team secured the cooperation of the Ohio Highway Patrol and located the involved vehicles and child safety seats. An on-site investigation of this crash was conducted on Thursday, July 10, 2003. The investigation involved the detailed inspection of the involved vehicles and the documentation of the child safety seats.

SUMMARY

Crash Site

The crash occurred during morning daylight hours on a two-lane state route during June 2003. The travel lanes were surfaced with new asphalt and were delineated by double yellow centerlines. A positive grade of two percent was present for the northbound travel direction. White fog lines bordered the travel lanes. A two meter (6.5 feet) asphalt shoulder extended beyond the east fog line and a 0.6 meter (1.9 feet) asphalt shoulder extended beyond the west fog line. The roadside consisted of lawns, private driveways,

mail boxes, trees and wooden utility poles. The posted speed limit for this roadway was 72 km/h (45 mph). The scene schematic is included as **Figure 13** of this report.

Vehicle Data

1994 Chevrolet Cavalier

The subject vehicle in this crash was a 1994 Chevrolet Cavalier. The Chevrolet was manufactured on 05/94 and was identified by Vehicle Identification Number (VIN) 1G1JC1448R7 (production number deleted). The odometer reading at the time of the SCI inspection was 156,876 kilometers (97,481 miles). The vehicle was a two-door coupe that was equipped with a 2.2-liter, four-cylinder engine linked to a three-speed automatic transmission with a console mounted transmission shifter. The service brakes were front disc and rear drum with anti-lock. The vehicle was equipped with six-spoke plastic wheel covers over steel rims with P195/70R14 tires. The tires on the Cavalier were Firestone Firehawk Indy 500. The manufacturer recommended front and rear tire pressures 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	200 kPa (29 PSI)	8 mm (10/32")	None
Left Rear	207 kPa (30 PSI)	9 mm (11/32")	None
Right Front	0 kPa	8 mm (10/32")	Cut to sidewall
Right Rear	200 kPa (29 PSI)	9 mm (11/32")	None

The interior of the Cavalier was configured with cloth surfaced front bucket seats with integrated adjustable head restraints. The second row was configured with a three-passenger bench seat.

1993 Ford F-250

The striking vehicle in this crash was a 1993 Ford F-250 extended cab pick-up truck that was identified by Vehicle Identification Number (VIN) 1FTHX26M3PK (production number omitted). The odometer reading at the time of the SCI inspection was unknown due to the expended vehicle battery. The Ford was equipped with a 7.3-liter, eight-cylinder diesel engine linked to a four-speed automatic transmission with four-wheel drive. The Ford was configured on a 394 cm (155.0") wheelbase and contained an aftermarket cap over the bed.

Crash Sequence

Pre-Crash

The 26-year-old male driver was operating the Cavalier northbound ascending the slight grade (**Figure 2**). The driver of the Ford was operating the vehicle southbound in the southbound lane. As the driver of the Ford continued southbound, he allowed the vehicle to drift across the double yellow centerline and entered the northbound lane. The driver of the Cavalier observed the Ford traveling in the northbound lane and applied a left steering input in an attempt to avoid the Ford.



Figure 2. Chevrolet's pre-crash travel direction.



Figure 3. POI from the Chevrolet's northbound approach.

Crash

The front right area of the Chevrolet struck the front right of the Ford in a head-on off-set configuration (**Figure 3**). The resultant directions of force were 1 o'clock for the Chevrolet and 12 o'clock for the Ford. The WINSMASH damage algorithm was used to calculate a delta-V for this impact. The total delta-V for the Chevrolet was 99 km/h (61.5 mph) and the Ford was 52 km/h (32.3 mph). The longitudinal and lateral components for the Chevrolet were -93 km/h (-57.8 mph) and -33.9 km/h (-21.0 mph), respectively. The longitudinal and lateral components for the Ford were -52 km/h (-32.3 mph) and 0 km/h, respectively.

As a result of the off-set frontal impact, the Cavalier's forward momentum was arrested as the vehicle was redirected rearward. Thus, the Chevrolet began to travel in a southwest direction while initiating a counterclockwise rotation. The travel path of the Chevrolet was evidenced by gouging and fluid on the asphalt road surface. These witness marks were approximately 6 meters (19.7 feet) in length and extended to the west curb on a diagonal path. The Chevrolet entered the roadside where the left side tires rolled under the steel rims and gouged the grass surface. The ground contact was evidenced by a 2 meter (6.6 feet) gouge in the grass surface. This contact tripped the Chevrolet into a left side leading rollover event. The greenhouse area of the Cavalier impacted and sheared a utility pole as it rolled to final rest on its roof. The Cavalier was displaced approximately 20 meters (65.6 feet) from the point of impact with the Ford. **Figure 4** is an overall view of the Cavaliers approach to the rollover event, the pole impact, and final rest.



Figure 4. Cavalier's approach to rollover event, pole impact, and final rest.

The off-set frontal impact to the Ford induced a counterclockwise rotation to the vehicle as it traveled through the initial impact. The Ford departed the east roadside and traveled approximately 9 meters (29.5 feet) in a southeast direction and impacted a sign post and two mailboxes with the left side. The Ford continued on the east roadside an additional 6 meters (19.7 feet) and impacted a wooden utility pole with the left rear axle area and came to rest.

Post-Crash

Police and Emergency Medical Services (EMS) personnel responded to the crash site. The female front right passenger and the 11-month-old male rear left passenger of the Chevrolet were fatally injured and were transported to the county Coroners office. The driver and the 2-year-old male rear right passenger sustained police reported serious injuries and were transported to a local hospital for treatment. Both vehicles sustained severe damage and were towed from the crash site.

Vehicle Damage

Exterior – 1994 Chevrolet Cavalier

The 1994 Chevrolet Cavalier sustained severe frontal damage as a result of the impact with the Ford (**Figures 5 and 6**). Maximum crush was 151 cm (59.4”), located 8 cm (3.1”) right of the centerline. The direct contact damage measured 117 cm (46”) and extended from bumper corner to bumper corner. The bumper beam was separated during the crash; therefore, the residual crush was measured along the full width of the deformed upper radiator support (Field L) of 80 cm (31.5”). Six equidistant crush measurements were documented at this level and were as follows: C1 = 48 cm (18.9”), C2 = 109 cm (42.9”), C3 = 141 cm (55.5”), C4 = 151 cm (59.4”), C5 = 145 cm (57.0”), C6 = 137 cm (53.9”). The Collision Deformation Classification (CDC) for this impact was 01-FDEW-6. The right front door was jammed closed and was cut from the vehicle by rescue personnel. The roof was cut from the vehicle and was not located; therefore the severity of damage to the roof of the Cavalier is unknown. The CDC for the rollover event was 00-T990-9 and the pole impact was 00-T999-9 (9’s = represent unknown).



Figure 5. Overhead view of the frontal damage.



Figure 6. Overall view of the resultant damage.

Interior – 1994 Chevrolet Cavalier

The interior of the Chevrolet sustained moderate severity damage from occupant contact points. The driver’s occupant contact points consisted of contact and loading to the steering components. The steering wheel rim was bent 10 cm (4.0”) forward and the shear capsules were completely separated from loading. The tilt steering lever was fractured from its mounting point. A right knee contact was noted to the knee bolster which was evidenced by a 5 cm (2”) dent that penetrated into the heater core and sub panel. Additionally, a scuff mark was noted on the bottom aspect of the steering column shroud.



Figure 7. Overall view of the passenger compartment.

The front right passenger contact points consisted of fractures to the glove box door from contact with her knees. The intruding front right instrument panel contacted the passenger, which resulted in scuffing and fracturing of the instrument panel. A scuff mark was noted to the rear of the front right seatback from contact with the child safety seat. However, no occupant contact points from the rear seat passengers were present in the vehicle. **Figure 7** is an overall view of the passenger compartment. The passenger compartment intrusions were as follows:

Seat Position	Intruded Component	Magnitude	Direction
Front Left	Toe pan	10 cm (3.9”)	Longitudinal
Right Front	Lower right instrument panel	30 cm (11.8”)	Longitudinal
Right Front	Right side of instrument panel at instrument cluster	25 cm (9.8”)	Longitudinal
Right Front	Right corner of instrument panel	35 cm (13.8”)	Longitudinal
Right Front	A-pillar	25 cm (9.8”)	Longitudinal
Right Front	Toe pan	15 cm (5.9”)	Longitudinal
Right Front	Right corner of hood	25 cm (9.8”)	Longitudinal
Right Rear	B-pillar	31 cm (12.0”)	Lateral
Right Rear	Side panel rear of B-pillar	25 cm (10.0”)	Lateral

Exterior – 1993 Ford F-250

The 1993 Ford F-250 sustained severe frontal damage as a result of the impact with the Chevrolet (**Figure 8**). The maximum crush measured 82 cm (32.3”) and was located at the front right bumper corner. The direct contact damage measured 150 cm (59.0”) and extended from the front left bumper corner to the front right bumper corner. A crush profile was documented along the front bumper to capture the residual crush. The profile was as follows: C1 = 0 cm, C2 = 2 cm (0.8”), C3 = 45 cm (17.7”), C4 = 47 cm (18.5”), C5 = 51 cm (20.0”), C6 = 82 cm (32.3”). The CDC for this impact was 12-FDEW-3.



Figure 8. Resultant damage to the front of the 1993 Ford F-250.

The left front area of the Ford impacted a sign post and two mailboxes as it traveled to final rest. These impacts were minor and resulted in no residual damage to the vehicle. The left rear wheel of the Ford impacted a utility pole as the vehicle came to rest. This impact was minor and did not result in damage to the Ford. The CDC’s for these impacts were 99-LF99-9, 99-LF99-9, 99-LF99-9, and 99-LB99-9.

Manual Safety Belt Systems – 1994 Chevrolet Cavalier

The 1994 Chevrolet Cavalier was equipped with door mounted 3-point automatic lap and shoulder belt systems for the front seating positions. The front safety belt utilized sewn on latch plates with separate Emergency Locking Retractors (ELR) for the lap belt and shoulder belts.

The driver used the safety belt in this crash which was supported by loading evidence on the belt webbing. This evidence consisted of stretching and curling of the webbing which was located 38-55 cm (15-21.5”) above the latch plate. Additionally, the safety belt was cut by rescue personnel and the latch plate remained buckled. The lap belt cut was located 70 cm (26.75”) below the latch plate and the shoulder belt cut was located 121 cm (47.5”) above the latch plate.

The front right passenger utilized the safety belt during the crash. Her forward motion was limited due to the intrusion thus, resulting in no loading evidence of the safety belt. This safety belt was also cut by rescue personnel. The latch plate was found buckled post-crash. The cut belt system and the buckled status of the latch plate supported belt usage by the passenger. The cut to the lap belt was located 62 cm (24.5”) below the latch plate and the shoulder belt cut was located 75 cm (29.5”) above the latch plate.

The rear outboard safety belts were used to secure two child safety seats at the time of the crash. The rear outboard safety belts were equipped with lap and shoulder belts, locking latch plates and ELR’s. The left rear latch plate was found fully engaged in the center

rear buckle and the belt webbing was cut by rescue personnel (**Figure 9**). The shoulder belt webbing was cut 61 cm (24.0”) above the latch plate and lap belt was cut 32 cm (12.75”) above of the anchor. Additional damage to the belt system consisted of a fractured plastic buckle sleeve. The SCI investigator noted the portion of lap belt that was exposed measured 75 cm (29.5”). The child safety seat was repositioned in the vehicle and it was determined that to obtain a snug fit installation, the exposed length of lap belt length would be approximately 56 cm (22.0”). Therefore, it appears that the child safety seat was loosely installed prior to the crash.

The right rear safety belt exhibited a vinyl transfer from the loading with the belt path of the child safety seat. This transfer measured 6 cm (2.25”) and was located 59 cm (23.25”) below the rear deck. The trunk contents, which consisted of a stroller, two bags of clothing, and two diaper bags were displaced forward and loaded the rear of the seatback deforming the center section forward. Due to this displacement, the side mounted release button for the rear right safety belt buckle was compressed and consequently released (**Figure 10**). The rear center belt was a lap belt only with a locking latch plate and no retractor.



Figure 9. Cut left rear safety belt.



Figure 10. Released right rear safety belt buckle.

Child Safety Seats – 1994 Chevrolet Cavalier

The 11-month-old male was restrained in the rear left position of the Cavalier. He was seated in a Cosco Alpha Omega convertible Child Safety Seat (CSS) and was restrained by the integrated five-point harness system. The CSS was manufactured on 04/14/00. The model number was illegible. The following was placarded on the safety seat:

Rear Facing:

2.3-10 kgs (5-22 lbs)

See instruction for using rear-facing for infants 10-15.9 kg (22-35 lbs)

This child restraint is designed for use only by children weigh between 2.3 and 18 kg (5 and 40 lbs) and whose height is between 48.3 and 102 cm (10 and 40”), the mid point of whose head is not above the top of the child restraint back.

Forward Facing:
10-18 kgs (22-40 lbs)

Forward Facing Without Shield/Harness:
13.6-36.3 kgs (30-80 lbs)

The history of the CSS was unknown. The CSS was located by the SCI investigator outside the vehicle exposed to weather. It was determined that the CSS was installed forward facing using the vehicle's lap and shoulder belt incorrectly routed through the rear facing belt paths. This was supported by loading evidence at the rear facing belt path. The left rear facing belt path of the CSS exhibited a 5 cm (1.875") tear from loading by the lap belt. And the right rear facing belt of the CSS contained a 3 cm (1.125") tear from the lap belt loading. The plastic shell at the tear location was deformed rearward and exhibited a white color at the deformation areas. **Figure 11** is of the left side of the CSS, the damage to belt path is highlighted with calibrated tape.



Figure 11. Loading damage to the belt path.



Figure 12. Century convertible CSS.

The five-point harness system was used to restrain the 11-month-old male. The harness straps were adjusted to the middle slot. Cushions were present on the harness straps. The right shoulder harness strap contained two twists and was folded in half and the left harness strap was folded in half. The retainer clip was located 24 cm (9.5") below the slots and was found engaged.

The 2-year-old male was restrained in the rear right position of the Cavalier. He was seated in a Century convertible Child Safety Seat (CSS) and was restrained by the tray-shield 3-point harness system (**Figure 12**). The CSS model number was 4479WAF and was manufactured on 07/14/95. The following was placarded on the safety seat:

This restraint is designed for use as follows:

- A) Rear-facing only by infants who weigh 9 kg (20 lbs) or less and whose height is 69 cm (27”) or less.
- B) Forward facing only by children who weigh between 9 kg and 18 kg (20 lbs-40 lbs) and whose height is between 69 cm and 102 cm (27 and 40”) and who are capable of sitting upright alone.

The harness straps were cut to remove the child from the CSS. The left strap was cut 32 cm (12.5”) below the top slots and the right strap was cut 34 cm (13.25”) below the top slot. The right harness strap was also twisted in the retainer clip. Damage to the CSS consisted of fractures to the tray shield. The right side of the tray shield was fractured at the junction of the arm and shield 36 cm (14”) below the pivot point. The left side of the tray shield was fractured 18 cm (7”) below the pivot point. The tray shield damage was attributed to the intruding B-pillar and the side panel rear of the B-pillar. Additional damage was noted to the shell of the CSS which was fractured at the rear facing belt path. This fracture measured 8 x 6 cm (3.25 x 2.25”) and resulted from contact with the intruding side panel rear of the B-pillar. Stress marks were noted across the full frontal width of the CSS from contact with the back of the front right seat.

Occupant Demographics/Data

Driver Demographics

Age/Sex: 26 year old/Male
 Height: Unknown
 Weight: Unknown
 Seat Track Position: Mid to rear track position
 Eyewear: Unknown
 Manual Safety Belt Usage: Automatic door mounted three-point lap and shoulder belt
 Usage Source: Vehicle inspection
 Egress from Vehicle: Assisted through left door
 Mode of Transport from Scene: Transported by ambulance to a hospital
 Type of Medical Treatment: Hospitalized

Driver Injuries

Injury	Injury Severity AIS90/Update 98	Injury Source
Serious injuries, NFS	Unknown	Unknown

Source – Police report

Driver Kinematics

The 26-year old male driver of the 1994 Chevrolet Cavalier was seated in an upright driving posture. The driver’s seat was adjusted between the mid to rear track position and he was restrained by the automatic three-point safety belt system.

At impact, the driver initiated a forward and slight right trajectory in response to the 1 o’clock direction of force. He loaded the safety belt system which was evidenced by

stretching and curling of the webbing. The stretching of the safety belt allowed the driver to contact the steering wheel with this torso which resulted in deformation to the steering wheel rim and complete separation of the shear capsules. His right knee contacted the knee bolster which was deformed by the contact.

The vehicle subsequently rolled onto its left side and then onto its roof as it traveled to the utility pole impact and final rest. The driver remained within the front left area of the vehicle during the rollover and utility pole impacts.

As a result of the crash, the driver sustained police reported serious injuries and was transported to a local hospital where he was treated.

Front Right Passenger Demographics

Age/Sex: 25-year-old/Female
 Height: Unknown
 Weight: Unknown
 Seat Track Position: Mid to rear track position
 Restraint Use: Automatic door mounted three-point lap and shoulder belt
 Usage Source: Vehicle inspection
 Egress from Vehicle: Removed by rescue personnel
 Mode of Transport from Scene: Transported by ambulance to the coroner’s office
 Type of Medical Treatment: Fatally injured

Front Right Passenger Injuries

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

Source – Police report

Front Right Passenger Kinematics

The 25-year-old female front right passenger was seated in a mid to rear track position and was restrained by the automatic three-point safety belt system.

At impact with the Ford, she initiated a forward and slight right trajectory in response to the 1 o’clock direction of force. As the vehicles reached maximum engagement, the frontal components grossly intruded into the passenger compartment. The front passenger contacted the instrument panel and knee bolster which was evidenced by the fractures to the glove box door from contact with her knees. The intruding front right instrument panel contacted the passenger which resulted in scuffing and fracturing of the instrument panel. Due to the intrusion, her forward motion was limited; thus, resulting in no loading evidence of the safety belt.

The vehicle subsequently rolled onto its left side and roof and engaged the utility pole impact prior to final rest. The front right passenger remained within the front right

passenger area of the vehicle during these events. As a result of the crash, the 25-year-old female front right passenger was fatally injured.

Rear Left Child Passenger

Age/Sex: 11-month-old/Male
 Height: Unknown
 Weight: Unknown
 Seat Track Position: N/A, fixed
 Eyewear: Unknown
 Child Restraint Use: Convertible child safety seat with five-point harness
 Usage Source: Vehicle inspection
 Egress from Vehicle: Unknown
 Mode of Transport from Scene: Transported by ambulance to a hospital
 Type of Medical Treatment: Fatally injured

Rear Left Child Injuries

Injury	Injury Severity AIS90/Update 98	Injury Source
Unknown fatal injuries	Unknown	Unknown

Source – Police report

Rear Left Child Kinematics

The 11-month-old male child passenger was restrained in a Cosco Alpha Omega convertible CSS by the five-point harness system. At impact with the Ford, the child responded to the frontal crash forces by initiating a forward and slight right trajectory. He loaded the internal harness system which retained him in the CSS. During the rollover and utility pole impacts, the child was minimally displaced and remained within the CSS. As a result of the crash, the 11-month-old male rear left passenger was fatally injured.

Rear Right Child Passenger

Age/Sex: 2-year-old/Male
 Height: Unknown
 Weight: Unknown
 Seat Track Position: N/A, fixed
 Eyewear: None
 Child Restraint Use: Convertible child safety seat with tray shield
 Usage Source: Vehicle inspection
 Egress from Vehicle: Unknown
 Mode of Transport from Scene: Transported by ambulance to a hospital
 Type of Medical Treatment: Hospitalized

Rear Right Child Injuries

Injury	Injury Severity AIS90/Update 98	Injury Source
Serious injuries, NFS	Unknown	Unknown

Source – Police report

Rear Right Child Kinematics

The 2-year-old male child passenger was restrained forward facing in a Century convertible CSS by the tray shield. The child responded to the frontal crash forces by initiating a forward and slight right trajectory and loading the internal harness system. The rearward displacement of the right front seat back restricted the forward movement of the CSS. During the rollover and utility pole impacts, the child was minimally displaced and remained within the CSS. As a result of the crash, the 2-year-old male rear right passenger sustained serious injuries and was transported to a hospital for treatment.

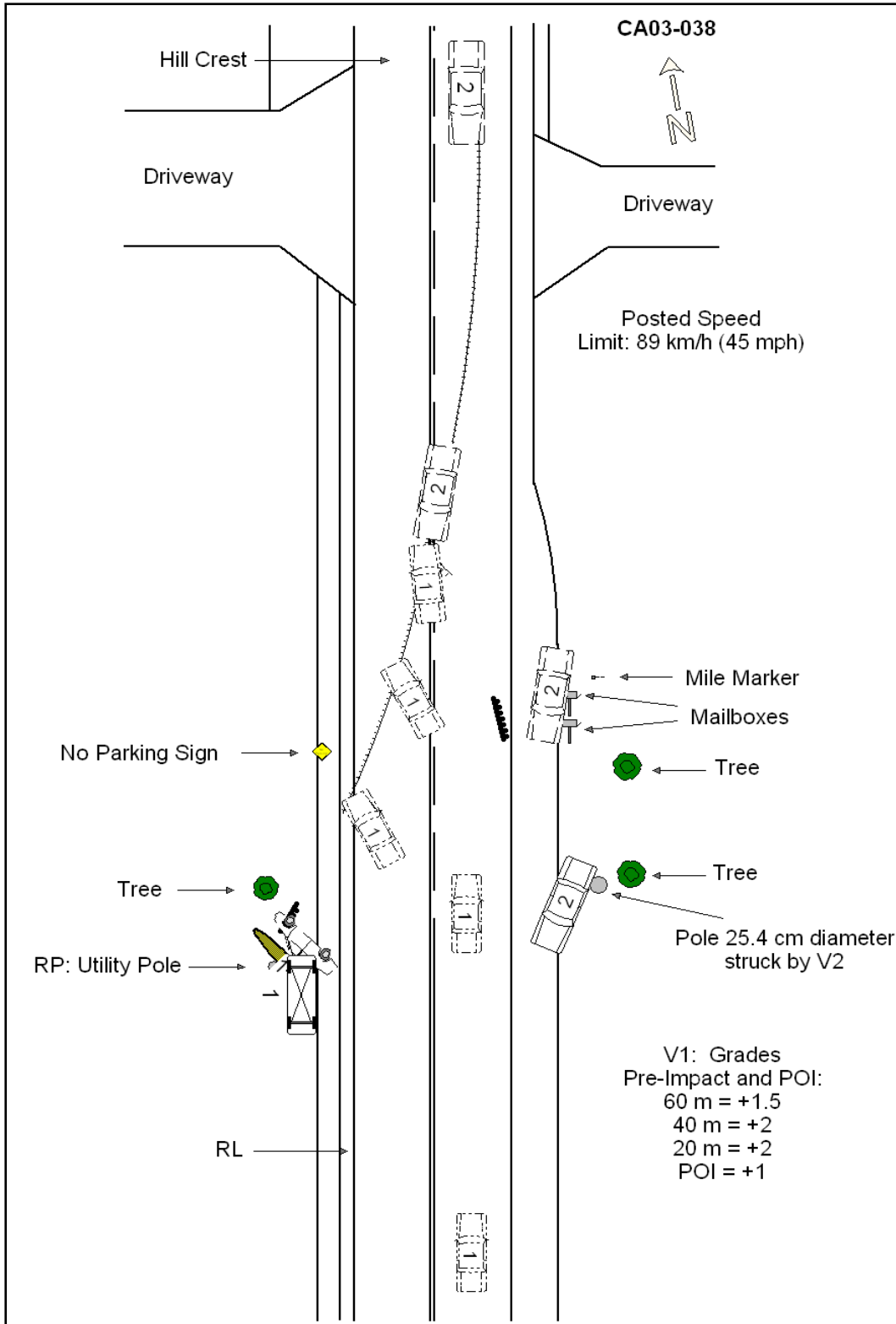


Figure 13: Scene Schematic