CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION

CASE NO: CA07-029

VEHICLE: 1992 CHEVROLET CAVALIER

LOCATION: NEW YORK

CRASH DATE: SEPTEMBER 2007

Contract No. DTNH22-07-C-00043

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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

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SCI CASE NO: CA07-029
VEHICLE: 1992 CHEVROLET CAVALIER
LOCATION: NEW YORK
CRASH DATE: SEPTEMBER 2007

BACKGROUND

This on-site investigation focused on the performance of a high back Belt Positioning Booster Safety Seat (BPBSS) that was present in a 1992 Chevrolet Cavalier four-door sedan. There were two occupants in the Chevrolet; a restrained 26-year old male driver and a 2-year old male child passenger who was restrained by the manual lap and shoulder belt within the BPBSS. The BPBSS was positioned on the right side of the second row seat. The Chevrolet was involved in a five-quarter turn rollover crash **(Figure 1)**. The driver of the Cavalier was operating his vehicle in a southbound direction when a non-contact vehicle encroached into his lane. The driver of the Cavalier steered right to avoid the encroaching vehicle and departed the right side of the roadway. The driver initiated a left steering action and the vehicle began to yaw in a counterclockwise (CCW) orientation. The vehicle traversed the roadway, reversing its rotation, and then departed the left roadside. The vehicle overturned in a left side leading five-quarter turn rollover event before coming to rest facing in a northwest direction. Following the crash, the driver reached into the second row seat, unlatched the child's safety belt, and pulled him into the front row. He then lifted the child up to passers-by through the front right window opening. The child was transported to a local hospital and admitted overnight for treatment of soft tissue injuries and observation. The driver sustained a strained neck and complained of headaches and dizziness. He was removed from the vehicle by rescue personnel and transported by ambulance to a regional trauma center and then released.

Figure 1 – Damaged front and left side of the 1992 Chevrolet Cavalier.

The crash was identified by the Calspan SCI team through local media coverage. Notification of the crash was forwarded to the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA). The Calspan SCI team located the vehicle and established cooperation with the investigating police agency. The case was assigned on September 7, 2007 for an on-site investigation. The vehicle was located at a local tow facility with the BPBSS confirmed as still being inside the vehicle. The vehicle and scene inspection took place on September 11, 2007. This report has been linked to the Electronic Data System (EDS).

SUMMARY

Crash Site

This single vehicle crash occurred on a well traveled five-lane north/south suburban roadway during daylight hours in September 2007. At the time of the crash, the

roadways were dry and there were no adverse weather conditions. The roadway was configured with two lanes in each direction and a center left turn lane. The travel lanes were delineated by broken white painted lines. The center turn lane was marked with inboard broken yellow painted lane lines and outboard solid yellow painted lane lines. The roadway was bordered by white fog lines and paved shoulders and the roadside environment consisted of commercial businesses and natural growth. The posted speed limit for the roadway was 89 km/h (55 mph). A roadway that emanated from the east formed a junction with the five lane roadway and created a "T" intersection. The eastbound roadway was controlled by an unobstructed stop sign that was mounted on the northeast corner. The SCI Scene Schematic is included as **Figure 13** on Page 11 of this narrative report.

Vehicle Data – 1992 Chevrolet Cavalier

The 1992 Chevrolet Cavalier was a four door sedan and was identified by the Vehicle Identification Number (VIN): 1G1JC5444N7 (production number omitted). The vehicle's odometer reading at the time of the SCI inspection was 121,890 km (75,739 miles). The total GVWR was 1,607 kg (3,543 lbs.) with 873 kg (1,924 lbs.) distributed to the front axle and 734 kg (1,618 lbs.) distributed to the rear. The front wheel drive vehicle was powered by a 4-cylinder, 2.2-liter transverse mounted engine which was linked to a 3-speed automatic transmission. The vehicle was configured with 36 cm (14") steel wheels and varied P185/75R14 tires. The manufacturer's recommended tire pressure was 207 kPa (30 PSI). The specific tire information was as follows:

Position	Tire Model	Tire Pressure	Tread Depth	Damage
LF	Douglas Xtra-Trac AW	Tire Flat	6 mm (8/32")	De-beaded
LR	Steel Belted Radial M+S	Tire Flat	3 mm (4/32")	De-beaded
RR	Steel Belted Radial M+S	193 kPa (28 PSI)	2 mm (3/32")	None
RF	Douglas Xtra-Trac AW	186 kPa (27 PSI)	6 mm (8/32")	None

The interior of the 1992 Chevrolet Cavalier was configured with front bucket seats with integral head restraints. The front seats were mounted on 18 cm (7") seat tracks and were adjusted to the full rear positions at the time of the SCI inspection. Adjusted to the full rear position, the longitudinal distance between the driver's seatback and the knee bolster was 66 cm (26"). The driver's seatback was reclined 20 degrees aft of vertical.

The second row consisted of a full length bench seat which accommodated three seating positions with a fixed seatback with a recline angle of 25 degrees. The longitudinal distance between the front and rear seatbacks was 84 cm (33"). The second row seating positions were not equipped with head restraints.

Crash Sequence

Pre-Crash

The 26-year old male driver of the Cavalier was traveling southbound on the inboard lane of the five-lane roadway and was approaching a "T" intersection **(Figure 2)**. A non-contact vehicle was reportedly entering the five-lane roadway from the intersecting road and was intending to travel southbound on the Cavalier's established lane of travel. In response to the encroachment of the non-contact vehicle, the driver of the Cavalier initiated a right steering input in an attempted avoidance maneuver. After initiating this action, the Cavalier traveled in a southwest direction and its right side tires departed the right side of the roadway. The driver of the Cavalier then counter steered left which induced a CCW yaw and the vehicle reentered the roadway and began off-tracking in a southeast orientation. Based on the physical evidence, the Cavalier's CCW rotation (slip angle) at this point was approximately 40 – 50 degrees. As the vehicle crossed the roadway's center turn lane, the driver maintained power to the drive wheels and steered right; as a result, the vehicle reversed its rotation to CW before it departed the left roadside. As the vehicle exited the roadway, it traveled across a commercial business parking lot, through a narrow grassy area, across an asphalt driveway, and then toward a ditch. The slip angle of the vehicle as it departed the roadway was approximately 20 degrees CW. The vehicle continued rotating CW and its slip angle reached approximately 70 degrees at the rollover trip point.

Figure 2 - Southbound approach of the Cavalier.

As the vehicle initially lost control off the right roadside the right side tires transferred significant amounts of yaw marks onto the asphalt roadway **(Figure 3)**. The CCW tire marks attributed to the right front wheel was 39 m (128') in length and had a radius of curvature of 159 m (522'). The CCW markings attributed to the right rear wheel were 46 m (151') in length and had a radius of 133 m (436'). Using the average radius of curvature of the right side yaw marks and the critical speed formula, the Cavalier was estimated to be traveling at 109 km/h (68 mph). The following equation was used to determine the critical speed:

Figure 3 – CCW yaw marks leading to the right side road departure.

$$S = 3.87 * (R * f)^{0.5}$$

$$R = 479'$$

$$f = 0.65$$

$$S = 109 \text{ km/h} \sim 68 \text{ mph}$$

The lengths of the left front and left rear tire marks on the west shoulder were minimally curved and were 4 m (13') and 7 m (23'), respectively. Following a separation of tire marks from the west fog line, a CCW yaw mark was present that began at the outer aspect of the southbound inboard lane and terminated at the midpoint of the center turn lane. The tire mark, which was 13 m (43') in length and had a radius of curvature of 53 m (174'), resulted as the vehicle off-tracked toward the left side of the roadway. This mark was attributed to the vehicle's right rear wheel. As the vehicle departed the left roadside, the center of gravity shifted the vehicle to the left side tires, which resulted in CW yaw marks leading toward the rollover trip point **(Figure 4)**. The tire mark attributed to the left front tire was 20 m (66') in length and its radius of curvature was 63 m (207'). The tire mark attributed to the left rear tire was 19 m (62') in length and had a radius of 57 m (187'). As the vehicle traversed the asphalt driveway, additional load was placed on the outboard sidewalls of left side tires. The tread rolled under the wheels and the tires de-beaded resulting in an air out of the tires. With the absence of air pressure, the left rims loaded the asphalt driveway, the soft soil and the grass at the apex of the ditch. This resulted in damage to the steel rims and deep gouges to the roadside. The damage to the left side rims as a result of contacting the asphalt driveway was circumferential along the outer aspects of the rims **(Figures 8** and **9)**. The left front and left rear rims sustained 23 cm (9") and 41 cm (16") of damage, respectively. The roadside gouge marks are illustrated in **Figure 5.**

Figure 4 - CW yaw marks leading to the left side road departure.

Figure 5 - Deep gouging across asphalt driveway leading to point of impact.

Crash

At approximately 5 m (16') past the point of departure from the asphalt driveway, the vehicle tripped into a five-quarter turn rollover event resulting in moderate damage to the sides and top of the vehicle. During the rollover sequence, the vehicle's left side contacted a manhole cover that protruded from the ground 5 cm (2.5"). This object did not alter the vehicle's path or create an obstructed rollover and was therefore integrated into the rollover sequence. The vehicle came to final rest on its left side approximately 10 m (25') off the east roadside and was facing in northeast

Figure 6 - Trip points leading to overturn.

direction. The distance between the vehicle's trip point and the final rest position was approximately 8 m (26'). **Figure 6** illustrates the vehicle's trip point, the contacted manhole cover and the area of final rest.

Post-Crash

The driver and right rear child passenger sustained minor injuries during the rollover crash. Several passers-by responded to the crash site following the event. To free the child, the driver reached into the back seat and unlatched the child's safety belt and pulled him into the front row. Thereafter, the driver pushed the child up through the front right window opening into the hands of a passer-by who removed the child from the vehicle. The driver remained inside the vehicle to await the arrival of emergency personnel. During a telephone interview, the driver claimed to be mechanically entrapped in the front left seating position; however, an on-site inspection of the vehicle revealed no evidence to support entrapment. Emergency personnel cut the three right side pillars and the A- and C- pillars on the left side. The roof was not removed, however, as the left B-pillar was left intact. Media coverage of this event clearly showed that the driver was already removed prior to the cutting of the pillars. After the driver was removed, he was transported to a regional trauma center by ambulance. He was treated and released the same day. The child passenger was transported to an area hospital by ambulance and was admitted overnight for treatment and observation. The vehicle sustained moderate damage and was towed from the crash scene.

Vehicle Damage

Exterior Damage – 1992 Chevrolet Cavalier

The 1992 Chevrolet Cavalier sustained moderate roof damage as a result of a five-quarter turn rollover crash. The maximum vertical and lateral crush measurements were 20 cm (8") and 17 cm (6.5"), respectively and were in the area of the right A-pillar zone. The direct contact damage on the roof side rail began at the junction of the A-pillar and extended 123 cm (48.5") rearward to the junction of the C-pillar and backlight header. An additional 58 cm (23") of direct contact damage was documented on the right A-pillar. The combined direct and induced damage along the roof side rail was also 123 cm (48"). The Collision Deformation Classification (CDC) was 00-TDDO-3. **Figure 7** illustrates the maximum area of damage and the gauge placement along the right roof side rail.

Figure 7 - Right side gauge placement on the Cavalier.

A second set of crush measurements were documented along the full width of the windshield header. The direct contact damage began at the junction of the right A-pillar and windshield header and was 56 cm (22") in length. The combined direct and induced damage along the header was 107 cm (42"), the full width of the component. The maximum crush was also located at the junction of the A-pillar and header and was 14 cm (5.5") in depth.

There was additional damage to the vehicle that occurred during the rollover event. All four wheels had grass and dirt debris embedded within the rim and tires. Both left side rims sustained moderate structural damage as a result of yawing across the asphalt driveway prior to overturning. The damage patterns were both circumferential around the outer aspect of the rim with the front left sustaining 23 cm (9") of deformation and the left rear wheel and 41 cm (16") of damage (**Figures 8** and **9**). In addition to the embedded debris, the right front tire had a post-crash negative camber of 5 degrees.

Figure 8 - Left front wheel of the Cavalier.

Figure 9 - Left rear wheel of the Cavalier.

The right fender sustained 136 cm (53.5") of damage in the form of vertical abrasions with the maximum crush totaling 18 cm (4"). The right front door exhibited a 30 cm (12") field of damage that was located at the rub strip 30 cm (12") above the sill and 3 cm (1") forward of the right rear door edge. The right quarter panel also exhibited vertical abrasions that were 81 cm (32") in length that began 33 cm (13") forward of the right rear bumper corner. Vertical abrasions were also present on all three right side pillars. All of the right side damage occurred during the rollover sequence.

The left front fender along the wheel opening exhibited damage that was 27 cm (10.5") in length which began 28 cm (11") forward of the A-pillar. An area of more pronounced damage was located 10 cm (4") forward of the base of the A-pillar and extended to 2 cm (0.75") aft of the same. Vertically, the damage began 3 cm (1.2") above the mid-door rub strip and extended upward 20 cm (8"). An associative yellowish transfer was embedded with the paint at this location that was attributed to a manhole cover located at the scene. The manhole cover protruded from the ground 5 cm (2"); however, this object did not interrupt the rollover because positioned as it was the object was not of sufficient height to impede or redirect the vehicle during the rollover sequence. Another rollover induced dent that was 6 cm (2.5") in diameter and was located 28 cm (11") rear of the base of the A-pillar. A separate 50 cm (20") x 27 cm (10.5") field of vertical abrasions was documented on the left side doors of the vehicle. This damage began 13 cm (5") forward of the B-pillar and extended to 50 cm (20") rear of the same.

Interior Damage -1992 Chevrolet Cavalier

The 1992 Chevrolet Cavalier sustained moderate interior damage due to intrusion and minor damage due to occupant loading of the interior components. The intrusion was limited mostly to the right side of the occupant seating areas as the right side roof, roof side rail, and front and rear headers compromised the integrity of the interior. The maximum intrusion was to the roof at the right rear seating position and intruded vertically 16 cm (6.3”). The intrusions listed by their magnitudes are outlined below this section in a table format. Only four occupant contact points were identified during the SCI inspection. The left aspect of the steering wheel rim was deformed 3 cm (1”), the flange was bent, and the left shear capsule bracket was compressed approximately 1 cm (0.5”). It is possible that the driver’s chest loaded the component during the rollover sequence. The second contact point identified was the left aspect of the driver’s lower knee bolster. The panel was separated from the base of the instrument panel. No correlative body or fabric transfer was located nor was loading evidence found; therefore, the knee bolster was listed only as a possible contact. The third area of possible contact was the center instrument panel. The housing panels for both the radio and temperature settings were fractured, and with the absence of intrusion in this area, the panels were documented as possible lower leg contact locations. The final potential contact point was the overhead dome light mounted at the center point of the roof. The clear plastic cover was fractured and a white body fluid transfer was found on and around the component. The area of possible contact points are illustrated in **Figure 10**. It is possible that other potential areas of contact were masked by the unkempt condition and age of the vehicle. The specific intrusions are listed by their magnitude in the following table:

Figure 10 - Contact pattern along the left and center instrument panel.

Position	Intruded Component	Magnitude	Direction
Front row right	Roof	16 cm (6.3”)	Vertical
Front row right	Roof side rail	15 cm (5.9”)	Vertical
Front row right	Windshield header	14 cm (5.5”)	Vertical
Second row right	Roof	14 cm (5.5”)	Vertical
Second row right	Roof side rail	13 cm (5.1”)	Vertical
Front row right	Window frame	11 cm (4.3”)	Lateral
Second row right	Window frame	11 cm (4.3”)	Lateral
Second row right	B-pillar	10 cm (3.9”)	Lateral
Front row right	B-pillar	10 cm (3.9”)	Lateral
Front row right	A-pillar	7 cm (2.8”)	Lateral
Front row middle	Roof	5 cm (2”)	Vertical
Second row middle	Roof	5 cm (2”)	Vertical
Second row right	Backlight header	4 cm (1.2”)	Vertical
Second row right	C-pillar	3 cm (1.2”)	Lateral
Front row middle	Windshield header	1 cm (0.5”)	Vertical

Automatic Restraints – 1992 Chevrolet Cavalier

The 1992 Chevrolet Cavalier was configured with door mounted 3-point automatic lap and shoulder belts for the driver and front right passenger seating positions. Both front seats were equipped with Emergency Locking Retractors (ELR) and sewn on latch plates. The driver's belt exhibited usage indicators and the belt was cut by emergency personnel presumably to free the driver. Ripple pattern marks with light abrasions were present on the belt webbing that were 6 cm (2.4") in length and began 79 cm (31") above the anchor point of the belt system. The latch plate was sewn to the belt webbing 163 cm (64") above the anchor point. The cut mark on the belt webbing administered by the emergency personnel was located 33 cm (13") above the latch plate. The front right seat was unoccupied and the belt was not in use.

Manual Restraints – 1992 Chevrolet Cavalier

The second row consisted of manual lap and shoulder restraints for the outboard positions and an adjustable length lap belt for the middle position. The outboard restraints were configured with ELR's and locking latch plates. The second row middle position also had a locking retractor. Upon arrival at the vehicle inspection, the right rear shoulder restraint was routed through the right side shoulder belt path of the BPBSS **(Figure 11)**. The webbing was twisted three revolutions, a 4 cm (1.2") abrasion was present on the shoulder webbing and a correlative abrasion was present within the BPBSS belt routing path. The abrasion on the belt was located 58 – 68 cm (23 – 27") below the uppermost aspect of the webbing. There was no further discernable loading evidence on the belt system.

Figure 11 - Right rear belt webbing still engaged in the BPBSS belt path.

Child Safety Seat – Evenflo Big Kid

A BPBSS was installed in the second row right seating position of the 1992 Chevrolet Cavalier **(Figure 12)**. The Model Number was 3371689A and the Date of Manufacture was 12/02/2006. The BPBSS had no internal hardware such as a harness or retainer clip. The BPBSS was designed with a detachable seatback. The BPBSS with the detachable high back installed was rated for children between 14 – 45 kg (30 – 100 lbs.) and between 96 – 145 cm (38 – 57"). If it was used with the high back component of the BPBSS detached, it was rated for children between 18 – 45 kg (40 – 100 lbs.) and 101 – 145 cm (40 – 57"). The child was 91 cm (36") tall and weighed 16 kg (35 lbs.). At these proportions, he was slightly undersized for the BPBSS.

Figure 12 - The belt positioning booster safety seat.

At the time of the SCI inspection, the shoulder restraint was routed through the right shoulder belt path of the BPBSS. The webbing was twisted three revolutions, a 4 cm (1.2") abrasion was present on the shoulder webbing and an accompanying abrasion was present within the BPBSS belt routing path.

During the SCI interview with the mother of the 2-year old child, she indicated that the child is not usually placed within this BPBSS. She stated that the child is usually placed in a forward facing CSS; however, the child's normal CSS was in another vehicle at the time of the crash and the child's father utilized the BPBSS as a temporary measure for an unexpected trip.

Occupant Demographics

Driver

Age/Sex:	26-year old/Male
Height:	183 cm (72")
Weight:	98 kg (216 lbs.)
Seat Track Position:	Full-rear
Restraint Use:	3-point automatic lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	None
Medical Treatment:	Transported by ambulance to a regional trauma center and released

Driver Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Source
Cervical spine strain (neck C-3)	Minor (640278.1,6)	Impact forces

Source: Interview

Driver Kinematics

The 26-year old restrained male driver was seated in an upright posture in the front left seating position. The driver was probably slightly forward of the seatback as he attempted to control the vehicle as it rotated CCW and then CW leading to the trip point of the rollover. The vehicle off-tracked left side leading and the driver responded with a slight trajectory to the left. As the vehicle overturned, the driver was likely displaced right to left until the vehicle came to final rest on its left side. It is possible that during the rollover event, the driver contacted the steering wheel hub, the lower left and center instrument panel, and the dome light mounted on the roof as these components were identified as possible contact points during the SCI vehicle inspection. Post-crash, the driver remained seated in the vehicle and reported that he was unable to free himself. He did however reach into the rear seat and unlatch the child from the BPBSS and passed him to passers-by outside the vehicle who had responded to the crash. The driver remained in his seating position until emergency personnel removed him from the vehicle. He was transported to a regional trauma center by ambulance where he was

treated for minor injuries and released. A complete medical report received from the trauma center revealed no additional injuries.

Right Rear Passenger

Age/Sex:	2-year old/Male
Height:	91 cm (36”)
Weight:	16 kg (35 lbs.)
Seat Track Position:	Not adjustable
Restraint Use:	3-point lap and shoulder belt with BPBSS
Usage Source:	Vehicle inspection
Eyewear:	None
Medical Treatment:	Transported by ambulance and to an area hospital and admitted overnight

Right Rear Passenger Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Source
Knee contusion	Minor (890402.1,1)	Door panel
Small lacerations to top aspect of both feet	Minor (890602.1,3)	Flying glass
Concussion	Minor (160402.1,0)	Impact forces

Source: Interview

Right Rear Passenger Kinematics

The 2-year old male passenger was seated in an upright posture within a BPBSS and was restrained by a 3-point manual lap and shoulder belt. As the vehicle lost control and traveled toward the point of impact, the child was likely displaced laterally in response to the dynamics of the vehicle. As the vehicle overturned, the child loaded the belt system that held him and the BPBSS in place as evidenced by the loading evidence on both the belt webbing and belt path on the upper right aspect of the BPBSS. As the vehicle was overturning, the child’s right knee contacted the right rear door panel resulting in a minor contusion to his right knee. Several side windows shattered during the crash and fragments of glass struck the top aspects of the child’s feet resulting in multiple minor lacerations. In addition to the integumentary injuries, the child sustained a concussion from the impact forces. Following the crash, the child’s father unlatched the child and pulled him into the front row. Thereafter, the child was lifted by the father and on-site passers-by who removed the child from the front right window opening. The child was stabilized by emergency personnel and transported by ambulance to an area hospital. He was admitted overnight for treatment and observation and was released the following day.

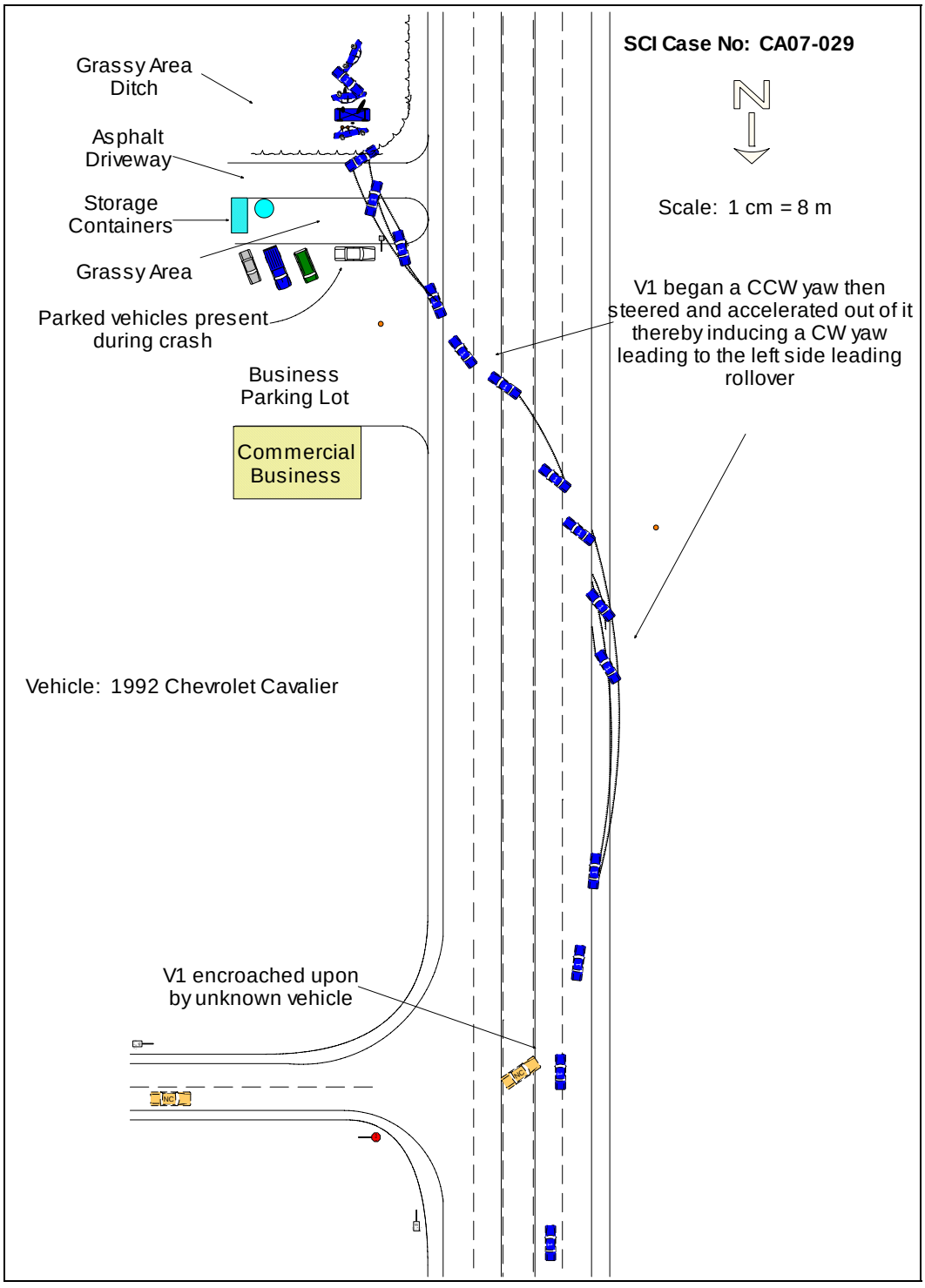

Figure 13 – Scene Schematic