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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
SCI CASE NO: CA07-018

VEHICLE: 2007 CHEVROLET EQUINOX
LOCATION: NEW YORK
CRASH DATE: JUNE, 2007

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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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16. Abstract This investigation focused on the crash dynamics, the child safety seat performance, and the injury sources surrounding the offset head-on crash of a 2007 Chevrolet Equinox and a 1995 Buick Century. The Chevrolet was occupied by a restrained 36 year old male driver, a restrained 35 year old female front right passenger, a 1 month old female second row left passenger and a 3 year old female second row right passenger. The children in the rear seats of the Equinox were restrained within child safety seats that were installed with the Lower Anchors and Tethers for CHildren (LATCH). After the initial impact, the Chevrolet Equinox subsequently rolled over six-quarter turns coming to rest on its roof in the middle of the road. The Chevrolet Equinox was equipped with a Certified Advanced 208 Compliant (CAC) frontal air bag system comprised of dual-stage frontal air bags, front safety belt retractor pretensioners, seat track position sensors, and a front right occupant detection sensor. The frontal air bags in the vehicle were certified by the manufacturer to be compliant with the Federal Motor Vehicle Safety Standard (FMVSS) 208 ruling. The Buick was equipped with a driver (only) air bag. The frontal air bag systems deployed in both vehicles. The adult passengers in the Equinox sustained minor severity injuries and were transported to local hospitals. The two children remained restrained within the child safety seats during the crash events and were not injured. The children were transported to a local hospital for evaluation and held overnight for observation. The restrained 30 year old male driver of the Buick sustained police reported minor injuries.			
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BACKGROUND

This investigation focused on the crash dynamics, the child safety seat performance, and the injury sources surrounding the offset head-on crash of a 2007 Chevrolet Equinox and a 1995 Buick Century. The Chevrolet was occupied by a restrained 36 year old male driver, a restrained 35 year old female front right passenger, a 1 month old female second row left passenger and a 3 year old female second row right passenger. The children in the rear seats of the Equinox were restrained within child safety seats that were installed with the Lower Anchors and Tethers for CHildren (LATCH). After the initial impact, the Chevrolet Equinox subsequently rolled over six-quarter turns coming to rest on its roof in the middle of the road. The Chevrolet Equinox was equipped with a Certified Advanced 2080-Compliant (CAC) frontal air bag system comprised of dual-stage frontal air bags, front safety belt retractor pretensioners, seat track position sensors, and a front right occupant detection sensor. The frontal air bags in the vehicle were certified by the manufacturer to be compliant with the Federal Motor Vehicle Safety Standard (FMVSS) 208 ruling. The Buick was equipped with a driver (only) air bag. The frontal air bag systems deployed in both vehicles. The adult passengers in the Equinox sustained minor severity injuries and were transported to local hospitals. The two children remained restrained within the child safety seats during the crash events and were not injured. The children were transported to a local hospital for evaluation and held overnight for observation. The restrained 30 year old male driver of the Buick sustained police reported minor injuries.

Figure 1: Left oblique view of the Equinox.

This crash was identified by the Calspan Special Crash Investigations (SCI) team through the local news media. Calspan forwarded the notification of the crash to the Crash Investigation Division of the National Highway Traffic Safety Administration on June 4, 2007. The agency subsequently assigned an on-site investigation of the crash to the SCI team due its interest in child passenger safety and the performance of child safety seats. Calspan SCI initiated a follow-up investigation and established cooperation with the investigating police department and the driver. The vehicles were available for inspection at a local tow yard. The child safety seats were in possession of the family and also available for inspection. The on-site portion of the investigation took place June 6 and 7, 2007.

SUMMARY

Vehicle Data

2007 Chevrolet Equinox

The 2007 Chevrolet Equinox was identified by the Vehicle Identification Number (VIN): 2CNDL13F776 (production sequence deleted). The front-wheel drive sport utility vehicle was equipped with a 3.4 liter/V6 engine linked to a five-speed automatic transmission. The Chevrolet Equinox was equipped with electronic stability control, traction control, and a direct Tire Pressure Monitoring System (TPMS). The service brakes were a four-wheel disc system with ABS. The vehicle was configured for five passengers (2/3). The front bucket seats were equipped with adjustable head restraints. The second row three-passenger bench seat had an adjustable seat track and was equipped with adjustable head restraints in the outboard positions. Each rear seat position was equipped with LATCH. The manual restraint system consisted of three point lap and shoulder belts in the five seat positions. The front restraints were equipped with retractor pretensioners. The advanced frontal air bags (driver and front right passenger) were certified by the manufacturer to meet the requirements of the advanced FMVSS 208 occupant protection standard. The vehicle was not equipped with side impact air bags or side curtains. The 2007 Equinox was equipped with an Event Data Recorder (EDR) that required v2.9 of the Vetronix software for download. This software was not available at the time of the SCI inspection. EDR data could not be accessed. The vehicle was purchased new by the driver approximately two months prior to the crash. The driver estimated the vehicle had been driven approximately 1,770 km (1,100 miles). The Equinox was equipped with Bridgestone Dueller HT P235/60R17 100S tires on OEM alloy wheels. The vehicle manufacturer recommended tire pressure was 221 kPa (32 PSI). The specific measured tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	Tire Flat	8 mm (10/32 in)	No	Wheel assembly separated at drive shaft, rim crushed, 13 cm cut in sidewall
LR	214 kPa (31 PSI)	8 mm (10/32 in)	No	Rim abraded, asphalt embedded in tire bead
RF	214 kPa (31 PSI)	8 mm (10/32 in)	No	Rim abraded
RR	214 kPa (31 PSI)	8 mm (10/32 in)	No	Rim abraded

1995 Buick Century

The 1995 Buick Century was identified by the Vehicle Identification Number (VIN): 1G4AG55M5S6 (production sequence deleted). The four-door, front-wheel drive sedan was powered by a 3.1 liter/V6 engine linked to a four-speed automatic transmission. The service brakes were a front disc/rear drum system with ABS. The manual restraint system consisted of three point lap and shoulder belts for the four outboard positions and a center rear lap belt. The Buick was equipped with a driver air bag that deployed as a result of the crash. The vehicle was not equipped with an Event Data Recorder. The odometer had registered 130,157 km (80,878 miles) at the time of the crash. The Century was equipped with Uniroyal Tiger Paw P185/75R14

tires on OEM steel wheels. The recommended tire pressure was 221 kPa (32 PSI). The specific measured tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	Tire Flat	6 mm (8/32 in)	Yes	Sidewall of tire cut, Rim crushed
LR	16 kPa (110 PSI)	6 mm (7/32 in)	No	None
RF	165 kPa (24 PSI)	6 mm (7/32 in)	No	None
RR	221 kPa (32 PSI)	6 mm (7/32 in)	No	None

Crash Site

This two vehicle crash occurred during the afternoon hours of June 2007. At the time of the crash, it was daylight and the weather was clear and dry. The crash occurred on a straight segment of a four-lane road immediately south of a concrete bridge. At the crash site, the roadway consisted of two 3.7 m (12 ft) lanes in each direction that were separated by double yellow centerlines. The outboard edges of the travel lanes were bordered by white fog lines and 3 m (10 ft) wide shoulders. The speed limit in the area of the crash was 72 km/h (45 mph). **Figure 2** is a southbound trajectory view 60 m (200 ft) north of the point of impact. **Figure 3** is a northbound trajectory view 30 m (100 ft) south of the point of impact. The point of impact was located within the inboard southbound lane, 0.9 m (3 ft) west of the double yellow centerline. The area of the impact (**Figure 4**) was denoted by a series of gouge and scratch marks and the beginning of a 24.4 m (80 ft) continuous scratch mark that defined the post-crash trajectory of the Buick. The post-crash trajectory of the Chevrolet was defined by a series of tire marks, scratches, and gouge marks on the southbound lanes of the road. The roadway physical evidence that defined the post-crash trajectories of the vehicles was documented during the SCI scene inspection.

Figure 2: Southbound trajectory view.

Figure 3: Northbound trajectory view.

Figure 4: Northbound view of the POI.

Crash Sequence

Pre-Crash

The 2007 Chevrolet Equinox was traveling south in the inboard southbound lane. The vehicle was driven by a 36 year old restrained male. The Chevrolet was occupied by a 35 year old restrained female front right passenger, a 1 month old female restrained within a rear-facing infant seat in the second row left position, and a 3 year old female restrained within a forward facing convertible child safety seat in the second row right position. The 1995 Buick Century was traveling north in the inboard northbound lane driven by a 30 year old restrained male. The driver was the sole occupant of the Buick. For unknown reasons, the driver of the Buick crossed the double yellow centerline directly into the path of the Chevrolet. The driver of the Chevrolet reported in his SCI interview that he was not aware of the approaching Buick and did not initiate any avoidance maneuvers prior to the crash. The driver estimated his speed was 64 to 72 km/h (40 to 45 mph). A schematic of the crash is attached to the end of this report as **Figure 16**.

Crash

The front left corner of the Buick impacted the front left corner of the Chevrolet in an offset frontal crash. The Buick's engagement with the Equinox occurred outboard of the forward frame rail and extended along the left side to the left B-pillar location. The left front wheel assembly of the Chevrolet was impacted during the prolonged engagement and separated from the vehicle. The force of the offset impact caused the retractor pretensioners to actuate and the frontal air bags in the Chevrolet to deploy. The driver air bag in the Buick also deployed. The offset location of the impact resulted in a counterclockwise rotation of the Equinox as it separated from the Buick. This rotation was evidenced by two yaw marks (**Figure 5**) attributed to the right tires of the Chevrolet. The right rear mark measured 4.8 m (15.7 ft) in length. The length of the right front mark measured 6.0 m (19.8 ft). Both marks terminated with gouges embedded within the tires marks indicative of a tripped rollover. The trip point was located 7.9 m (26 ft) south of the impact. The Chevrolet rolled two-quarter turns onto its roof evidenced by scratches south of the trip point. As the vehicle rolled three-quarter turns, the left front suspension and left rear wheel rim contacted the pavement 12.2 m (40 ft) downstream of the trip point. Refer to **Figure 6**. Asphalt was embedded in the bead of the left rear tire indicative of the contact. The Chevrolet then continued to roll an additional three-quarter turns coming to rest on its roof straddling the centerline of the road facing

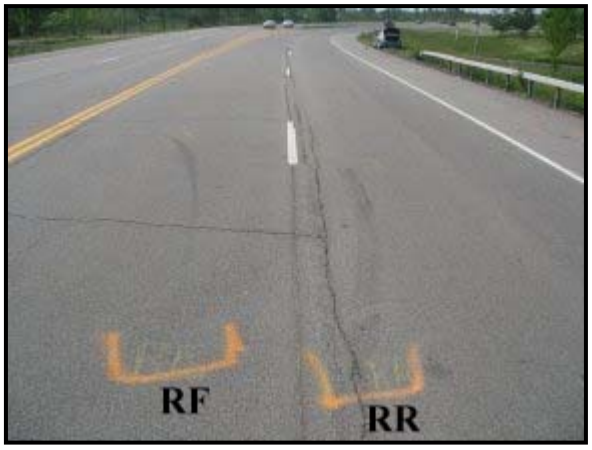

Figure 5: Southbound view of the yaw marks.

Figure 6: Left front and left rear gouge marks.

east. The Chevrolet came to rest 39.0 m (128 ft) from the point of impact. The Chevrolet's total roll distance from the trip point to final rest measured 31.1 m (102 ft). The Buick separated from the impact with a northward trajectory. The vehicle traveled 24.4 m (80 ft) from the point of impact evidenced by a continuous scratch mark and came to rest facing westward straddling the southbound lanes.

Post-Crash

The police and ambulance personnel responded to the crash scene. The driver and front right passenger in the Chevrolet indicated they released their safety belts and exited the vehicle through the respective front windows. The driver subsequently removed the right rear child passenger and then the left rear child passenger. He reported that each child had remained within the confines of their respective child safety seats and were uninjured. These individuals then moved to the road shoulder. All four occupants of the Chevrolet were transported to local hospitals for treatment. The driver was examined in the emergency room and released approximately three hours post-crash. The front right passenger and the child passengers were examined, treated and held overnight for observation. The driver of the Buick had to be extricated from the vehicle. The Buick's roof was removed and the base of the left B-pillar was cut to facilitate opening the left front door. The driver was removed and transported via ground ambulance with police reported minor injuries. The Chevrolet and Buick were towed from the scene due to disabling damage and were inspected at a local tow yard.

Exterior Damage

2007 Chevrolet Equinox

The exterior damage to the Chevrolet consisted of frontal impact damage and rollover damage consistent with the multiple event impact sequence. **Figures 7 and 8** are the front and left side views of the Equinox, respectively. The direct contact damage to the frontal plane measured 19 cm (7.5 in) and began 58 cm (23 in) left of center extending to the left corner. The frontal contact occurred immediately outboard of the forward left sub-frame. There was no longitudinal compression/deformation of this component. The force of the impact separated the left front wheel assembly at the lower control arm. The direct contact along the left side extended rearward to the trailing edge of the left front door and measured 235 cm (92.5 in). The maximum lateral deformation measured 19 cm (7.5 in) and was located at the lower aspect of the left A-pillar. The left wheelbase was reduced 30 cm (12 in). The right wheelbase lengthened 5 cm (1.8 in) due to deformation of the right rear suspension. The left front door was jammed shut. The left rear door and the right doors remained closed and were operational post-crash. The Collision Deformation Classification (CDC) was 12-FLEE9.

Figure 7: Front view of the Chevrolet.

The Chevrolet's exterior damage was consistent with a six-quarter turn rollover event. The vehicle's two side planes, top plane and the wheels/tires exhibited damage from ground contacts. The scratch pattern along the right roof side rail was bi-directional in nature indicating the right side contacted the road at two different times. Similarly, bi-directional scratch patterns were observed on the roof and hood. The maximum vertical deformation of the roof was located at the junctions of both A-pillars and the respective roof side rails. The maximum vertical deformation measured 4 cm (1.5 in). There was no lateral deformation of the greenhouse. The CDC of the rollover damage was 00-TDD02

Figure 8: Left side view.

Figure 9: View of the roof.

Exterior Damage

1995 Buick Century

The Buick Century sustained severe damage as a result of the frontal impact with the Chevrolet. **Figure 10** is a left front oblique view of the Buick. The front plane sustained 30 cm (12 in) of direct contact damage that began 48 cm (19 in) left of center and extended to the left corner of the bumper. The combined width of the direct and induced damage extended across the entire 157 cm (62 in) frontal end width of the vehicle. The residual crush profile measured along the bumper reinforcement bar was as follows: C1 = 95 cm (37.5 in), C2 = 51 cm (20.0 in), C3 = 39 cm (15.5 in), C4 = 23 cm (9.0 in), C5 = 0, C6 = 0. The exterior damage associated with this corner impact extended 182 cm (71.5 in) rearward to the forward aspect of the left front door. The left front wheel rim was deformed in the impact and the tire was cut. The left wheelbase was reduced 29 cm (11.3 in). The right wheelbase lengthened 8 cm (3.2 in) due to body deformation. The left front door was jammed shut by deformation. The left rear door and the right doors remained closed and were operational post-crash. The left corner of the instrument panel was deformed rearward 13 cm (5 in). The roof was removed and base of the left B-pillar was cut to

Figure 10: Left oblique view of the Buick.

extricate the driver. The CDC of the exterior damage was 12-FLEE8. The delta V of the Buick calculated by the Barrier Equivalent Model of the WINSMASH program was 36 km/h (22.3 mph). The longitudinal and lateral components were -36 km/h (22.3 km/h) and 0, respectively.

Interior Damage

2007 Chevrolet Equinox

The interior damage to the Equinox consisted of intrusion into the driver interior space, the deployment of the frontal air bags, and minor interior occupant contact points. The lateral intrusion of the left kick panel in the driver's foot well measured 27 cm (10.5 in). The lateral intrusion of the left sill and left front door panel measured 25 cm (10 in). The vertical intrusion of the header above the driver's position measured approximately 3 cm (1 in). The floor of the Chevrolet was buckled in the first and second row. There was no intrusion into the second row seating area.

The driver seat was located in a mid-track position that measured 7 cm (2.8 in) forward of full rear. The total seat track travel measured 19 cm (7.5 in). The seat back was reclined 15 degrees. The horizontal distance from the seat back to the center of the steering wheel hub measured 64 m (25 in). The head restraint was adjusted up 6 cm (2.5 in). There was no deformation of the four–spoke steering wheel rim. The steering column shear capsule displacement was approximately 1 cm (0.5 in).

Minor interior contacts within the driver's interior space were identified during the inspection. The mirror attached to the back side of the driver's sun visor was cracked indicative of a probable head contact. Although not substantiated by residual contact evidence, the driver's knee bolster was displaced from probable bilateral knee contacts. Post-crash blood evidence was observed on the left roof rail 11 cm (4.5 in) forward of the left B-pillar.

The front right seat was located in a rear-track position that measured 5 cm (2 in) forward of full rear. The total seat track travel measured 19 cm (7.5 in). The seat back angle measured 10 degrees aft of vertical. The horizontal distance from the seat back to the most rearward protrusion of the instrument panel measured 74 cm (29 in). The head restraint was adjusted up 5 cm (2.2 in). There were no identified interior contacts.

The second row of the Chevrolet Equinox consisted of an adjustable three passenger 60/40 split bench seat (left side wide). The seat was adjusted 10 cm (4 in) forward of full rear. The outboard seat positions were equipped with head restraints that were adjusted up 6 cm (2.5 in). The seat back angle measured 20 degrees. The horizontal distance from the rear seat back to the front row seat backs measured 81 cm (32 in). The rear seat was equipped with Lower Anchors and Tethers for CHildren (LATCH) in all three positions, **Figure 11**. Inspection of the lower

Figure 11: Second row seat with LATCH.

anchors revealed the surfaces of the bars were scratched from use. An interview with the driver indicated that LATCH was routinely used to install the child safety seats and the LATCH system was used at the time of the crash. Inspection of the second row seating area determined that there were no occupant contacts within the compartment.

Manual Restraint System

2007 Chevrolet Equinox

The manual restraint system in the Chevrolet Equinox consisted of three-point lap and shoulder restraints in the five seat positions. The driver's restraint consisted of continuous loop webbing, an Emergency Locking Retractor (ELR) with a pretensioner, an adjustable D-ring, and a sliding latch plate. The D-ring was 2 cm (1 in) above the lowest position. Upon initial inspection, the driver's webbing was found extended from the retractor and the retractor was locked due to the actuated pretensioner. **Figure 12** is a view of the driver's restraint in the reconstructed buckled condition. A 6 cm (2.5 in) abrasion to the webbing from latch plate loading was located 66 (26 in) above the outboard anchor. An 8 cm (3 in) webbing abrasion was located 2 cm (1 in) below/behind the D-ring. Due to its location (on the retractor side) below the D-ring, this abrasion was a result of the pretensioner actuating. The SCI inspection of the belt system determined the driver was restrained at the time of the crash.

Figure 12: Driver's restraint.

The front right passenger restraint consisted of continuous loop webbing, a switchable Automatic Locking/Emergency Locking retractor (ALR/ELR) with pretensioner, an adjustable D-ring, and a sliding latch plate. The D-ring was 2 cm (1 in) above the lowest position. Inspection of the restraint found the webbing extended and the retractor locked due to the actuated pretensioner (**Figure 13**). A 5 cm (2 in) webbing abrasion from latch plate loading was located 64 cm (25 in) above the outboard anchor. A 10 cm (4 in) abrasion was located on the retractor side of the webbing (below the D-ring) similar to the driver's belt. This abrasion began 5 cm (2 in) below the D-ring and occurred as a result of the actuated pretensioner. Inspection of this restraint determined that the front right passenger was restrained at the time of the crash.

Figure 13: Front right passenger's restraint.

The second row three-point restraints in the Chevrolet Equinox consisted of continuous loop webbing, a switchable ALR/ELR retractor, a fixed D-ring and a sliding latch plate. The center

three-point restraint was integrated into the seat back. Inspection of these restraints found no crash related evidence of use. These manual restraints were not used to restrain the child safety seats; the safety seats were restrained by the LATCH system. This determination was further confirmed by the driver interview.

Air Bag System

2007 Chevrolet Equinox

The Chevrolet Equinox was equipped with a frontal air bag system that consisted of advanced dual stage air bags for the driver and front right passenger, seat track position sensors, front safety belt buckle switches, front safety belt pretensioners and a front right occupant detection sensor. The frontal air bag system was certified by the manufacturer to have met the requirements of the Federal Motor Vehicle Safety Standard 208. The vehicle was not equipped with inflatable side air bags. The driver air bag deployed from an I-configuration module located in the center of the steering wheel rim. The symmetrical cover flaps measured 5 cm x 13 cm (2 in x 5 in) width by height. The deflated air bag measured 51 cm (20 in) in diameter. It was tethered by two internal straps and was vented by two ports located at the 11/1 o'clock sectors of the back side of the bag. There was no residual evidence of driver contact to the air bag. The front right passenger bag deployed from a top mount module located in the right aspect of the instrument panel. The cover flap was a rectangular forward hinge design that measured 33 cm x 17 cm (13 in x 6.5 in) width by height. The face of the air bag measured 38 cm x 48 cm (15 in x 19 in) width by height. The rearward excursion of the bag measured 48 cm (19 in) from the face of the instrument panel. The bag was not tethered. It was vented by two 38 cm (1.5 in) ports located on the side panels. The top surface of the bag exhibited a 30 cm x 38 cm (12 in x 15 in) black flap transfer that occurred during the deployment sequence. There was no residual evidence of occupant contact to the bag.

Child Safety Seat Data

The two children seated in the second row of the Chevrolet were each restrained within a Child Safety Seat (CSS). The 1 month old female was restrained by the five-point harness system of a Graco Snug Ride rear-facing infant seat, **Figure 14**. The CSS was designed with a detachable base. The seat was identified by the Model No: 7411KBK and Serial No: JJ1205032109. The seat was manufactured on 12-05-2003 and was rated for rear-facing use by infants that weigh less than 9 kg (20 lb) and are less that 66 cm (26 in) in length. At the time of the crash, the infant seat and base were restrained by the LATCH belt to the lower anchors of the second row left seat position. The harness straps were adjusted to the lowest slots. The harness retainer clip was present and it was operational. The barness buckle operated as designed. The harness straps

Figure 14: View of the Graco infant seat and base.

were not roped and were properly routed. There was no crash related evidence identified on the harness straps or on the safety seat shell.

The 3 year old female was restrained within a Graco Comfort Sport convertible child safety seat, **Figure 15**. This seat was installed in a forward-facing mode in the second row right position with the LATCH system (lower anchors and tether). The seat was identified by the Model No: 863DEU and it was manufactured on November 17, 2004. The CSS was designed for rear facing use by children weighing 2.2 to 9 kg (5 to 20 lb) and for forward facing use by children that weigh from 9 to 18 kg (20 to 40 lb) and have a height less than 102 cm (40 in). The straps of the five point harness were to be adjusted to top slots for children weighing (30 to 40 lb). The five-point harness straps were adjusted to the top slots and were not roped or creased. The harness retainer clip was present and the retainer clip and buckle functioned properly. The adjustable foot was in the upright position as instructed for forward facing use. Examination of the shell was unremarkable for crash related evidence.

Figure 15: Convertible CSS.

The driver reported in his interview that he installed both seats himself and routinely checked their installation. He was aware of the technique of compressing the seat cushion and tightening the belts and reported that he had checked the seats' installation on the day of the crash. He further reported that he adjusted the harness retainer clips to approximately the mid-chest area of each child. The harness straps were "snug" with approximately 1 to 2 fingers of slack. The driver indicated he was aware of the child safety seat check points but had not attended one. He is a police officer by occupation, but had no specialized child safety seat training. He indicated that he read the instruction manuals.

Occupant Demographics

2007 Chevrolet Equinox

	Driver	***Front Right Passenger***
Age/Sex:	36 year old / Male	35 year old / Female
Height:	175 cm (69 in)	163 cm (64 in)
Weight:	82 kg (180 lb)	72 kg (158lb)
Seat Position:	Mid-track	Rear-track
Restraint Use:	3-point Lap and Shoulder belt	3-point Lap and Shoulder belt
Usage Source:	SCI inspection	SCI inspection
Medical Treatment:	Treated and Released	Transported by ground ambulance and held overnight for observation

	Row 2 Left	***Row 2 Right***
Age/Sex:	1 month old / Female	3 year old / Female
Height:	56 cm (22 in)	86 cm (34 in)
Weight:	5 kg (10.5 lb)	15 kg (32 lb)
Seat Position:	Rear-facing child safety seat restrained by LATCH (lower anchors only)	Forward-facing child safety seat restrained by LATCH (lower anchors and tether)
Restraint Use:	Five-point harness	5-point harness
Usage Source:	SCI inspection	SCI inspection
Medical Treatment:	Transported and held for observation, not injured	Transported and held for observation, not injured

Driver Injury

Injury	***Injury Severity (AIS 98 Update)***	***Injury Source***
13 cm x 8 cm right forearm abrasion	Minor (790202.1,1)	Driver air bag
Bilateral knee contusions	Minor (890402.1,3)	Knee bolster

The above injuries were identified during the driver's interview. Medical records were not available.

Driver Kinematics

The driver was seated with an upright posture in a mid-track position and was restrained by the three-point lap and shoulder belt at the time of the crash. Upon impact, the ELR retractor locked, the safety belt pretensioner actuated and the driver air bag deployed. The actuated pretensioner removed the slack for the belt system and tightened the restraint about the driver. The driver responded to the 12 o'clock direction of the impact force and loaded the belt system and deployed driver air bag. During the expansion of the bag, the driver's right forearm was abraded by contact with the bag. The driver's lower extremities contacted the knee bolster and sustained contusions. During the rollover sequence, the driver remained in contact with the locked safety belt system and rode down the force of the crash. The use of the safety belt minimized the driver's contact with the interior. The driver came to rest inverted within the driver seat. He

released his safety belt and exited the vehicle through the left front window. He then rendered aid to the second row passengers.

Front Right Passenger Injury

Injury	***Injury Severity (AIS 98 Update)***	***Injury Source***
Right corneal abrasion, NFS	Minor (240602.1,1)	Flying glass
Right forearm abrasion (posterior aspect)	Minor (790202.1,1)	Egress from the vehicle (possible)
Right knee abrasion, NFS	Minor (890202.1,1)	Egress from the vehicle (possible)

The above injuries were identified in the passenger's medical records.

Front Right Passenger Kinematics

The front right passenger was seated with an upright posture in a rear track position. She was restrained at the time of the crash by the three-point lap and shoulder belt. Upon impact, the ELR retractor locked, the safety belt pretensioner fired and the front right air bag deployed. The fired pretensioner removed the slack for the belt system and tightened the restraint about the passenger. The passenger responded to the 12 o'clock direction of the impact force and loaded the belt system and deployed air bag. During the rollover sequence, the passenger remained in contact with the locked safety belt system and rode down the force of the crash. The passenger came to rest inverted within the front right seat. She released the safety belt and exited the vehicle through the right front window.

The front window glazings disintegrated during the rollover. A piece of the disintegrated glazing became lodged under the passenger's right eyelid and abraded her right cornea. The glass was removed in the hospital's emergency room. The forearm and knee abrasion were possibly sustained during her exit from the vehicle. There was no occupant contact evidence within the vehicle to support these injuries.

Second Row Left Passenger Injury

The one month old female passenger was not injured. There were no identified injuries in her medical records.

Second Row Left Passenger Kinematics

The 1 month old infant was seated in a rear-facing child safety seat (CSS) and was restrained by the internal five-point harness. The harness straps were reported as snug with approximately one to two fingers of slack and harness retainer clip was adjusted to the mid-chest. The CSS was restrained to the vehicle by the LATCH system (lower anchors only). The driver reported that he checked the installation the day of the crash.

Upon impact, the child responded to the frontal impact by initiating a forward trajectory. The child loaded the harness straps with her shoulders and the CSS shell with her back and began to

ride down the crash force. As the vehicle rolled over, the child remained in contact with the harness straps and the CSS shell and rode down the remainder of the crash. The child maintained her position within the CSS and was protected by the safety seat. She came to rest inverted and was removed from the safety seat by the driver.

Second Row Right Passenger Injury

Injury	***Injury Severity (AIS 98 Update)***	***Injury Source***
Left shoulder abrasion	Minor (790202.1,2)	CSS harness strap

The above injured was identified in the child's emergency room records.

Second Row Right Passenger Kinematics

The 3 year old infant was seated in a forward facing mode in a convertible child safety seat (CSS) and was restrained by the internal five-point harness. The harness straps were reported as snug with approximately one to two fingers of slack and harness retainer clip was adjusted to the mid-chest. The CSS was restrained to the vehicle by the LATCH system (lower anchors and tether). The driver reported that he checked the installation the day of the crash.

Upon impact, the child responded to the frontal impact by initiating a forward trajectory. The child loaded the harness straps with her shoulders and chest and began to ride down the crash force. The child sustained an abrasion to the left shoulder as a result of her loading of the harness strap. As the vehicle rolled over, the child remained in contact with the harness straps and rode down the remainder of the crash. The child maintained her position within the CSS and was protected by the safety seat. She came to rest inverted and was removed from the safety seat by the driver.

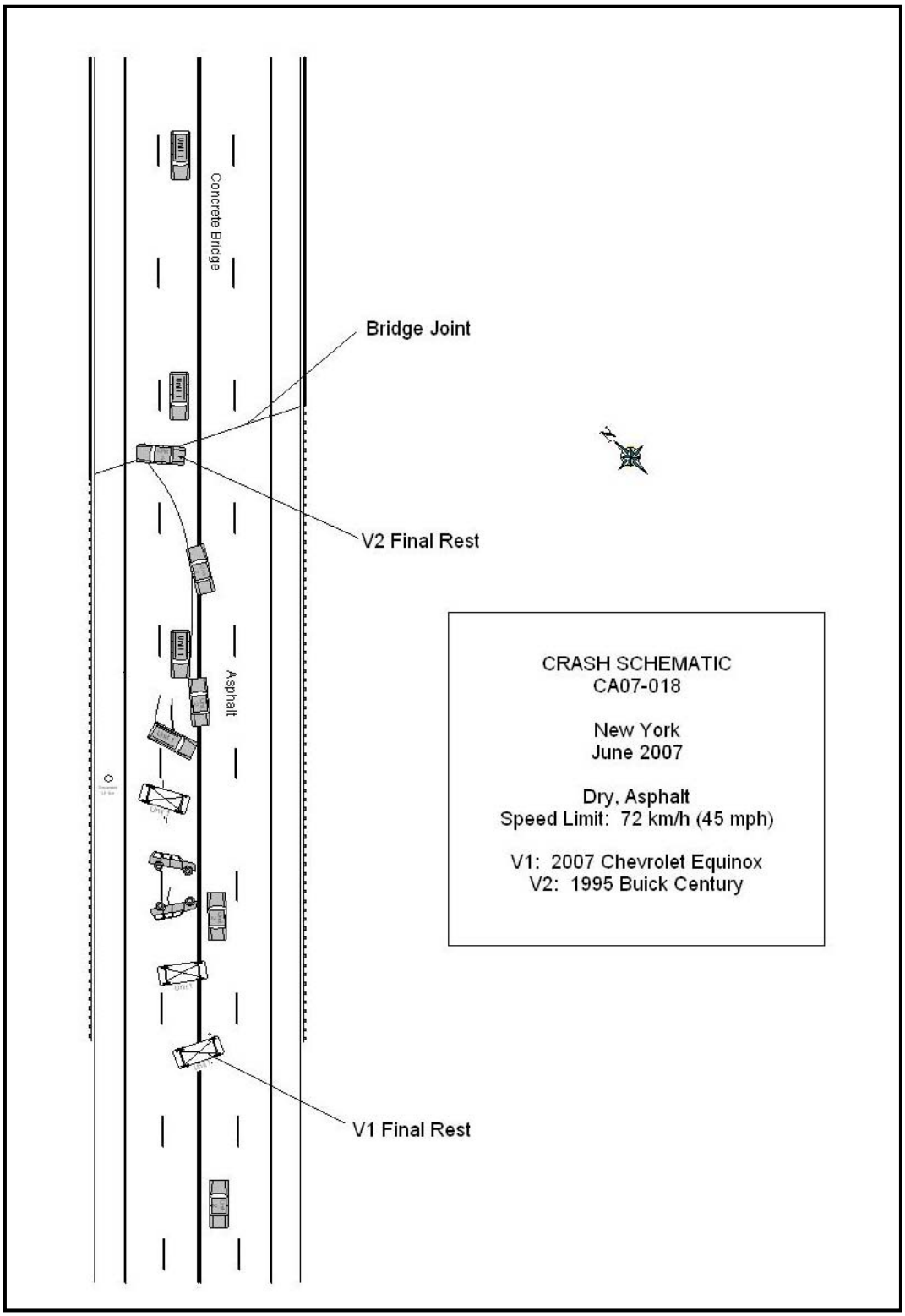

Figure 16: Crash schematic.