CRASH DATA RESEARCH CENTER

Calspan Corporation
Buffalo, NY 14225

CALSPAN ON-SITE CHILD RESTRAINT SYSTEM CRASH INVESTIGATION

SCI CASE NO: CA08051

VEHICLE: 2000 CHEVROLET MALIBU

LOCATION: NEW YORK

CRASH DATE: OCTOBER 2008

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.

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BACKGROUND

This on-site investigation focused on a Child Restraint System (CRS) and the injury sources for a restrained 5-year-old male passenger that was positioned in a backless booster seat in the rear right seating position of a 2000 Chevrolet Malibu **(Figure 1)**. The Chevrolet was occupied by a 30-year-old female driver and the 5-year-old male passenger. A 1998 Oldsmobile Aurora and a 2003 Ford Explorer were also involved in this crash. The Ford and the Oldsmobile were traveling in the opposite direction of the Chevrolet. During the pre-crash event, the Ford and the Oldsmobile were traveling adjacent to each other with the Oldsmobile traveling over the centerline of the lane roadway. The front of the Oldsmobile impacted the front of the Chevrolet resulting in severe damage. As a result of the crash, the frontal air bags deployed in the Chevrolet. The driver of the Chevrolet sustained minor severity injuries and was transported to a hospital where she was treated. The 5-year-old male sustained a fractured clavicle and was transported to hospital where he was treated and released.

Figure 1. 2001 Chevrolet Malibu case vehicle.

This crash was identified by the Calspan Special Crash Investigations Team (SCI) on October 9, 2008 through an Internet news search. Details of the crash were forwarded to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) on October 14, 2008. Due to the presence of the CRS, NHTSA assigned an on-site investigation to the Calspan SCI team on October 14, 2008. The vehicles and the CRS were located and cooperation was established with the police department and the tow yards to inspect the vehicles. The on-site investigation was conducted on October 15, 2008. Attempts to locate the driver for an interview were unsuccessful. The medical records were not obtained as the treating hospital refused to release the records.

SUMMARY

Crash Site

This three-vehicle crash occurred during the nighttime hours of October 2008. At the time of the crash, it was dark with artificial overhead street lighting. The weather was clear and the road surface was dry at the time of the crash. The crash occurred on a two-lane north/south roadway in an urban residential setting. The traffic lanes were separated by a double yellow centerline. At the crash site, the road continued over a bridge overpass that carried traffic over a series of railroad tracks. The grade of the northbound approach lanes measured positive 4 percent. The southbound approach grade measured positive 2 percent. The point of impact was located 9 meters (29.5 feet) south of the hillcrest within the northbound lane. The respective traffic lanes were bordered by 15 cm (6 in) concrete curbs and concrete sidewalks. A 1 meter (3 feet) tall concrete wall was located immediately outboard of the sidewalks. The speed limit in the area of the crash was 64 km/h (40 mph). **Figures 2 and 3** are northbound and southbound trajectory views along the roadway. The Scene Schematic is included as **Figure 15**.

Figure 2. Northbound trajectory view 60 m (197 ft) from the point of impact.

Figure 3. Southbound trajectory view 40 m (130 ft) from the point of impact.

Vehicle Data

2000 Chevrolet Malibu

The 2000 Chevrolet Malibu was identified by the Vehicle Identification Number (VIN): 1G1NE52J3Y6 (production number omitted). The 4-door sedan was manufactured in 03/00 and was a uni-body design powered by a 3.1-liter, V6 engine that was linked to a 4-speed automatic transmission. The service brakes consisted of front disc and rear drum with an Anti-lock Braking System (ABS). The digital odometer could not be read due to crash related damage to the vehicle's electrical system. The Chevrolet was equipped with OEM alloy wheels with Remington XT-120CTR tires on the left front and rear and a Cooper Lifeliner Touring SLE tire on the right front. All four tires were size P215/60R15. The vehicle manufacturer recommended front and rear cold tire pressure was 200 kPa (29 PSI) and 179 kPa (26 PSI), respectively. The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Damage
LF	221 kPa (32 PSI)	0 mm (0/32”)	None
LR	186 kPa (27 PSI)	6 mm (7/32”)	Rim bead abrasions
RF	Tire flat	2 mm (3/32”)	Cut sidewall
RR	159 kPa (23 PSI)	6 mm (7/32”)	None

The interior of the Chevrolet was equipped with front bucket seats with height adjustable head restraints. The driver’s head restraint was adjusted to the full-down position and the front right head restraint was adjusted to 4 cm (1.5 in) above full-down. The driver’s seat was adjusted to the mid-track position and was reclined 40 degrees aft of vertical at the time of the SCI inspection. The second row was configured with a left-side-wide 60/40 split bench seat with integrated head restraints for the outboard positions.

1997 Oldsmobile Aurora

The 1997 Oldsmobile Aurora was designed as a four-door sedan and identified by the VIN: 1G3GR62CXV4 (production number omitted). The front-wheel drive vehicle was equipped with a 4.0-liter V8 engine linked to a 4-speed automatic transmission. The Oldsmobile was equipped with Wanli S-1088 tires, size 245/35ZR20 with after market rims. The manufacturer recommended tire size was P235/60R16 inflated to a cold pressure of 207 kPa (30 PSI) for the front and rear. The tire information at the time of the SCI inspection is detailed in the following table:

Tire	Measured Pressure	Tread Depth	Damage
LF	234 kPa (34 PSI)	6 mm (7/32”)	None
LR	248 kPa (36 PSI)	3 mm (4/32”)	None
RF	Tire Flat	6 mm (7/32”)	Rim deformed
RR	110 kPa (16 PSI)	6 mm (8/32”)	None

2003 Ford Explorer

The 2003 Ford Explorer was designed as a body-on-frame sport utility vehicle and was identified by the VIN: 1FMZU73K33U (production number omitted). The 4-wheel drive vehicle was equipped with 4.0-liter, V6 engine linked to an automatic transmission. The Ford was equipped with Uniroyal Laredo tires, size P235/70R16. The manufacturer recommended cold tire pressure was 207 kPa (30 PSI) for the front and 241 kPa (35 PSI) for the rear. The tire data is detailed in the following table:

Tire	Measured Pressure	Tread Depth	Damage
LF	255 kPa (37 PSI)	9 mm (11/32”)	Rim bead abrasions
LR	Tire flat	8 mm (10/32”)	Fractured rim bead
RF	234 kPa (34 PSI)	9 mm (11/32”)	Cut side wall and minor rim bead abrasions
RR	Tire flat	8 mm (10/32”)	Fractured rim

Crash Sequence

Pre-Crash

The 2000 Chevrolet Malibu was northbound driven by the 30-year-old female with the 5-year-old male in the backless booster CRS in the second row right position. The child was restrained by the vehicle's safety belt system. The 2003 Ford Explorer was southbound followed by the 1998 Oldsmobile Aurora. The Ford Explorer was driven by a 46-year-old male. The Oldsmobile was driven by a 35-year-old male. These vehicles were ascending the southbound grade onto the bridge. The Oldsmobile crossed the centerline into the northbound lane and was in the process of passing the Ford as the vehicles approached the hillcrest. There was no pre-crash physical evidence to support avoidance by the drivers of the vehicles.

Crash

The front plane of the Oldsmobile struck the front plane of the Chevrolet in an off-set right head-on configuration (Event 1). **Figure 4** is a view of the area of impact from the northbound approach of the Chevrolet. Both vehicles experienced impact forces of 12 o'clock. The force of the impact caused the deployment of the frontal air bag systems in both vehicles. The southbound momentum of the Oldsmobile stopped and reversed the direction of the northbound Chevrolet.

Figure 4. Point of impact from the Chevrolet's northbound approach.

The Damage Algorithm of the WinSMASH program was used to calculate the severity (delta-V) of the crash. The total calculated delta-V of the Chevrolet was 58 km/h (36.0 mph). The longitudinal and lateral components of the delta-V were -57 km/h (-35.4 mph) and -10 km/h (-6.2 mph), respectively. The total calculated delta-V of the Oldsmobile was 50 km/h (31.1 mph). The longitudinal and lateral components of its delta-V were -49 km/h (-30.4 mph) and 9 km/h (5.6 mph), respectively.

The road evidence at the scene indicated that the vehicles rotated counterclockwise (CCW) post-crash as they separated. As the Oldsmobile began its CCW rotation, its rear right quarter panel contacted the left fender and front door of the Ford (Event 2) resulting in minor body panel deformation. The Ford continued its northbound travel and its left rear door and tire contacted the left plane of the Chevrolet (Event 3). This contact was evidenced by scuffing to the body panels of the Malibu.

The Ford slid approximately 36 meters (118 feet) to the southeast and rotated CCW approximately 100 degrees. The vehicle mounted the east sidewalk and impacted the concrete bridge wall with its front plane (Event 4). The Ford's right rear wheel rim impacted the curb and fractured the rim bead (Event 5). The Explorer separated from the

wall and slid an additional 25 meters (82 feet) to final rest on the east sidewalk facing north.

After the secondary contact with the Ford, the Chevrolet and Oldsmobile separated and continued to rotate CCW. The Oldsmobile rotated approximately 165 degrees CCW and came to rest facing northeast, straddling the centerline of the road. A 4 meter (13 feet) long tire mark attributed to the Oldsmobile defined the vehicle's southwest trajectory. The final rest of the vehicle was 15 meters (49 feet) south of the initial impact.

The Chevrolet came to rest facing southeast 55 meters (180 feet) south of the initial impact at the east curb line. During its post-impact travel, the Chevrolet rotated approximately 190 degrees CCW. A 35 meter (115 feet) long fluid trail defined the trajectory of the Chevrolet as it slid to final rest **(Figure 5)**. The trail began at the roadway centerline and was directed to the southeast.

Figure 5. Fluid trail depicting the Chevrolet's travel to final rest.

Post-Crash

The police and ambulance personnel responded to the scene. The driver and child passenger were removed from the Chevrolet. The driver of the Chevrolet sustained minor severity injuries and was transported to a hospital where she was treated. The 5-year-old male sustained a fractured clavicle and was transported to the hospital where he was treated and released.

Vehicle Damage

Exterior Damage – 2000 Chevrolet Malibu

The 2000 Chevrolet Malibu sustained severe frontal damage as a result of the head-on impact with the Oldsmobile **(Figure 6 and 7)**. The damage from this impact consisted of longitudinal deformation of the frontal structure that involved the following components: bumper fascia, bumper beam, upper and lower radiator supports, frame members, hood, and the right fender. The damage was slightly off-set to the right resulting in 66 cm (26 in) of compression to the right wheelbase. The direct contact damage began 30 cm (12 in) left of the centerline and extended 76 cm (30 in) to the right bumper corner. The maximum crush was located 13 cm (5 in) inboard of the right bumper corner and measured 111 cm (43.7 in) in depth. Six equidistant crush measurements were documented along the bumper beam and were as follows: C1 = 4 cm (1.6 in), C2 = 25 cm (9.8 in), C3 = 45 cm (17.7 in), C4 = 97 cm (38.2 in), C5 = 111 cm (43.7 in), C6 = 110 cm (43.3 in). The Collision Deformation Classification (CDC) for the impact with the Oldsmobile was 12-FDEW-5.

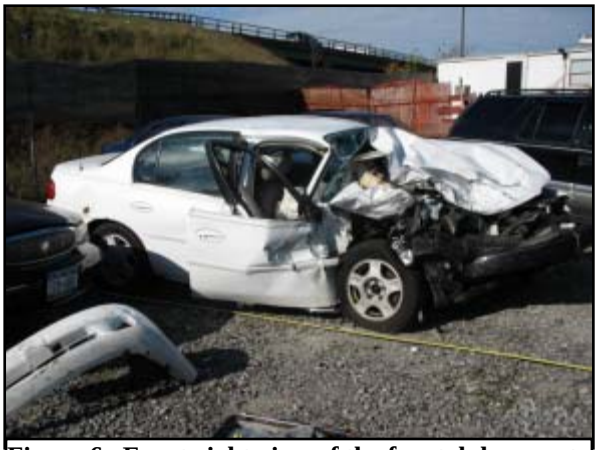

Figure 6. Front right view of the frontal damage to the Chevrolet .

Figure 7. Overall view of the Chevrolet's frontal crush profile.

The Chevrolet sustained minor damage to the left plane from the secondary impact with the Ford **(Figure 8)**. This impact consisted of abrasions to the left fender and doors and minor lateral deformation to the fender and left front door. The direct contact damage which contained rubber transfers from the left rear tire of the Ford measured 252 cm (9.2 in) beginning on the center of the left rear rim and extended forward. The direct contact had a maximum height of 83 cm (32.7 in). The maximum crush measured 6 cm (2.3 in) and was located at the rear aspect of the left fender. The CDC assigned to this impact was 12-LDES-1.

Figure 8. Left side damage to the Chevrolet from the impact with the Ford.

All four doors remained closed during the crash. Post-crash, the left side doors were operational and the right side doors were jammed in the closed position. The windshield was fractured and the right front door glazing was disintegrated during the crash. The remainder of the side glazing and the backlight were not damaged.

Interior Damage – 2000 Chevrolet Malibu

The interior damage to the Chevrolet consisted of intrusion and occupant contact. The complete profile of intruded components identified during the SCI vehicle inspection are listed in the following table:

Position	Component	Magnitude	Direction
Front left	Toe pan	16 cm (6.3 in)	Longitudinal
Front center	Instrument panel	20 cm (7.9 in)	Longitudinal
Front right	Instrument panel	43 cm (16.9 in)	Longitudinal

Position	Component	Magnitude	Direction
Front right	Toe pan	63 cm (24.8 in)	Longitudinal
Front right	A-pillar	53 cm (20.9 in)	Longitudinal
Front right	Roof	Approx. 4 cm (1.5 in)	Vertical

Figure 9. Occupant contact to the rear of right front seat back.

Several discernable occupant contact points were identified during the SCI vehicle inspection. The unbelted female driver of the Chevrolet was displaced forward during the impact. She loaded the steering wheel, knee bolster, and center instrument panel. The driver's right knee contacted and deformed the knee bolster. This deformation was located 15 cm (6 in) right of the centerline of the steering column. Her abdomen contacted and deformed the steering wheel rim. As the driver loaded the steering wheel rim, the steering column rotated upward to a post-crash angle of 45 degrees. A possible contact point was noted to the center stack mounted radio, evidenced by the dislodged power button. The restrained 5-year-old male was also displaced in a forward direction. During his forward motion, his right foot contacted the rear aspect of the front right seat back **(Figure 9)**. This contact was evidenced by deformation of the seat back over an area that measured 13 cm (5 in) in height and 9 cm (3.5 in) in width. Although not considered an occupant contact point, the child passenger loaded the CRS which resulted in loading marks to the vehicle's seat cushion from the CRS.

Exterior Damage – 1997 Oldsmobile Aurora

Figure 10. Resultant damage to the front of the Oldsmobile.

The 1997 Oldsmobile Aurora sustained severe damage as a result of the collision with the Chevrolet **(Figure 10)**. The direct contact damage extended across the 142 cm (56 in) wide bumper fascia. The bumper beam was separated from its mounting points; therefore the crush documentation was obtained at the upper radiator support. The maximum crush was located 19 cm (7.5 in) inboard of the right end of the upper radiator support and was 83 cm (32.7 in) in depth. The crush profile along this component was as follows: C1 = 18 cm (7.1 in), C2 = 31 cm (12.2

in), C3 = 64 cm (25.2 in), C4 = 79 cm (31.1 in), C5 = 83 cm (32.7 in), C6 = 79 cm (31.1 in). The CDC for the impact with the Chevrolet was 12-FDEW-3.

The Oldsmobile sustained minor damage to the right rear corner from the impact with the Ford. The damage from this event consisted of the right rear taillight being displaced from its mounting points and slight buckling of the bumper fascia at the right aspect. The direct contact damage began at the rear right corner and extended inboard approximately 30 cm (11.8 in). The CDC for this impact was 06-BREE-1.

Exterior Damage – 2003 Ford Explorer

The 2003 Ford Explorer sustained moderate damage to the front and left side planes from this multiple event crash. The second event in this crash sequence consisted of the left plane of the Ford impacting the rear right aspect of the Oldsmobile. This impact resulted in sideswipe-type damage to the left fender and left front door areas on the Ford. The direct contact damage was 59 cm (23.2 in) in length and began 58 cm (23 in) rear of the left front axle. The direct contact damage extended to 117 cm (46 in) rear of the referenced point. Minor lateral deformation of approximately 4 cm (1.5 in) in depth occurred during this event. In addition to the deformation, the side view mirror was fractured and separated from its mount. The resultant CDC for this impact was 12-LYES-1.

Figure 11. Overall view of the left side damage.

During the third event of this crash, the left center and rear aspects of the Ford sideswiped the left side of the Chevrolet. The direct contact damage for this impact began on the rear portion of the left rear door 157 cm (62 in) rear of the left front axle and extended onto the left quarter panel 333 cm (131 in) rear of the left axle. The direct contact damage included longitudinally oriented abrasions, slight lateral deformation, and fracturing of the left rear rim bead with subsequent airing out of the tire. A crush profile was documented for this sideswipe-type impact. A CDC of 12-LDES-1 was assigned to this event. **Figure 11** is an overall view of the left plane depicting the damage from the impacts with the Chevrolet and the Oldsmobile.

The Ford departed the roadside where it impacted a concrete wall (Event 4). This event resulted in moderate damage to the front of the Ford **(Figure 12)**. The direct contact damage measured 100 cm (39.3 in) in width and began 19 cm (7.3 in) left of the centerline and

Figure 12. Frontal damage from the wall impact.

extended 81 cm (32 in) to the right corner. Longitudinal deformation was present at the bumper beam was documented at six points along the bumper beam. The maximum deformation occurred 22 cm (8.7 in) inboard of the right corner and measured 17 cm (6.7 in). The six crush measurements were as follows: C1 = 0 cm, C2 = 0 cm, C3 = 0 cm, C4 = 9 cm (3.5 in), C5 = 17 cm (6.7 in), C6 = 9 cm (3.5 in). The CDC for this frontal impact was 12-FDEW-1.

The right rear tire and wheel of the Ford impact a curb as it traveled to final rest (Event 5). The damage from this impact resulted in fracturing of the right rear rim bead and airing out of the tire. The CDC for this tire impact was 02-RBWN-1.

Frontal Air Bag System – 2000 Chevrolet Malibu

The Chevrolet was equipped with a redesigned frontal air bag system that deployed during the crash.

The driver's air bag was housed within the steering wheel and was concealed by two I-configuration cover flaps. The cover flaps were symmetrical measuring 14 cm (5.4 in) in height and 8 cm (3 in) in width. The air bag was 62 cm (24.5 in) in diameter in its deflated state and had a maximum excursion of 28 cm (11.3 in). The air bag was free of occupant contact and damage. A 9 cm (3.5 in) vinyl expansion transfer was present on the face of the air bag at the 7 o'clock position.

The front right air bag deployed from a top mount module in the instrument panel. The air bag module contained a single cover flap that was 14 cm (5.5 in) in height and 32 cm (12.5 in) in width. The deflated air bag measured 69 cm (27 in) in height and 46 cm (18 in) in width. There was no damage or occupant contact points to the air bag; however, there were several spots of body fluid scattered throughout the air bag.

Event Data Recorder – 2000 Chevrolet Malibu

The 2000 Chevrolet Malibu was equipped with an Event Data Recorder (EDR). Permission to download the EDR was denied by the investigating police agency as the vehicles were impounded as evidence for criminal prosecution.

Manual Safety Belt Systems – 2000 Chevrolet Malibu

The Chevrolet was equipped with 3-point lap and shoulder belt systems for the four outboard seating positions and rear center lap belt. The outboard safety belts consisted of continuous loop webbing.

The driver's safety belt retracted onto an Emergency Locking Retractor (ELR) and was configured with a height adjustable D-ring which was in the full-up position. The driver did not use the safety belt in the crash which was supported by the lack of loading evidence on the belt webbing and the latch plate. The webbing contained two black-colored marks that appeared to have resulted from its positioning against the D-ring. Additionally, the buckle stalk was captured between the cushion and center console.

The front right safety belt retracted onto an ELR and was configured with a height adjustable D-ring which was in the full-up position. The front right belt system contained a light weight locking latch plate. This seating position was not occupied during the crash.

The second row outboard belt systems were equipped with ELR and locking latch plates. The rear right safety belt was used to restrain the 5-year-old male in a backless booster seat. During the crash, the child passenger loaded the belt system resulting in two transfers of the lap and torso section. The transfer on the lap section measured 31 cm (12 in) in length and began 10 cm (4 in) above the stop button. The torso transfer began 71 cm (28 in) above the stop button and extended upward 32 cm (12.5 in).

The rear center belt system consisted of an adjustable length lap belt with a locking latch plate.

Child Restraint System – 2000 Chevrolet Malibu

The 5-year-old male was positioned in a Cosco/Dorel High Rise backless booster seat **(Figures 13 and 14)** and was restrained by the vehicle's lap and should belt system.

The CRS Model Number was 22-296-WAL and was manufactured on 02/11/2006. The CRS was embossed with an expiration date of 2012. It is unknown if the CRS was purchased new or if it was involved in any previous crashes. The CRS was constructed of a plastic shell and a cloth cushion. The CRS was designed to be used by children with a weight between 14-45 kg (30-100 lbs) and whose height is between 86-145 cm (34-57 in). Additionally, this CRS is intended to be used with a lap and shoulder belt system only.

In this crash, the backless booster seat was used to position the 5-year-old male passenger in the rear right of the vehicle. These types of booster seats are designed to raise the profile of the child passenger to correctly position the vehicle's safety belt across the child. Based on the loading evidence on the belt webbing, the lap and shoulder portions were snug against the child. There was no crash related damage to the safety seat; however, minor surface scratches were scattered throughout the shell of the seat.

Figure 13. Cosco backless booster seat.

Figure 14. Backless booster seat positioned in the right rear of the vehicle.

Occupant Demographics/Data – 2000 Chevrolet Malibu

Driver Demographics

Age/Sex:	30-year-old/Female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Mid-track position
Eyewear:	Unknown
Manual Safety Belt Usage:	None used
Usage Source:	Vehicle inspection
Egress from Vehicle:	Assisted by rescue personnel
Mode of Transport from Scene:	Ground ambulance
Type of Medical Treatment:	Unknown

Driver Injuries

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

Driver Kinematics

The unrestrained 30-year-old female driver of the Chevrolet was seated in the front left position with the seat track adjusted to a mid-track position.

At impact with the Oldsmobile, the frontal air bags deployed. The driver initiated a forward trajectory in response to the 12 o'clock direction of force. The unrestrained driver contacted the deployed air bag. Her loading force was transmitted through the air bag resulting in bending of the steering wheel rim. Her right knee contacted and deformed the knee bolster. The driver sustained police reported minor severity injuries and was transported to a local hospital for treatment.

Rear Right Child Passenger

Age/Sex:	5-year-old/Male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	N/A, fixed
Eyewear:	Unknown
Child Restraint Use:	3-point lap and shoulder belt with a backless booster seat
Usage Source:	Vehicle inspection
Egress from Vehicle:	Removed by first responders
Mode of Transport from Scene:	Ambulance to hospital
Type of Medical Treatment:	Treated and released

Rear Right Child Injuries

Injury	Injury Severity AIS90/Update 98	Injury Source
Right clavicle fracture, NFS	Moderate (752200.2,1)	Safety belt loading
Complaint of neck pain, NFS	Not coded under AIS rules	Crash force

Source = Police report

Rear Right Child Kinematics

The 5-year-old male was seated on a backless booster seat and was restrained by the vehicle's 3-point lap and shoulder safety belt in the rear right position of the vehicle. At impact, the safety belt retractor locked and the child initiated a forward trajectory. He loaded the belt system with his torso and began to ride down the crash. His loading of the belt system was evidenced by the webbing abrasions and the loading marks to the vehicle's seat cushion from the booster seat. This loading resulted in a fracture of the right clavicle. The child's right leg flexed forward and his foot contacted the front right seat back evidenced by the aforementioned contact to this component. The child rebounded back into the seat and came to rest within the booster seat. He was transported to a local hospital where he was treated for the fractured clavicle and released.

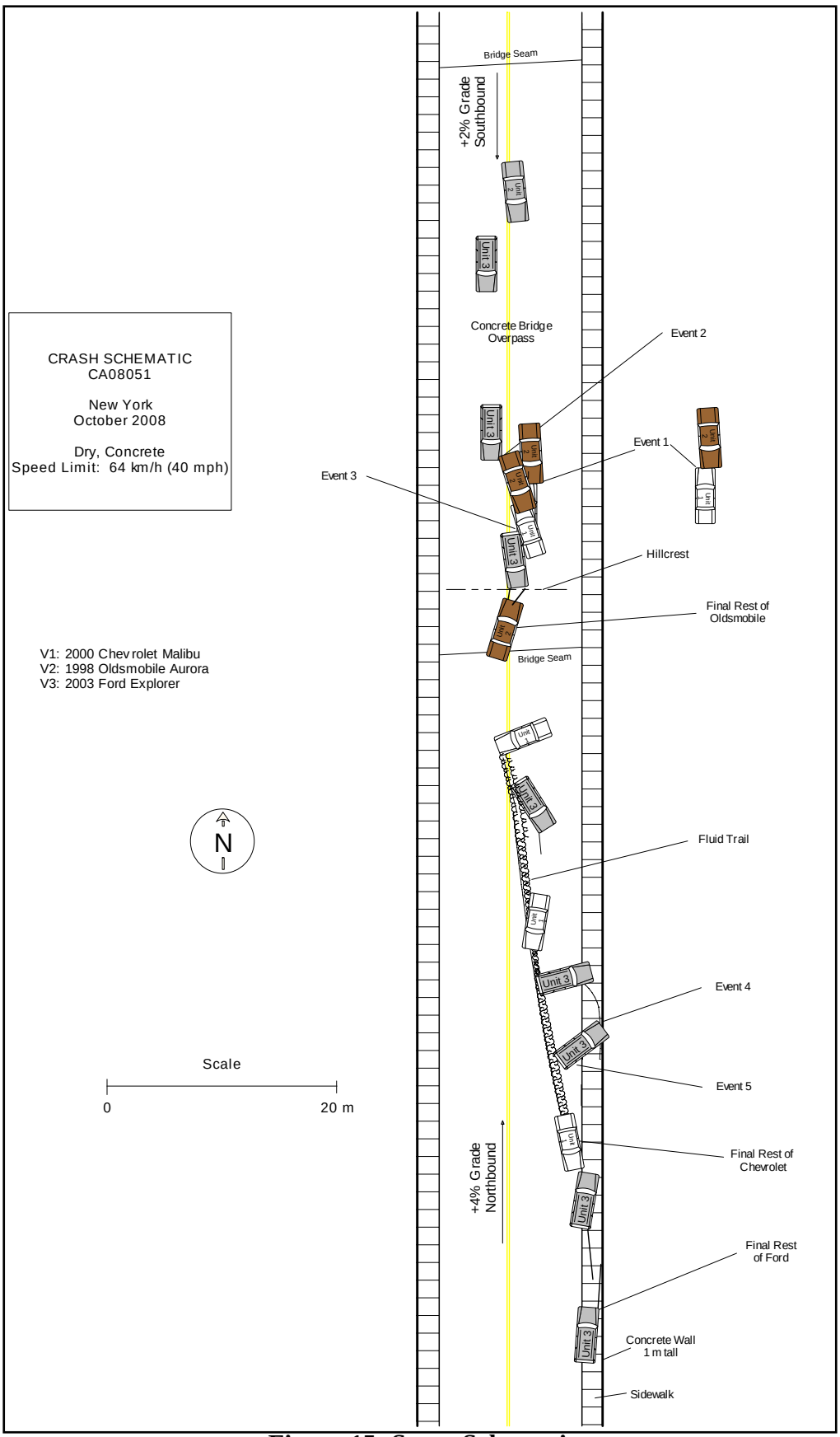

Figure 15: Scene Schematic