

**CRASH DATA RESEARCH CENTER**

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**CALSPAN ON-SITE CHILD SAFETY SEAT  
CRASH INVESTIGATION**

**CASE NO: CA06-027**

**VEHICLE: 1998 CHEVROLET LUMINA**

**LOCATION: NEW JERSEY**

**CRASH DATE: OCTOBER 2006**

Contract No. DTNH22-01-C-17002

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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 investigation focused on the performance of a Graco CarGo booster Child Safety Seat (CSS) that was present in a 1998 Chevrolet Lumina four-door sedan. The vehicle was occupied by a restrained 20-year old female driver and a 4-year old female seated in the booster CSS in the right rear seating position. The child was restrained within the CSS by the vehicle's manual lap and shoulder restraint. The Chevrolet was equipped with redesigned frontal air bags for the driver and front right passenger position, which deployed during the crash. The Lumina was involved in a multiple frontal impact sequence with the back of a 2005 Toyota 4-Runner and a light standard. The driver of the Lumina was traveling southbound on a three-lane roadway approaching a controlled intersection. The driver claimed that her contact lens became dislodged from her eye and as she attempted to reapply the lens, her vehicle impacted the back of the stopped Toyota. The Toyota was displaced forward into a 1999 Plymouth Voyager which was stopped in front of the Toyota at the signal. After the initial impact, the Lumina traveled across the intersection and exited the roadway at the southwest corner. The Lumina impacted the light standard with its frontal plane. The driver of the Lumina sustained multiple soft tissue injuries and was transported to a local hospital by ambulance for treatment and then released. The 4-year old child impacted the front seat back and sustained a frontal skull fracture, a fracture to her left orbital floor, a trochlear nerve contusion, a closed head injury with loss of consciousness, and multiple soft tissue injuries. She was transported via helicopter to a regional trauma center and was admitted for seven days.</p>			
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**CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION**  
**CASE NO.: CA06-027**  
**VEHICLE: 1998 CHEVROLET LUMINA**  
**LOCATION: NEW JERSEY**  
**CRASH DATE: OCTOBER 2006**

**BACKGROUND**

This on-site investigation focused on the performance of a Graco CarGo booster Child Safety Seat (CSS) that was present in a 1998 Chevrolet Lumina four-door sedan (**Figure 1**). The vehicle was occupied by a restrained 20-year old female driver and a 4-year old female seated in the booster CSS in the right rear seating position. The child was restrained within the CSS by the vehicle's manual lap and shoulder restraint. The Chevrolet was equipped with redesigned frontal air bags for the driver and front right passenger position, which



**Figure 1 - Subject Vehicle - 1998 Chevrolet Lumina**

deployed during the crash. The Lumina was involved in a multiple frontal impact sequence with the back of a 2005 Toyota 4-Runner and a light standard. The driver of the Lumina was traveling southbound on a three-lane roadway approaching a controlled intersection. The driver claimed that her contact lens became dislodged from her eye and as she attempted to reapply the lens, her vehicle impacted the back of the stopped Toyota. The Toyota was displaced forward into a 1999 Plymouth Voyager which was stopped in front of the Toyota at the signal. After the initial impact, the Lumina traveled across the intersection and exited the roadway at the southwest corner. The Lumina impacted the light standard with its frontal plane. The driver of the Lumina sustained multiple soft tissue injuries and was transported to a local hospital by ambulance for treatment and then released. The 4-year old child impacted the front seat back and sustained a frontal skull fracture, a fracture to her left orbital floor, a trochlear nerve contusion, a closed head injury with loss of consciousness, and multiple soft tissue injuries. She was transported via helicopter to a regional trauma center and was admitted for seven days.

The crash was identified by the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) through an Internet news article. The article was forwarded to the Calspan SCI team who located the vehicles and established cooperation with the investigating police agency. The case was assigned on October 26<sup>th</sup> for an on-site investigation. The vehicle was located at a secured impound facility with the CSS confirmed as still being inside the vehicle. The investigating police agency contacted the facility allowing the release of the vehicle for the SCI inspection that was conducted on October 31, 2006.

## SUMMARY

### *Crash Site*

This three vehicle crash occurred on a well traveled level three-lane urban roadway at the mouth of an active four-leg intersection in October 2006. The north/south roadway was configured with one lane in each direction and transitioned to three lanes 40.4 m (133') prior to the intersection to accommodate a center left-turn lane. The lanes were delineated by a double yellow painted centerline. The east/west roadway was configured with two lanes in each direction. At the time of the crash, the asphalt roadway was dry and level and there were no adverse weather conditions. Concrete curbs that were 10 cm (4") in height enclosed the roadway and the roadside environment consisted of multiple businesses and private dwellings in a setting that was mostly developed. The posted speed limit for north/south traffic was 64 km/h (40 mph). The SCI scene schematic is included as **Figure 9** at the end of this narrative report.

### *Vehicle Data*

#### *1998 Chevrolet Lumina*

The 1998 Chevrolet Lumina was a four-door sedan and was identified by the Vehicle Identification Number (VIN): 2G1WL52M4W9 (production number omitted). The vehicle's mileage was 63,676 km (102,475 miles). The total GVWR was 2,004 kg (4,419 lb) with 1,105 kg (2,437 lb) distributed to the front axle and 899 kg (1,982 lb) distributed to the rear axle. The front wheel drive vehicle was equipped with a six-cylinder, 3.1-liter engine linked to a four-speed automatic transmission with a column mounted transmission selector. The vehicle was also equipped with four-wheel disc brakes with anti-lock, power windows, and tilt steering. The vehicle was configured with 38 cm (15") steel wheels and Kumho 795 Touring A/S P220/75R15 tires. The manufacturer's recommended tire pressure was 221 kPa (32 PSI). The specific tire information was as follows:

<b>Position</b>	<b>Tire Pressure</b>	<b>Tread Depth</b>	<b>Damage</b>
LF	165 kPa (24 PSI)	4 mm (5/32")	None
RF	165 kPa (24 PSI)	4 mm (5/32")	None
LR	179 kPa (26 PSI)	7 mm (9/32")	None
RR	152 kPa (22 PSI)	6 mm (8/32")	None

The 1998 Chevrolet Lumina was configured with a 60/40 split-bench seat (driver side wide) with separate back cushions for the outboard front seating positions. The seats were equipped with adjustable head restraints both of which were in the full-down position. The left front seat ran along a 23 cm (9") seat track and was adjusted to a track position 10 cm (4") forward of full rear. The horizontal distance between the middle of the seatback and the steering wheel hub was 62 cm (24.5"). The second row consisted of a fixed bench seat with no head restraints.

#### *2005 Toyota 4-Runner*

The 2005 Toyota 4-Runner was a four-door sport utility vehicle (SUV) and was identified by the VIN: JTEEP21A750 (production number omitted). The four-wheel drive vehicle was powered by a six-cylinder, 3.3-liter engine and was equipped with an

anti-lock braking system. The Toyota was driven from the crash scene and was not inspected. Further information regarding this vehicle was unknown.

### ***1999 Plymouth Voyager Minivan***

The 1999 Plymouth Voyager Minivan was identified by the VIN: 2P4FP25BXXR (production number omitted). The vehicle was powered by a four-cylinder, 2.4-liter engine linked to an automatic transmission. The Plymouth did not contact the subject vehicle and was driven from the crash scene. This vehicle could not be located during the on-site SCI investigation.

### ***Crash Sequence***

#### ***Pre-Crash***

The 20-year old female driver of the Chevrolet Lumina was traveling in a southerly direction on the two-lane north/south roadway and was approaching stopped traffic at a signalized four-leg intersection (**Figure 2**). The Plymouth Voyager was stopped at the intersection in the left turn lane with the Toyota 4-Runner directly behind. As the Chevrolet approached the intersection, the driver's contact lens became dislodged from her eye and the driver attempted to reapply the lens. A witness who was traveling behind the Chevrolet contended that the vehicle proceeded to the initial impact without initiating any avoidance measures.

#### ***Crash***

The full frontal plane of the Chevrolet impacted the back plane of the Toyota in the southbound left turn lane. The force of the impact deployed the frontal air bags of the Chevrolet. The Toyota was subsequently displaced forward into the back of the Plymouth Voyager. The Chevrolet separated from the impact with the Toyota by moving forward and to the right and traveled through the intersection a distance of approximately 45 m (150') before departing the roadway at the southwest quadrant of the intersection. The Chevrolet mounted the curb and traveled an additional 3.3 m (10.8') before the vehicle impacted the light standard located outboard of the southwest corner (**Figure 3**).

Both impacts involved the frontal plane which resulted in a combined crush profile. The combined crush profiles of the two impacts were used to generate a barrier algorithm of the WinSMASH program. The program computed a total delta-V of 43 km/h (26.7 mph). The specific longitudinal and lateral velocity



**Figure 2 – Southbound approach of Chevrolet.**



**Figure 3 - Impacted light standard.**

changes were -43 km/h (-26.7 mph) and 0 km/h, respectively. These results are not representative of the crash severity for a single event due to the overlapping damage.

The impacted light standard was mounted on a 22 cm (8.5") concrete base. The Chevrolet had a bumper clearance of 40 cm (15.5"); therefore it is improbable that the front plane of the vehicle contacted the concrete base. The vehicle's undercarriage did engage the base of the light standard evidenced by black transfers on the concrete base. The vehicle came to final rest against the light standard.

### ***Post-Crash***

The driver exited the vehicle unassisted through the front left door. A passerby assisted the driver in the removal of the 4-year old child from the right rear position. The passerby unlatched the child's safety belt and the driver lifted the child from the CSS. Emergency personnel transported the driver by ambulance to a local hospital where she was treated for soft tissue injuries and released. The child was transported by air to a regional trauma center with multiple injuries. The child was admitted to the facility for seven days. The Chevrolet Lumina was towed from the scene due to damage. The Toyota 4-Runner and Plymouth Voyager were driven from the scene by their respective operators.

### ***Vehicle Damage***

#### ***Exterior Damage – 1998 Chevrolet Lumina***

The 1998 Chevrolet Lumina sustained moderate damage as a result of the impact with the Toyota 4-Runner and the light standard (**Figure 4**). One crush profile was generated for the two events due to overlapping damage. An analysis of the damage pattern reveals that the majority of the crush was caused by the impact with the Toyota due in part to the uniformity of the damage across the full width of the hood. Isolating this damage, the SCI inspection revealed that the direct contact damage and induced damage encompassed the width of the bumper beam and measured 109 cm (43") in width. The maximum crush was located 4 cm (1.6") right of the vehicle's centerline and measured 64 cm (25") in depth. The crush profile consisted of six equidistant crush measurements taken along the bumper beam and was as follows: C1 = 10 cm (3.9"), C2 = 42 cm (16.5"), C3 = 59 cm (23.2"), C4 = 64 cm (25"), C5 = 36 cm (14.2"), C6 = 11 cm (4.3"). The estimated Collision Deformation Classification (CDC) for the impact with the Toyota was 12-FDEW-2.



**Figure 4 - Damaged 1998 Chevrolet Lumina.**

The direct damage for the impact with the light standard began 3 cm (1") right of the vehicle's centerline and measured 34 cm (13.5") in width. The CDC for this impact was 12-FCEN-2.



### ***Interior Damage - 1998 Chevrolet Lumina***

The 1998 Chevrolet Lumina sustained minor interior damage as a result of occupant contact. The contact was confined to the front left knee bolster and was in the form of three fractures to the rigid plastic knee bolster covering (**Figure 5**). The first fracture was located 14 cm (5.5") inboard of the left aspect of the instrument panel and 3 cm (1") below the top of the knee bolster. The vertical fracture was 8 cm (3") in length top to bottom. The fracture had associative blue jean fabric transfers embedded into the crack that resulted from the loading of the driver's left knee. The second fracture was located 20 cm (8") inboard of the left aspect of the instrument panel and was vertically located on the mid-seam separating the instrument panel from the knee bolster covering. The second fracture was 1 cm (0.5") in length and probably resulted from the deformation of the plastic panel during the knee contacts. The third fracture was located 38 cm (15") inboard of the left aspect of the knee bolster and directly underneath the base of the steering column. This vertical fracture was 3 cm (1.25") in length and probably resulted from the loading of the driver's right knee. The underlying energy absorption material was deformed as a result of the first and third panel fractures.



**Figure 5 - Damaged knee bolster.**

The right aspect of the windshield was also extensively fractured during the crash sequence. The fractures were caused by a combination of contact by the front right passenger's air bag cover flap, the expanding front right air bag, and the front right visor.

### ***Manual Restraints - 1998 Chevrolet Lumina***

The 1998 Chevrolet Lumina was equipped with 3-point lap and shoulder belts for the four outboard seating positions and fixed length lap belts for the front and rear center positions. The driver's belt was configured with a sliding latch plate, an Emergency Locking Retractor (ELR) and an adjustable D-ring that was at the mid-position. The front right lap and shoulder belt was configured with a sliding latch plate, an ELR/Automatic Locking Retractor (ALR) which was in the ELR mode, and an adjustable D-ring. The rear seat lap and shoulder belts were configured with sliding latch plates, fixed D-rings and ELR/ALR's which were in the ELR mode.

Loading evidence was present on the driver's belt webbing at two locations indicative of belt usage. Frictional abrasions were present 57 cm (22.5") above the anchor point and were 8 cm (3") in length. Additional abrasions were located 86 – 97 cm (34 – 38") above the anchor point on the shoulder belt webbing.

The right rear restraint exhibited loading evidence in the form of abrasions in three separate locations. The first was located 74 – 97 cm (29 – 38") above the anchor point on the inboard aspect of the webbing. The second area began 107 cm (38") above the anchor point and extended upward on the outboard aspect of the webbing 56 cm (22"). The last area of abrasions was on the inboard aspect of the webbing and was located 114

cm (45") above the anchor point and extending upwards 15 cm (6"). Associative evidence in the form of a 10 cm (4") frictional abrasion was located on the upper right aspect of the right rear seat back caused by friction between the locking belt system and the fixed seat back.

### ***Redesigned Frontal Air Bag System - 1998 Chevrolet Lumina***

The 1998 Chevrolet Lumina was equipped with redesigned frontal air bags for the driver and front right passenger. The driver's air bag was housed in the center of the steering wheel hub and deployed through symmetrical I-configuration cover flaps. The cover flaps measured 10 cm (4") horizontally and 11 cm (4.5") vertically. The driver's air bag (**Figure 6**) measured 67 cm (26.5") in diameter in its deflated state. The air bag was not tethered and had a total excursion of 48 cm (19"). The air bag was vented by two circular ports located in the 3 and 9 o'clock positions on the back aspect the bag. There was no discernable contact evidence on the driver's air bag.

The front right air bag (**Figure 7**) deployed from a top-mount module configured with a single rectangular cover flap that was tethered at the top aspect. The cover flap measured 40 cm (15.5") horizontally and 25 cm (10") vertically and had an excursion of 23 cm (9"). The front right air bag measured 69 cm (27") horizontally and 51 cm (20") vertically in its deflated state. The bag was vented by two circular ports located in the 10 and 2 o'clock sectors of the back aspect of the bag and was tethered by two 6 cm (2.5") straps. Shards of glass were present on the membrane of the air bag due to contact with the windshield.



### ***Child Safety Seat Graco CarGo***

A Graco CarGo CSS (**Figure 8**) was installed forward-facing in the rear right position of the 1998 Chevrolet Lumina. The CSS was present inside the vehicle at that location during the SCI inspection. The model number of the CSS was 8481SVD and the date of manufacture was 03/03/2004. The CSS was rated for children between 14 and 45 kg (30 –



100 lb) in weight and within 89 and 137” (35 – 54”) in height and whose ears are below the top of the booster seat. The subject child weighed 20 kg (44 lb) which was within the range of usage of this product; however, the driver was uncertain of the child’s height and ear location with respect to the back of the CSS.

The high back booster CSS was configured with a shoulder belt positioner on the upper aspect of the CSS seat back. During the SCI interview, the driver stated that the positioner was used to fasten the belt in place. The CSS was purchased new by the driver who also installed it into the vehicle.

***Occupant Demographics***

***Driver***

Age/Sex: 20-year old/Female  
 Height: 175 cm (69”)  
 Weight: 73 kg (160 lb)  
 Seat Track Position: Mid-track  
 Manual Restraint Use: Manual 3-point lap and shoulder belt  
 Usage Source: Vehicle inspection  
 Eyewear: Contact lenses  
 Type of Medical Treatment: Transported by ambulance to local hospital where she was treated and released

***Driver Injuries***

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Injury Source</b>
Left shoulder contusion and laceration*	Minor (790402.1,2) (790602.1,2)	Seat belt shoulder webbing
Right knee contusion* and abrasion	Minor (890402.1,1) (890202.1,1)	Knee bolster
Chest contusion, NFS	Minor (490402.1,9)	Seat belt shoulder webbing
Neck abrasion	Minor (390202.1,2)	Seat belt shoulder webbing

*Source: Medical records and driver interview (\*denotes interview).*

***Driver Kinematics***

The 20-year old driver was seated in a mid-track position in an upright posture and restrained by a 3-point lap and shoulder belt. At impact the driver initiated a forward trajectory responding to the 12 o’clock direction of force and loaded the seat belt. The air bag deployed during this event; however, the driver does not recall whether she contacted the expanding air bag. As the driver loaded the belt she sustained a minor contusion and laceration to the left shoulder above the collar bone. After the initial impact, the vehicle traversed the intersection and exited the roadway striking a light standard. Responding to the 12 o’clock direction of force for this second event, the driver’s right knee contacted and deformed the knee bolster resulting in a contusion to the driver’s right knee. The driver exited the vehicle under her own power and proceeded to attend to the 4-year old child in the rear seat. A passerby assisted the driver in the unlatching of the child’s lap

and shoulder belt and removal from the vehicle. The driver was transported to a local hospital by ambulance where she was treated and released for her injuries.

***Occupant Demographics***

***Rear Right Occupant***

Age/Sex: 4-year old/Female  
 Height: Unknown  
 Weight: 20 kg (44 lb)  
 Seat Track Position: Not adjustable  
 Manual Restraint Use: Forward facing high back booster CSS with manual lap and shoulder restraint  
 Usage Source: Vehicle inspection  
 Eyewear: None  
 Type of Medical Treatment: Transported by helicopter to regional trauma center where she was admitted for seven days

***Rear Right Occupant Injuries***

<b>Injury</b>	<b>Injury Severity (AIS 90/Update 98)</b>	<b>Injury Source</b>
Closed head injury with LOC, NFS	Serious (160802.3,0)	Front seatback
Vault fracture (non-displaced frontal skull fracture)	Moderate (150400.2,5)	Front seatback
Left orbital floor fracture	Moderate (251202.2,2)	Front seatback
Level IV trochlear nerve contusion (palsy)	Moderate (131002.2,1)	Front seatback
Abrasion to medial aspect of right ankle	Minor (890202.1,1)	Front seatback
Abrasions lateral to left eye orbit	Minor (290202.1,2)	Front seatback

*Source: Medical records.*

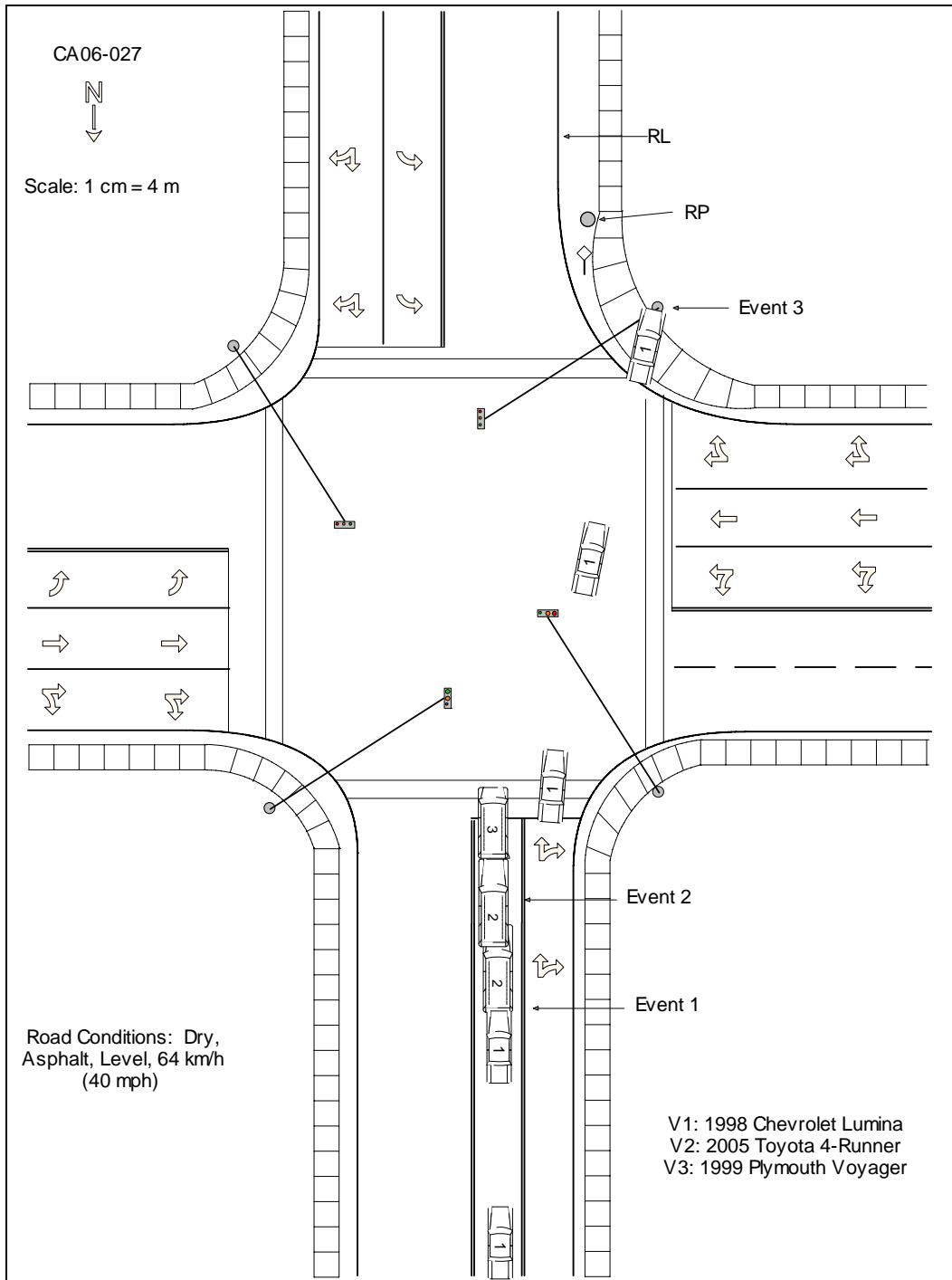
***Rear Right Occupant Kinematics***

The 4-year old occupant was seated in an upright posture within the high back booster CSS in the right rear position of the vehicle. It was probable that the shoulder belt was positioned off the right shoulder. The 3-point lap and shoulder belt exhibited extensive loading evidence as described in the ***Manual Restraints*** section of this report. The transfer evidence wasn't consistent with occupant loading; rather, the length and type of abrasions on the belt appeared to be consistent with loading of the CSS against the locked shoulder belt. Additionally, the absence of torso injuries to the child indicated that the belt was not securing the child into the CSS.

At impact with the 2005 Toyota 4-Runner, the child and the CSS initiated a forward trajectory responding to the 12 o'clock direction of force. It was probable that the child jackknifed the lap belt loaded the front right seatback with her face and head during the first impact, rebounded, and then possibly struck the seatback a second time when the

vehicle impacted the light standard with its frontal plane. The front right seat was positioned slightly rear of mid track. The horizontal measurement from the front right seatback to the seatback of the CSS was 58 cm (23"). The child sustained a frontal skull fracture, a left orbital floor fracture, a closed head injury with loss of consciousness, a level IV trochlear nerve contusion, and soft tissue injuries to the left side of her face and the medial aspect of her right ankle. There was no evidence of loading on the shell of the CSS and no discernable evidence that a component within the back seat of this vehicle attributed to the child's injuries. The driver was unable to provide the child's estimated height.

The child was removed from the vehicle by the driver and a passerby. Upon removal from the vehicle, the child was unconscious and did not respond to the driver's attempts to wake her. The child was transported to a regional trauma center by air and admitted for seven days for treatment.



**Figure 9 – Scene Schematic.**