On-Site Child Restraint System Investigation
Dynamic Science, Inc. (DSI), Case Number DS09036
2002 Nissan Xterra
Oregon
November 2009

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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 be 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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16. Abstract

This on-site child restraint system (CRS) investigation focused on the occupants and Infant Safety Seat (ISS) in a 2002 Nissan Xterra sport utility vehicle that was involved in a side impact crash. The vehicle was being driven by a restrained 21-year-old female. The front right seat of the Nissan was occupied by a restrained 55-year-old female and the second row left seat was occupied by a restrained 28-year-old female. The second row right seat was occupied by a 1-month-old female who was seated in the rear-facing ISS. The other vehicle was a 1979 GMC pickup that was being driven by a 75-year-old male. The crash occurred in the northbound lane of a state highway. The Nissan was traveling southbound and the GMC was traveling northbound. The driver of the Nissan lost control of the vehicle, initiated a counterclockwise rotation, and entered the northbound travel lane. The front of the GMC impacted the right side of the Nissan. The driver of the Nissan sustained moderate injuries and was transported to a local hospital where she was treated and released. The front right occupant was fatally injured. The second row left occupant sustained minor injuries and was transported to a local hospital where she was treated and released. The infant sustained serious chest and head injuries. She was transported by ambulance to a local hospital and was then airlifted to a local trauma center where she was hospitalized for seven days.

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Crash Investigation
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BACKGROUND

This on-site Child Restraint System (CRS) investigation focused on the occupants and Infant Safety Seat (ISS) in a 2002 Nissan Xterra sport utility vehicle that was involved in a side impact crash (**Figure 1**). The crash occurred in November 2009 at 1000 hours. The vehicle was being driven by a restrained 21-year-old female. The front right seat of the Nissan was occupied by a restrained 55-year-old female and the second row left seat was occupied by a restrained 28-year-old female. The second row right seat was occupied by a 1-month-old female who was seated in the rear-facing ISS. The ISS was anchored to the vehicle using the Lower Anchors and Tethers for Children (LATCH) hardware. The other vehicle was a 1979 GMC Sierra Grande pickup with a slide-in camper that was being driven by a 75-year-old male.

Figure 1. Subject vehicle, 2002 Nissan Xterra

The crash occurred in the northbound lane of a state highway. The Nissan was traveling southbound and the GMC was traveling northbound. The driver of the Nissan lost control of the vehicle, initiated a counterclockwise rotation, and entered the northbound travel lane. The front of the GMC impacted the right side of the Nissan. The Nissan was displaced rearward to the northeast and impacted a guardrail with its left side. The Nissan came to rest against the guardrail facing south and the GMC came to rest against the Nissan facing northeast.

The driver of the Nissan sustained moderate injuries and was transported to a local hospital where she was treated and released. The front right occupant was fatally injured. The second row left occupant sustained minor injuries and was transported to a local hospital where she was treated and released. The infant sustained serious chest and head injuries. She was transported by ambulance to a local hospital and was then airlifted to a local trauma center where she was hospitalized for seven days.

This CRS investigation was initiated by the National Highway Traffic Safety Administration (NHTSA) in response to a report of injuries to a child seated in a properly installed CRS. DSI was notified of the crash by a member of a Crash Injury Research Engineering Network (CIREN) located in the state of Washington. The CIREN staff member was notified of the crash by the state patrol. Both vehicles in the crash were inspected on November 18, 2009. Police investigators and members of the family were present during the inspections.

SUMMARY

Crash Site

The crash site was a north/south three-lane undivided state highway that was bordered on both sides by paved asphalt shoulders and metal guardrails (**Figure 2**). There were two southbound lanes that

were separated from the northbound lane by a solid/dashed yellow line. The roadway alignment was straight and there was a positive 6 percent grade in the southbound direction. The roadway composition was asphalt and it was snow-covered at the time of the crash. The posted speed limit was 89 km/h (55 mph).

Figure 2. Southbound approach, subject vehicle

Pre-Crash

The Nissan was traveling southbound in the inboard travel lane at a driver-stated speed of 97 km/h (60 mph). The GMC was traveling northbound.

Crash

The Nissan lost traction due to the snowy conditions, began a counterclockwise rotation, and entered the northbound travel lane. The front end of the GMC struck the right side of the Nissan (Event 1). The force of the impact caused the frontal air bags to deployed and seat belt pretensioners to actuate. For the Nissan, the Damage algorithm of the WinSMASH program computed a Total Delta-V of 48.0 km/h (29.8 mph). The longitudinal and lateral components were -30.9 km/h (-19.2 mph) and -36.8 km/h (-22.8 mph), respectively. For the GMC, the program computed a Total Delta-V of 39.0 km/h (24.2 mph). The longitudinal and lateral components were -38.4 km/h (-23.9 mph) and 6.8 km/h (4.2 mph), respectively. The slide-in camper in the rear of the GMC was displaced from the vehicle, rolled two quarter-turns, and came to rest on its roof in the northbound travel lane. The Nissan was displaced rearward to the northeast and impacted a guardrail with its left side (Event 2).

Post-Crash

The Nissan came to rest against the guardrail facing south and the GMC came to rest against the Nissan facing northeast (**Figure 3**). The Nissan's right side doors and left front door were jammed shut. The driver of the Nissan sustained moderate injuries and was reported to have been unconscious at the scene. She was extricated by emergency personnel and transported to a local hospital where she arrived with a Glasgow Coma Score (GCS) of 15. She was treated at the hospital and then released.

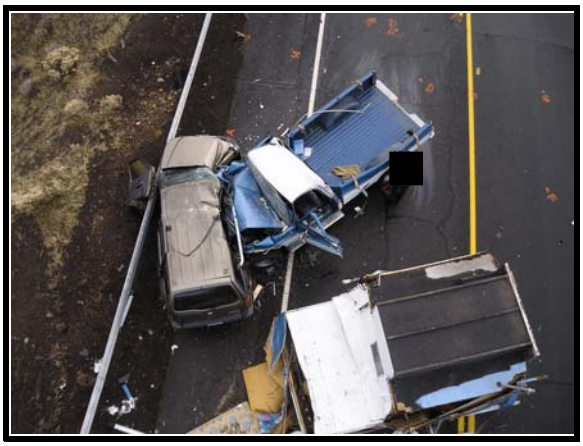

Figure 3. Final rest (police photo)

The front right occupant was declared deceased at the scene. The cause of death was reported by the state medical examiner as death due to multiple traumatic injuries.

The second row left occupant sustained minor chest injuries. She was able to exit the vehicle under her

own power through the left door and also removed the second row right occupant from the vehicle. She was transported to a local hospital where she was treated and released.

The second row right occupant sustained serious brain and chest injuries. She was transported to a local hospital by ground ambulance and arrived at the hospital with a GCS of 10 (eyes = 2, verbal = 2, motor = 6). She was examined and was then airlifted to a local trauma center where she was hospitalized for seven days. According to the interviewee, she has recovered completely from her injuries.

Both vehicles were transported from the scene due to damage and were placed into police custody.

Vehicle Data -2002 Nissan Xterra

The 2002 Nissan Xterra sport utility vehicle was identified by the Vehicle Identification (VIN): 5N1ED28Y32Cxxxxxx. The vehicle's date of manufacturer was August 2002. The vehicle was equipped with a 3.3-liter, 6-cylinder engine, automatic transmission, 4-wheel drive, front disc/rear drum brakes, 4-wheel anti-lock brakes, and tilt steering column functionality.

The vehicle manufacturer's recommended tire size was P265/70R16 for the front and rear; the recommended cold tire pressure was 207 kPa (30 psi). The vehicle was equipped with Futura Dakota H/T P265/70R16 tires, which had a tire manufacturer's recommended pressure of 241 kPa (35 psi). The specific tire information was as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	234 kPa (34 psi)	6 mm (8/32 in)	No	None
LR	241 kPa (35 psi)	5 mm (6/32 in)	No	None
RR	159 kPa (23 psi)	6 mm (8/32 in)	No	None
RF	Tire Flat	7 mm (9/32 in)	Yes	Holed, tread

The Nissan's interior was configured with seating for five occupants. The front row consisted of outboard bucket seats with adjustable head restraints. The second row consisted of a split bench with folding backs with integral head restraints for the outboard positions.

Vehicle Damage

Exterior Damage

The Nissan sustained moderate right side damage due to the impact with the front of the GMC (**Figure 4**). The direct damage began 31.0 cm (12.2 in) forward of the rear axle and extended forward 240.0 cm (94.4 in). The Field L began 13.0 cm (5.1 in) aft of the rear axle and extended forward 314.0 cm (123.6 in). Six crush measurements were documented at the mid-door level: C_1 = 0 cm, C_2 = 32.0 cm (12.6 in), C_3 = 46.0 cm (18.1 in), C_4 = 32.0 cm (12.6 in), C_5 = 40.0 cm (15.7 in), C_6 = 0 cm. The maximum crush was located 85.0 cm (33.4 in) forward of the rear axle and measured 69.0 cm (27.1in). The height of the maximum crush was 74.0 cm (29.1 in) and the Door Sill Differential (DSD) was 26.0 cm (10.2 in). The Collision Deformation Classification (CDC) for the right side impact was 02RZAW3.

Figure 4. Right side damage, subject vehicle

The vehicle sustained minor left side damage due to the impact with the guardrail (**Figure 5**). The direct damage began at the front left bumper corner and extended rearward 84.0 cm (33.0 in) along the bumper fascia and including light contact to the wheel hub. The maximum crush was located at the left bumper corner and measured 3.0 cm (1.2 in). The CDC for the guardrail impact was 07LFES1. There was also damage to the side panel near the left A-pillar that was probably a result of extrication efforts.

Figure 5. Left front damage

Interior Damage

The Nissan sustained moderate interior damage from intrusion and occupant contacts (**Figures 6-7**). Contacts and loading were documented to front row right door, center console, second row right door, driver's seat belt webbing, and the right instrument panel. There was lateral intrusion of the right doors, right A-pillar, right sill, right B-pillar, center console, right roof rail, front seat back, and right C-pillar; there was longitudinal intrusion of the right and center instrument panel. Both right side doors were jammed shut. The left front door was reported by the police to have been jammed shut; it was removed from the vehicle during extrication efforts.

Figure 6. Front row contacts and intrusion

Figure 7. Overview of second row

Manual Restraints

The Nissan was configured with 3-point manual lap and shoulder belts for the four outboard seat positions and a lap belt for the second row middle seat position. The vehicle was equipped with driver and front passenger safety belt retractor pretensioners that actuated as a result of the crash. The front seats were equipped with seat belt anchorages that were in the full-up position. The driver's safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR); it was being used at the time of the crash. There were abrasions observed at the latch plate and at the anchorage consistent with driver loading (**Figure 8**). The belt webbing had been cut by emergency personnel at a point 18.0 cm (7.0 in) from the stop button.

Figure 8. Driver seat belt loading

The front right passenger safety belt was configured with a sliding latch plate and a switchable ELR/Automatic Locking Retractor (ALR); it was being used at the time of the crash. There was blood observed along the lap portion of the belt and the belt had been cut by emergency personnel. The belt was torn and damaged from vehicle damage at a point 16.0 cm (6.3 in) from the anchor (**Figures 9 and 10**).

The rear outboard seat safety belts were configured with sliding latch plates and switchable ELR/ALR retractors. The left safety belt was reported by the police to have been in use during the crash. There were indications of historical usage but no indication of loading related to this crash. The right safety belt and the middle lap belt were not used in the crash.

Figure 9. Front right seat belt (at anchor)

Figure 10. Front right seat belt (in vehicle)

Supplemental Restraint Systems

The Nissan was equipped with a frontal air bag system that consisted of dual-stage redesigned driver and front right passenger air bags and front safety belt retractor pretensioners.

The driver air bag module was located in the center hub of the steering wheel. The module cover flaps were designed in a tri-fold pattern. The upper flap measured 14.0 x 4.0 cm (5.5 x 1.6 in), width by height. The symmetrical lower flaps measured 8.0 x 6.0 cm (3.1 x 2.4 in), width by height. There was no damage or occupant contact to the flaps. The driver air bag measured 62.0 cm (24.4 in) in diameter in its deflated state. The bag was tethered by a single strap and vented by two ports located on the back side of the bag in the 11/1 o'clock sectors. The right side of the face of the air bag was dirt and grease covered; a small blood drop was located at the bottom of the bag (**Figure 11**). The front right passenger air bag was located in the right aspect of the instrument panel. The air bag deployed from a top-mount

Figure 11. Driver air bag

module. The module was designed with a single 24.0 x 7.0 cm (9.4 x 2.8 in) vinyl flap that rotated forward at the top aspect during deployment. There was no occupant contact evidence on the cover flap. The air bag measured 58.0 cm (22.8 in) in height and 36.0 cm (14.1 in) laterally seam-to-seam. There was no contact evidence observed on the air bag.

Child Restraint System

The 1-month-old female child was seated in a Evenflo Embrace ISS (**Figure 12**). The seat was identified by the Model No. 4851928A and was manufactured on 4-15-2009. The seat was designed to be used in the rear-facing orientation only and was to be used for children weighing between 2.3-10.0 kg (5.0-22.0 lbs) and whose height was between 48.2-73.6 cm (19.0-29.0 in). The 1-month-old weighed approximately 5.0 kg (11.0 lbs) and was within the weight guideline; her height was 57.0 cm (22.5 in) and was within the height guideline. The seat was equipped with a 3-position handle that rotated from a vertical carry position, to a horizontal car position, to a 45 degree stand position. The handle was in the car position at the time of the crash. The seat was also equipped with a fabric cushioning shell, an attached pillow, and a canopy. The canopy was in the down position at the time of the crash. The seat was designed with a 5-point harness with 2 crotch strap buckle positions and 3 shoulder harness positions; at the time of the crash the crotch strap was in the rear-most position and the shoulder harness straps were routed through the middle slots. According to the interviewee, the retainer clip was at the chest/armpit level and the harness straps were tightly fastened. The seat was attached to a stay-in-car base that was anchored to the vehicle using the two ISS LATCH connector straps and the vehicle's lower anchors (**Figure 13**). The seat base was equipped with an adjustment foot that was used to adjust the level of the base. At the time of the vehicle inspection, the base indicator was green–meaning that the base was level.

Figure 12. Damaged ISS base

Figure 13. LATCH anchors and straps (looking toward rear of vehicle)

According to Evenflo literature, this seat model had been side impact tested.

After the ISS carrier was removed from the vehicle, the seat base and its installation was observed with the base still anchored to the vehicle. The driver had been instructed in the installation procedures by a local law enforcement office. To all appearances, the installation appeared correct and there was virtually no movement of the seat. It should be noted that the right rear door intruded into this seating area and seat was pinned into place by the door. Efforts were undertaken to remove the seat base by the investigating officer. When this could not be done by loosening the adjuster strap, the LATCH straps were cut and the base was removed from the vehicle. The distance from the anchor attachment to the buckle adjuster measured 32.0 cm (12.6 in).

Figure 14. Evenflo Embrace ISS

Figure 15. Damage to ISS carrier

Both the ISS carrier and the base were damaged during the crash due to the lateral intrusion of the second row right door (**Figures 14-15**). References to the damage to the rear-facing seat will be as viewed forward-facing in the vehicle. The seat base was deformed and fractured on the right side (side next to the door). There were several fractures in the center area and a 12.0 x 4.0 cm (4.7 x 1.6 in) section of plastic was fractured and displaced. At either end, there were hazed areas of plastic that was indicative of compression or bending. The carrier was fractured on the left side and the fracture extended to the bottom of the left base insertion area.

Vehicle Data - 1979 GMC Sierra Grande C-Series Pickup

The 1979 GMC 1-ton pickup was identified by a partial VIN: TCL349Zxxxxxx. The vehicle was manufactured in June 1979. The vehicle was equipped with a 5.7-liter, 8-cylinder engine, automatic transmission, and rear wheel drive. The GMC was carrying a slide-in 2.4 m (8.0 ft) 1978 Kit Cabover camper.

Exterior Damage

The GMC sustained moderate front end damage due to the impact with the right side of the Nissan (**Figure 16)**. The direct damage began at the right front bumper corner and extended 182.0 cm (71.6 in) across the front of the vehicle. The Field L included the entire front end. Six crush measurements were documented at the bumper level: C_1 = 33.0 cm (12.9 in), C_2 = 17.0 cm (6.7 in), C_3 = 26.0 cm (10.2 in), C_4 = 33.0 cm (12.9 in), C_5 = 44.0 cm (17.3 in), C_6 =74.0 cm (29.1 in). The CDC for the frontal impact was 12FDEW4.

During the impact, the Kit camper was displaced from the bed of the vehicle, rolled two quarter turns, and came to rest on its roof.

Figure 16. Front right, 1979 GMC pickup

Figure 17. Kit Cabover Camper

OCCUPANT DEMOGRAPHICS

	Driver	**Front Row Right Occupant**
Age/Sex:	21/Female	55/Female
Seated Position:	Front row left	Front row right
Seat Type:	Bucket	Bucket
Seat Track Position:	Mid-track	Unknown
Height:	165 cm (65 in)	170 cm (67 in)
Weight:	104 kg (229 lbs)	125 kg (276 lbs)
Alcohol/Drug Involvement:	None	N/A
Body Posture:	Normal, upright	Normal, upright
Hand Position:	Both hands on steering wheel, unknown clock position	Unknown
Foot Position:	Left on floor, right on accelerator	Both feet on floor
Restraint Usage:	Lap and shoulder belt	Lap and shoulder belt

	Second Row Left Occupant	Second Row Right Occupant
Age/Sex:	28/Female	1-month/Female
Seated Position:	Second row left	Second row right
Seat Type:	Split bench with folding back	Split bench with folding back
Seat Track Position:	N/A	N/A
Height:	170 cm (67 in)	56 cm (22 in)
Weight:	77 kg (170 lbs)	5 kg (11 lbs)
Alcohol/Drug Involvement:	N/A	N/A
Body Posture:	Normal, upright	Seated in ISS
Hand Position:	Unknown	Unknown
Foot Position:	Both feet on floor	N/A
Restraint Usage:	Lap and shoulder belt	Lap and shoulder belt not used with ISS/LATCH system used

Occupant Injuries

Driver: Injuries obtained emergency room records and radiology report.

Injury	AIS Code	Injury Mechanism	Confidence Level
Concussion with loss of consciousness, headache, and nausea. Unconsciousness less than one hour.	160416.3,0	Occupant 2	Probable
Fracture, glenoid fossa of right scapula	753000.2,1	Occupant 2	Possible
Non-displaced fracture, right clavicle	752200.2,1	Occupant 2	Possible
Non-displaced hairline fractures, posterior left ribs 2-5, right ribs 3-4	450230.3,3	Occupant 2	Possible
Tongue laceration	243402.1,8	Occupant 2	Probable
Abrasion/ecchymosis, upper right anterior chest	490202.1,1 490402.1,1	Occupant 2	Probable
Abrasion, posterior aspect of right shoulder	790202.1,1	Occupant 2	Probable

Injury	AIS Code	Injury Mechanism	Confidence Level
Contusion, right knee	890402.1,1	Left lower IP	Probable
Cervical strain	640278.1,6	Occupant 2	Probable

Front Row Right Occupant: Injuries obtained from state medical examiner.

Injury	AIS Code	Injury Mechanism	Confidence Level
Head injury, died without further evaluation	115999.7,0	Unknown	Unknown
Fracture, distal right lower leg	852002.2,1	Door/Forward lower quadrant	Certain
Avulsion, 11.0 x 5.0 cm (4.3 x 1.9 in), right elbow	790802.1,1	Exterior V2	Certain
Abrasion, 3.0 cm (1.2 in), left foot. Abrasion, 3.0 cm (1.2 in), left lower leg.	890202.1,2	Center console	Possible
Abrasion, 13.0 x 4.0 cm (5.1 x 1.6 in), right neck	390202.1,1	Seat belt webbing	Certain
Multiple minor abrasions, anterior chest. Curved 18.0 cm (7.0 in) abrasion, right upper quadrant.	490202.1,0	Seat belt webbing	Probable
Abrasion, 7.5 cm (2.9 in), right lateral thigh	890202.1,1	Door/Forward upper quadrant	Certain
Contusion, 11.0 cm (4.3 in), left thigh	890402.1,2	Center console	Probable
Abrasions, medial aspect left heel	890202.1,2	Floor	Possible

Second Row Left Occupant: Injuries obtained from interviewee.

Injury	AIS Code	Injury Mechanism	Confidence Level
Contusion, right chest	490402.1,1	Seat belt webbing	Probable
Contusion, two ribs on right side	450202.1,1	Seat belt webbing	Probable

Second Row Right Occupant: Injuries obtained from the emergency room records and radiology reports.

Injury	AIS Code	Injury Mechanism	Confidence Level
Hemorrhagic contusions within the bilateral frontal and left temporal lobes. Intraparenchymal hemorrhage, right frontal and left parietal and temporal lobes	140620.3,3	ISS shell	Probable
Non-displaced left frontal skull fracture	150402.2,2	ISS shell	Probable
Left parietal subdural hematoma	140650.4,2	ISS shell	Probable
Bilateral pulmonary contusion	441410.4,3	ISS shell	Probable
Scalp hematoma, left, anteriorly in the frontal region	190402.1,2	ISS shell	Probable
Displaced rib fractures, left 4-5, non-displaced rib fractures, right 7-11	450230.3,3	ISS shell	Probable
Abdominal injury	515099.7,0	ISS harness	Probable

OCCUPANT KINEMATICS

Driver Kinematics

The 21-year-old female driver was seated in an upright posture and was restrained by the vehicle's lap and shoulder belt. The seat was adjusted to the mid-track position and the seat back was slightly reclined. According to the interviewee, the driver had both hands on the steering wheel and her right foot was on the accelerator. The Nissan was traveling southbound in the inboard travel lane at a driver-stated speed of 97 km/h (60 mph). The Nissan lost traction due to the snowy conditions, initiated a counterclockwise rotation, entered the northbound travel lane, and was impacted on the right side by the GMC pickup. At impact, the driver's air bag deployed and the seat belt retractor pretensioner actuated. The driver was displaced slightly forward and to the right. Her head, right shoulder area, and torso contacted Occupant 2, causing a concussive head injury and right clavicle, scapula, and rib fractures. After the initial impact, the Nissan was displaced rearward and rotated slightly in a clockwise direction before impacting a guardrail on the left side. This was a low Delta-V event and its effect on the driver's movement was negligible. It was reported that the driver lost consciousness for a short time period after the crash. She remained in the vehicle until she was extricated by emergency personnel. She was then transported to a local hospital where she was treated and released.

Front Right Occupant Kinematics

The 55-year-old female front right occupant was seated in an upright posture and was restrained by the vehicle's lap and shoulder belt. At impact with the GMC, the frontal air bag deployed and the safety belt retractor pretensioner actuated. This occupant was displaced forward and to the right. She sustained abrasions to the right side of her neck and chest due to safety belt loading. She engaged the intruding right front door and sustained a right lower leg fracture and an abrasion to the right lateral thigh. Her right arm contacted the front of the other vehicle and she sustained a large avulsive injury to the right elbow. She contacted Occupant 1 but there were no related injuries reported in the medical examiner's report. She remained restrained and in place during the minor second impact. She was declared deceased at the scene. The caused of death was reported by the state medical examiner as death due to multiple traumatic injuries. Her body was removed from the vehicle approximately three hours after the crash.

Second Row Left Occupant Kinematics

The 28-year-old female second row left occupant was seated in an upright posture and was restrained by the vehicle's lap and shoulder belt. At impact with the GMC, she was displaced forward and to the right, loading the seat belt webbing and causing the right torso contusions She remained restrained and in place during the minor second impact. There were no indications that she contacted any interior surfaces. She removed the child in the second row right position and exited the vehicle under her own power through the second row left door. She was transported to a local hospital where she was treated and released.

Second Row Right Occupant Kinematics

The 1-month-old female second row right occupant was seated in a rear-facing ISS that was anchored to the vehicle using the LATCH hardware and straps. The child was restrained by the ISS internal harness straps. The shoulder strap was routed through the middle set of slots and the crotch strap was adjusted to the rear most position. At impact with the GMC, she was displaced forward and to the right. She loaded the interior shell of the ISS causing the head and torso injuries. The second row right door intruded into the passenger compartment and deformed the ISS. The child remained in place during the second impact. After the crash, she was removed from the ISS by the second row left occupant. The child was transported by ambulance to a local hospital and was then airlifted to a local trauma center where she was hospitalized for seven days.

Attachment 1. Scene Diagram