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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
GRACO SNUG RIDE REAR-FACING CHILD SAFETY SEAT
SCI CASE NO: CA05-024

VEHICLE: 2004 NISSAN QUEST
LOCATION: CONNECTICUT
CRASH DATE: MARCH, 2005

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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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16. Abstract

This on-site investigation focused on the crash dynamics and the performance of two Graco Snug Ride rear-facing infant child safety seats (CSS) that were installed in the second row of a 2004 Nissan Quest. The child safety seats were occupied by twin 8 month old males. The Nissan's 31 year old female driver relinquished directional control of the vehicle during a reported medical episode which allowed the Nissan to depart the right roadside. The vehicle traveled 84 m (275 ft) along the road side into the parking lot of a local business. An under-repair Caterpillar 330B track-driven construction excavator was parked in the lot. The front plane of the Nissan impacted the back plane of the excavator and came to rest. The force of the crash resulted in the deployment of the Nissan's frontal air bags and the left side inflatable impact protection. Both infants remained secured in the child safety seats during the crash. However, the infant secured in the CSS on the left side of the second row sustained an AIS 6 cervical spine injury and brain hemorrhages due to the acceleration/deceleration of the crash. He was pronounced deceased 185 minutes post-crash. The infant secured in the second row right CSS was transported to a local hospital, evaluated and released without injury. The restrained driver of the Nissan was not injured. The unrestrained front right passenger sustained blunt force head and chest trauma which required hospitalization.

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BACKGROUND

This on-site investigation focused on the crash dynamics and the performance of two Graco Snug Ride rear-facing infant child safety seats (CSS) that were installed in the second row of a 2004 Nissan Quest. The child safety seats were occupied by twin 8 month old males. The Nissan's 31 year old female driver relinquished directional control of the vehicle during a reported medical episode which allowed the Nissan to depart the right roadside. The vehicle traveled 84 m (275 ft) along the road side into the parking lot of a local business. An under-repair Caterpillar 330B track-driven construction excavator was parked in the lot. **Figure 1** is an on-scene view of the crash site. The front plane of the Nissan impacted the back plane of the excavator and came to rest. The force of the crash resulted in the deployment of the Nissan's frontal air bags and the left side inflatable impact protection system. Both infants remained secured in the child safety seats during the crash. However, the infant secured in the CSS on the left side of the second row sustained an AIS-6 cervical spine injury and brain hemorrhages due to the acceleration/deceleration of the crash. He was pronounced deceased 185 minutes post-crash. The infant secured in the second row right CSS was transported to a local hospital, evaluated and released without injury. The restrained driver of the Nissan was not injured. The unrestrained 59 year old female front right passenger sustained blunt force head and chest trauma which required hospitalization.

Figure 1: On-scene view of the crash site and the final rest position of the Nissan

The crash was identified through conversations with the local police investigator during a State Child Passenger Safety Conference. Due to the National Highway Traffic Safety Administration's interest in child passenger safety, an on-site investigation was assigned by the agency's Crash Investigation Division upon their notification. Cooperation was established with the local police and with the insurance carrier for the Nissan. The child safety seats were retained by the police investigators and inspected in the police property room during the SCI investigation. The Nissan was available for inspection in an insurance salvage yard. The on-site portion of the investigation took place April 27-28, 2005.

SUMMARY

Crash Site

This single vehicle crash occurred during the afternoon hours in March 2005. At the time of the crash, it was daylight and there were no adverse weather conditions. The asphalt road surface was dry. There was an estimated 10 cm (4 in) of snow covering the roadside terrain The Nissan Quest was westbound on a two lane east/west 7.3 m (24 ft) wide roadway. The north roadside was bordered by level, snow covered, grass terrain with spaced utility poles and several deciduous trees. A small business with an asphalt parking lot was located on the north side of the road downstream of the vehicle's pre-crash trajectory. A 10 m (31 ft) wide driveway intersected the road from the north and served as an entrance/exit for the parking lot. An under-repair construction excavator was parked at the business and was the point of impact. The speed limit in the area of the crash was 72 km/h (45 mph). **Figures 2 and 3** are trajectory views of along the Nissan's path.

Figure 3: Trajectory view at the roadside departure.

Figure 2: Trajectory view 24 m (80 ft) from the point of impact.

Crash Sequence

Pre-Crash

The 2004 Nissan Quest traveling westbound and was driven by a 31 year old restrained female. An unrestrained 59 year old female was the vehicle's front right passenger. The second row of the Nissan was occupied by twin 8 month old males restrained within rear-facing Graco SnugRide Child Safety Seats. The child safety seats were individually restrained in their respective positions by both the vehicle's 3-point safety belt and the Lower Anchors and Tethers for CHildren (LATCH) webbing provided with the child seat.

The crash occurred when the driver relinquished directional control of the vehicle after a reported medical episode. The Nissan departed the right (north) side of the road at a shallow angle (estimated 5 degrees). The Nissan traveled along a west-northwest trajectory 84 m (275 ft) into the parking lot and impacted a parked Caterpillar 330BL track driven construction excavator. The left front aspect of the Nissan swiped the edge of a shrub located adjacent to the driveway during the later part of this travel (Event1). This minor impact did not alter the vehicle's trajectory. The Nissan's trajectory was evidenced by rolling tire marks through the

roadside grass terrain and the snow cover. The direction and nature of the tire marks indicated there was no driver input to the vehicle after departing the road. Refer to **Figures 2 and 3** above.

The Caterpillar excavator was under repair at the time of the crash. The excavator was designed with the cab, boom, engine, and hydraulics housed in a pivoting turret above the track drive. The base of the turret was located 118 cm (46.5 in) above the ground. A counterweight was attached to the back aspect of the turret. In the excavator's parked position, the aft aspect of the track drive was located 91 cm (36 in) forward of the counterweight. This position of the turret created an overhanging structure. **Figure 4** is a view of an exemplar excavator located at the crash site at the time of the SCI scene inspection.

Figure 4: View of an exemplar excavator.

Crash

Figure 15 at the end of this report is a schematic of the crash. The front plane of the Nissan struck the back plane of the parked excavator. The directions of the impact force were in the 12/6 o'clock sectors for the Nissan and Caterpillar, respectively. Due to the overhanging design of the excavator, the front bumper of the Nissan passed under the excavator's counterweight and impacted the left drive track. Nearly simultaneously with the bumper impact, the upper aspect of the right A-pillar, the windshield, and the windshield header impacted the counterweight. The force of the frontal impact caused the front safety belt pretensioners to fire and the deployment of the frontal air bags and the left side inflatable impact protection. The total delta V of the Nissan calculated by the Damage Algorithm of the WINSMASH model was 40.6 km/h (24.9 mph). This value appeared to underestimate the severity of the impact based on SCI field experience.

Figure 5: Close-up view of the impact configuration and final rest position of the Nissan.

Post-Crash

The police, fire, and ambulance personnel responded to the scene. The driver was found outside the Nissan walking about the scene dazed but not injured. The front right passenger of the Nissan was assisted from the vehicle due to the blunt force injuries received as a result of the crash. She was transported and hospitalized for her injuries. The second row passengers were removed from the vehicle in their child safety seats. The CSS's were removed by cutting the vehicle's seat belts and the LATCH webbings that secured them to the vehicle.

The police officer that notified the SCI team of the crash was one of the first responders. He was also trained as a Child Safety Seat Technician. He reported that he was handed the second row

left CSS and its occupant. He noted that the harness straps were secure on the child and the harness retainer clip was at the appropriate level on the chest. The child was pulseless and unresponsive at that time. The emergency responders began CPR and rescue breathing and transported the child to a regional trauma center located approximately 24 km (15 miles) from the crash site. Upon arrival in the emergency room, the child had no spontaneous respirations and an irregular pulse. Medical efforts to revive the child were unsuccessful and the child was pronounced deceased 185 minutes post-crash. The child secured in the CSS on the second row right was not injured in the crash. He was transported to the emergency room, examined and released.

2004 NISSAN QUEST

The 2004 Nissan Quest was identified by the Vehicle Identification Number (VIN): 5N1BV28UX4N (production sequence deleted). **Figure 6** is the front right view of an exemplar Nissan Quest. The four-door, seven passenger minivan had a 315 cm (124 in) wheelbase and a Gross Vehicle Weight Rating (GVWR) of 2600 kg (5732 lb). The subject vehicle was equipped with SE level trim. The power train consisted of a 3.5 liter/V6 engine linked to a 5-speed automatic transmission. The service brakes were a four-wheel disc system with ABS. The seating configuration consisted of captain's chairs in the first and second row, and a third row bench seat. The vehicle was manufactured in December 2003. The digital odometer could not be read at the time of the inspection due to impact damage to the electrical system. The Nissan was equipped with a CAC frontal air bag system (driver and front right passenger air bags) that was certified by the manufacturer to have met the requirements of the advanced Federal Motor Vehicle Safety Standard (FMVSS) 208 ruling. The supplemental inflatable side impact protection system consisted of seat-back mounted thorax air bags in the front seats and roof rail mounted side curtains for all three rows. The frontal air bags and left side impact air bags deployed as a result of the impact. The Nissan was equipped with Goodyear Eagle P225/60R17 tires on OEM alloy wheels. The recommended tire pressure was 240 kPa (35 PSI). The specific measured tire data was as follows:

Figure 6: Front right view of an exemplar Nissan Quest.

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0 kPa	5.6 mm (7/32 in)	Yes	Fractured rim
LR	219 kPa (32.0 PSI)	7.1 mm (9/32 in)	No	None
RF	219 kPa (32.0 PSI)	4.8 mm (6/32 in)	No	None
RR	226 kPa (33.0 PSI)	7.1 mm (9/32 in)	No	None

Exterior Damage

Figure 7 is a front view of the damaged Nissan taken during the SCI inspection. The direct contact damage was comprised of two distinct regions of contact directly associated to the overhanging structure of the excavator. The combined width of direct contact damage associated to the two regions extended across the entire 160 cm (63 in) frontal end width. The regions of contact could be separated at the base of the A-pillars. The direct and induced damage at the bumper elevation was associated to contact with the left track of the excavator. The direct contact at the bumper elevation began 22 cm (8.6 in) right of center and extended 102 cm (40.1 in) to the left corner of the front bumper. The residual crush profile at the bumper elevation was as follows: C1 = 78 cm (30.7 in), C2 = 49 cm (19.3 in), C3 = 39 cm (15.4 in), C4 = 17 cm (6.7 in), C5 = 5 cm (2.0 in), C6 = 17 cm (6.7 in). The direct damage at the windshield header resulted from a nearly simultaneous impact with the excavator's counterweight. The direct damage at this elevation began 43 cm (17.0 in) left of center and extended 107 cm (42.0 in) to the right corner of the header. The residual crush profile across the windshield header was: C1 = 0 cm (0.0 in), C2 = 18 cm (7.1 in), C3 = 18 cm (7.1 in), C4 = 20 cm (7.9 in), C5 = 16 cm (6.3 in), C6 = 8 cm (3.2 in). **Figures 8 and 9** are left and right lateral views of the Nissan's impact, respectively. All the doors remained closed during the impact. The front left door and the front right door were open at the time of the inspection but could not be relatched due to deformation of the vehicle's structure. Both sliding second doors were operational. The windshield fractured and the glazing of the front row windows disintegrated during the impact. The left wheelbase was reduced 33 cm (13.1 in). The left front wheel rim was fractured during the impact. The right wheelbase was unchanged. The Collision Deformation Classification was 12-FDAA6.

Figure 7: Nissan frontal damage.

Figure 9: Left lateral view.

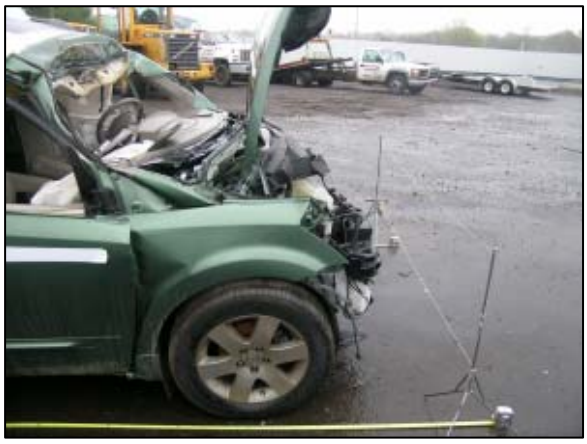

Figure 8: Right lateral view

Interior Damage

The interior damage to the Nissan Quest consisted of moderate intrusion into the driver and front right interior space, deployment of the driver, front right passenger and left side impact air bags, and the front interior occupant contacts. There also was damage to the back surfaces of the respective front seat backs from their interaction with the child safety seats restrained in the vehicle's second row. The windshield header intruded rearward and vertically downward as a result of contact to the counterweight. The magnitude and location of the header intrusion is summarized in the table below:

Component: Windshield Header			
ROW 1 LEFT	ROW 1 CENTER	ROW 1 RIGHT	DIRECTION
0 cm (0 in)	18 cm (7 in)	5 cm (2 in)	Longitudinal
10 cm (4 in)	18 cm (7 in)	10 cm (4 in)	Vertical

The left A-pillar, instrument panel, and left toe pan intruded longitudinally as a result of the impact with the left drive track. The left A-pillar intrusion measured 4 cm (1.5 in). The intrusion of the instrument panel measured 11 cm (4.5 in) at the left corner and 14 cm (5.5 in) at the right corner. The intrusion of the outboard aspect of the left toe pan measured 22 cm (8.7 in).

Figure 10: Left interior view of the driver seat.

The leather upholstered, 8-way powered, driver seat was adjusted to a rear-third track position that measured 7 cm (2.9 in) forward of full rear, **Figure 10**. The total seat track travel measured 24 cm (9.5 in). The seat back recline angle measured 10 degrees. The anti-submarine angle of the seat cushion measured 3 degrees. The upper outboard aspect of the driver seat back appeared to be deformed rearward by a counterclockwise rotation. The estimated deformation of the upper left aspect of the seat back was 9 cm (3.5 in). The horizontal distance from the seat back to the center hub of the steering wheel measured 41 cm (16 in). This distance was measured 46 cm (18 in) above the seat bight. The Nissan Quest was equipped with adjustable pedals. The pedals were adjusted to the rear most position (closest to the driver). The total pedal adjustment measured 8 cm (3 in).

The three-spoke tilt steering wheel rim was adjusted to the center position. The forward side of the rim was cut over a 38 cm (15 in) arc length measured along the circumference in the 10 to 2 o'clock sectors. This damage resulted from contact between the steering wheel rim and the fractured windshield at its impact with the excavator's counterweight. The estimated rim deformation through the 10/2 o'clock sector was 1 cm (0.5 in) rearward toward the driver. Examination of the steering column's shear capsules identified a 1.2 cm (0.5 in) separation of left shear capsule. The right shear capsule did not separate. The only identified driver contact was to the face of the deployed driver air bag. (Refer to the ***Supplemental Restraint*** section

below.) There were no identified contacts by the restrained driver to the hard structures of the interior.

The 4–way powered front right passenger seat was adjusted to a rear track position that measured 2 cm (0.8 in) forward of full rear. The total seat track travel measured 24 cm (9.5 in). The seat back angle measured 22 degrees and the anti-submarine angle measured 6 degrees. The horizontal distance from the seat back to the rearmost protrusion of the instrument panel measured 61 cm (24 in). This horizontal distance was measured 30 cm (12 in) above the seat bight. The front right passenger air bag module was recessed within the instrument panel 22 cm (8.5 in) forward of the protrusion of the instrument panel. The horizontal distance from the seat back to the air bag module was 88 cm (34.8 in) [measured 51 cm (20 in) above the seat bight].

The unrestrained front right passenger contacted the center and right aspect of the cylindrical center instrument panel with her torso and lower extremities, **Figure 11**. The circular panel comprising the top of the center instrument panel was displayed to the left and forward by front right occupant contact. An 8 cm (3 in) vertical fracture at the 5 o'clock sector of the cylindrical panel was also noted. Body fluid transfers were noted adjacent to the fracture site and to the lower right aspect of the side panel. A lower extremity contact was noted to the central aspect of the glove box door. This contact was identified by a 9 cm (3.5 in) long scuff mark located 10 cm (4 in) right of the glove box latch. The latching mechanism of the glove box was also fractured by this contact.

Figure 11: View of the occupant contacts to the center instrument panel.

The Nissan Quest's second row of seats consisted of two captain's chairs, **Figure 12**. The chairs had a fixed track position. The seat back recline angle of both the left and right chair measured 15 degrees. The antisubmarine angle of both chair cushions measured 4 degrees.

The child safety seats (CSS's) were restrained in a rear-facing mode within the second row and took up a majority of the volume of occupant space. Although it was not possible to remove the CSS's from the police property room and reinstall the seats in the Nissan, it was possible to compare the physical dimensions involved. Dimensional comparison indicated the installed CSS's were in-close proximity to the backs of the front seats. The gross overall longitudinal dimension of the child safety seat and base measured 86 cm (34 in). The horizontal distance from the Row 2 left seat back to the

Figure 12: View of the second row.

driver's seat back measured 91 cm (36 in). This measurement was taken at the elevation of the seat bight. The horizontal distance from the seat back to the driver's seat back 58 cm (23 in) above the seat bight measured 95 cm (37.5 in). The horizontal distance from the Row 2 right seat back to the front right passenger seat back measured 86 cm (34 in) at the seat bight. The horizontal distance from the seat back to the front passenger seat back 58 cm (23 in) above the seat bight measured 85 cm (33.5 in). **Figure 13** is a left interior view depicting the interior volume between the first and second row of seats.

Figure 13: Left interior view of the second row.

During the ride down of the crash, the backs of the front seats were contacted by the shells of the respective CSS's. **Figures 14 and 15** are views of the left front and right front seat back respectively. The seat backs consisted of a map pocket sewn onto a vinyl insert that covered the seat's internal structure. The driver's seat back exhibited a 1 cm (0.4 in) abrasion to the upper outboard aspect. Additionally, the vinyl insert was displaced rearward. As reported earlier in this report, the upper outboard aspect of the seatback appeared deformed rearward approximately 9 cm (3.5 in). Refer to **Figure 14** The front right seat back exhibited an 8 cm (3 in) long vertical linear abrasion located 8 cm (3 in) left of center. The inboard aspect of the map pocket stitching was torn over a 13 cm (5.3 in) length.

Figure 14: Driver's seat back.

Figure 15: Front right passenger seat back.

Manual Restraint Systems

The driver's manual three-point lap and shoulder restraint consisted of a continuous loop webbing, a sliding latch plate, Emergency Locking Retractor (ELR), and an adjustable D-ring. The retractor was mounted in the base of the B-pillar and was equipped with a pretensioner. The pretensioner had fired as a result of the impact and locked the retractor. Upon inspection the

driver's belt webbing was locked in an extended position and lying on the seat, refer to **Figure 10** above. The exposed length of the webbing measured 212 cm (83.5 in). The D-ring was adjusted to the full-up position. The webbing was jammed in the D-ring from loading by the driver during the ride-down of the crash. Additionally, the webbing exiting the D-ring was abraded over an 11 cm (4.5 in) length and the frictional surface of the D-ring was also heavily abraded. The evidence identified during the SCI inspection indicated the driver was restrained at the time of the crash.

The front right passenger's manual three-point restraint consisted of a continuous loop webbing, a sliding latch plate, a B-pillar mounted switchable Automatic Locking/Emergency Locking Retractor (ALR/ELR), and an adjustable D-ring. The retractor was equipped with a pretensioner that fired as a result of the impact. The front right restraint was stowed within the retractor at the time of the SCI inspection and the retractor was locked because of the fired pretensioner. The webbing was taut and could not be moved. The latch plate was displaced to the outboard aspect of the seat back and was trapped by the deformed cushion. The physical condition of the safety belt observed during the SCI inspection indicated the front right passenger was unrestrained at the time of the crash.

The manual restraint systems in the second row of the Nissan Quest consisted of three-point lap and shoulder belts that consisted of continuous loop webbing, C-pillar mounted switchable ALR/ELR retractors and fixed D-rings. The two second row captain's chairs were equipped with LATCH compatible anchors. Examination of the respective restraints revealed that the child safety seats had been installed in a rear-facing mode using both the manual three-point safety belt and the LATCH webbing provided with the child seat. Locking clips were installed on each of the vehicle's safety belts adjacent to the latch plates. The emergency responders cut all the respective belts in order to remove the child seat and their occupants as a complete unit.

The second row left safety belt was cut 20 cm (8 in) above the floor anchor and 73 cm (28.8 in) from the latch plate. Refer to **Figure 16**. The total length of the cut section measured 146 cm (57.6 in). This section of webbing was removed from the Nissan and transported with the CSS. It was located in the police property room and inspected at that location. There was no evidence of loading noted on the webbing. The balance of the webbing above the cut section spooled back into the retractor and was not available for inspection. The Row 2 left seat LATCH webbing was cut at the locking slide adjuster attached to the seat's outboard LATCH anchor and 8 cm (3 in) above the inboard LATCH anchor. This cut section measured 39 cm (15.2 in) in length and was still threaded through the CSS base. The outboard ends of this webbing were creased due to loading from the CSS base. This webbing section was also inspected in the police property room.

Figure 16: Cut seat belt of the Row 2 left seat.

Figure 17 is a view of the second row right seat and its restraints. The second row right safety belt was cut 44 cm (17.2 in) above the floor anchor and 53 cm (21 in) from the latch plate. The cut webbing section was still buckled into the latch plate receiver. A locking clip was installed on the webbing adjacent to the latch plate. The total length of the cut section measured 118 cm (46.5 in). The webbing section appeared loaded over a 20 cm (7.8 in) length that began 24 cm (9.5 in) from the latch plate due to loading from the CSS base. The balance of the webbing had spooled back into the retractor and was not available for inspection. The LATCH webbing was cut in a single place and was still attached to the seat. The cut was located 9 cm (3.5 in) above the outboard anchor and 45 cm (17.8 in) from the locking slide adjuster adjacent to the inboard LATCH anchor. No residual evidence of loading was found during examination of the LATCH webbing. The reader is encouraged to refer to the ***Child Safety Seat Data*** section of this report for further information regarding the CSS installation and for additional photographs.

Figure 17: Second row right seat cut vehicle seat belt and cut LATCH webbing.

Air Bag System

The Certified Advanced 208-Compliant (CAC) frontal air bag in the Nissan Quest consisted of advanced dual-stage air bags for the driver and front right passenger, a seat track position sensor for the front right seat, and a front right occupant detection sensor. The frontal air bag system was certified by the manufacturer to have met the requirements of the advanced Federal Motor Vehicle Safety Standard 208. The subject Nissan was also equipped with inflatable side impact protection that consisted of front seat back mounted thorax air bags and roof rail mounted side curtains. The frontal air bags and the inflatable left side impact air bags deployed as a result of the crash.

The driver air bag, **Figure 18**, was housed within an H-configuration module designed into the center hub of the steering wheel. The diameter of the deployed air bag measured 53 cm (21 in). It was tethered by two 10 cm (4 in) wide straps and vented by two 4 cm (1.5 in) diameter ports on the back side of the bag in the 11/1 o'clock sector. There was a 3 cm (1.2 in) cut of the bag's fabric in the 12 o'clock on the back side membrane due to contact with the fractured windshield during the impact. The cut did not affect the performance of the air bag. A 4 cm (1.5 in) long lip stick transfer was noted on the face of the air bag. It was located within the 3 o'clock sector of

Figure 18: View of the deployed air bags.

the tether circle 6 cm (2.5 in) right of the center line. The transfer resulted from contact between the driver's face and the deployed air bag. Post-crash blood spatters were noted in the 2 and 11 o'clock sectors of the bag.

The front right passenger air bag was housed within a top-mount module located within the right aspect of the instrument panel. The module was designed with a rectangular cover flap that rotated forward during the deployment sequence. The flap was constructed of vinyl with a metal backer that acted as a hinge. The face of the front right air bag measured 38 cm x 61 cm (15 in x 24 in), width by height. The bag was not tethered and was vented by two 5 cm (2 in) ports located on the bag's side panels. Two small 6 mm (0.25 in) lacerations were noted on the top surface of the bag from contact with the fractured windshield. The face of the bag was spattered with post-crash blood evidence.

The left front seat back mounted thorax air bag was mounted in the outboard aspect of the seat back's bolster. The air bag deployed through a 38 cm (15 in) separation of the seam. The air bag measured 25 cm x 30 cm (10 in x 12 in) and was not vented. There was no evidence of occupant contact. The roof rail mounted side curtain consisted of three separate rectangular chambers, one chamber per seat row. The driver's chamber measured 53 cm x 46 cm (21 in x 18 in), length by height, respectively. It was not vented. The deployed chamber covered an area from the left B-pillar trim forward to the apex of the left A-pillar trim and the left roof rail. There was no noted contact evidence to the deployed chamber. The second row side curtain chamber measured 53 cm x 46 cm (21 in x 18 in). The coverage of this chamber began 51 cm (20 in) aft of the left B-pillar trim and continued rearward to the left C-pillar. There was no contact evidence noted to the chamber. The third row side curtain chamber measured 41 cm x 38 cm (16 in x 15 in), length by height. This chamber's coverage began 24 cm (9.5 in) aft of the left C-pillar and extended to the left D-pillar. There was no contact to the chamber in this unoccupied position.

CHILD SAFETY SEAT DATA

The 8 month old male twins were restrained within identical Graco Snug Ride rear-facing Child Safety Seats (CSS's), **Figures 19 and 20**. Each seat consisted of a carrier shell with a five-point harness and a detachable base. The CSS was designed and equipped with a LATCH webbing that was used in conjunction with the vehicle's seat belt at the time of the crash. The seat was labeled for use by infants who weigh less than 9 kg (20 lb) and are less than 66 cm (26 in) in height. The twins were at the weight limit for the CSS and had outgrown the height limit of the CSS based on the reported demographics of the fatally injured infant.

The left CSS was manufactured on November 14, 2003 and was designated with the following Model and Serial numbers: 8643 HMP, *PO 133A.* The five point harness was adjusted to the top slots. The length of the left and right harness strap each measured 51 cm (20.0 in). There was a double twist of the inboard strap. There was no evidence of occupant loading. The chest retainer clip was present and was located 24 cm (9.3 in) below the top slots. The left detachable base was manufactured November 15, 2003. The CSS base was designed with an adjustable foot to control the recline angle of the CSS. The base was adjusted to the mid-position. In this base adjustment, the recline angle of CSS shell (at the top slots) measured 50 degrees from vertical.

The right CSS was manufactured on November 15, 2003 and was designated with the following Model and Serial numbers: 8643 HMP, *PO 133D.* The five point harness was adjusted to the top slots. The length of the left and right harness strap each measured 51 cm (20.0 in) (similar to the left seat). There was a single twist of the outboard strap. No evidence of occupant loading was identified. The chest retainer clip was present and was located 26 cm (10.3 in) below the top slots. The right detachable base was manufactured November 14, 2003. The adjustable foot of the right base was adjusted to the most-reclined position. With this base adjustment, the recline angle of CSS shell (at the top slots) measured 55 degrees from vertical.

Figure 19: View of the Graco CSS's.

Figure 20: View of the CSS recline adjustment.

The CSS's were restrained in the Nissan utilizing both the LATCH webbing and the vehicle's safety belt. Additionally, each vehicle safety belt had a locking clip installed on the webbing in-close proximity to the latch plate. Through the inspection of the respective safety belts it was determined that the left CSS was secured in the Nissan utilizing 93 cm (36.8 in) of the vehicle's 3-point restraint webbing and 46 cm (18.2 in) of the LATCH webbing. The right CSS was secured in position utilizing 97 cm (38.2 in) of the vehicle's 3-point restraint webbing and 54 cm (21.4 in) of the LATCH webbing. The different lengths of the restraints were consistent with the different angles of the adjustable bases. Examination of each CSS base revealed that both had been stressed across the rear-facing belt path during the ride-down of the crash.

Examination of the left CSS shell revealed minor indications of stress across the shell's top center aspect, and on the outboard arm of the carrier handle. Similarly, the top center aspect of the right CSS shell and its carrier handle exhibited minor stress marks. These stress marks were related to the respective CSS's interactions with the backs of the front seats during the ride down of the crash.

Examination of the bucket of the CSS shells revealed a significant difference in the post-crash condition of the respective seats. Major stress marks were identified in the bucket of the left shell and in the belt guides where the 5-point restraint webbing passes under the bucket, **Figure 21**. These stress indicators were absent in the bucket and on the belt guides of the right shell, **Figure 22**. The presence of the stress marks in the left seat indicated the left CSS was subjected

to larger deceleration forces. In-turn, the occupant of the left seat was subjected to these larger deceleration forces. The stressed condition of the left seat was consistent with the greater trauma suffered by the left occupant as compared to the right.

Figure 21: Stress marks in the bucket of the left CSS shell.

Figure 22: Bucket of the right shell.

ADULT PASSENGER DEMOGRAPHICS

	Driver	***Front Right Passenger***
Age/Sex:	31 year old / Female	59 year old / Female
Height:	Not Reported	Not Reported
Weight:	Not Reported	Not Reported
Seat Position:	Rear-Third Track	Rear Track
Restraint Use:	3-point Lap and Shoulder belt	None
Usage Source:	SCI inspection	SCI inspection
Medical Treatment:	Treated and Released	Transported by ground ambulance and hospitalized

DRIVER INJURY

The 31 year old female was not injured in the crash.

DRIVER KINEMATICS

The 31 year old female driver was seated in a rear-third track position and was restrained by the vehicle's 3-point lap and shoulder belt. The driver relinquished directional control of the Nissan as a result of a reported medical episode. The Nissan departed the right side of the road at a shallow angle and traveled 84 m (275 ft) off-road to impact. Reconstruction of the crash determined that approximately 4 to 5 seconds elapsed from the point of roadside departure to the impact with the excavator.

Upon impact, the emergency locking retractor of the safety belt system locked, the driver's safety belt pretensioner fired, and frontal air bags deployed. The driver responded to the 12

o'clock direction of the impact force by initiating a forward trajectory. The driver contacted and loaded the locked belt system with her chest and pelvis and began to ride down the force of the impact. The driver's face and chest contacted the deployed air bag. The facial contact was identified by a lip stick transfer to the center face of the air bag. The rearward seat track adjustment and rearward adjustment of the adjustable pedals pre-positioned the driver away from the driver knee bolster and hard structures of the interior. The driver's interior contact was mitigated by her rearward position and the effective use of the manual restraint system coupled with the driver air bag. After the ride down of the crash, the driver rebounded back into her seat and came to rest. She exited the vehicle under her own power and was found walking outside the vehicle by the first responders.

FRONT RIGHT PASSENGER INJURY

Injury	***Injury Severity (AIS 98 Update)***	***Injury Source***
Blunt force head injury, NFS	Unknown (115099.7,0)	Contact to the excavator counterweight
Blunt force chest injury, NFS	Unknown (415099.7,0)	Contact to the center console

Note: the above injury data was based on police reported. Medical records were not available.

FRONT RIGHT PASSENGER KINEMATICS

Prior to the crash, the 59 year old female front right passenger was seated in a rear track seat position with a presumed upright posture. She was not restrained by the vehicle's 3-point lap and shoulder belt. When the driver relinquished directional control of the vehicle, it was probable the front right passenger moved out-of-position toward the center of the vehicle in an effort to aid the driver.

Upon impact, the frontal air bags deployed. The unrestrained passenger initiated a forward trajectory in response to the 12 o'clock direction of the impact. The passenger impacted the center instrument panel exhibited by the identified contacts. It was probable she interacted with the inboard aspect of the deployed front right passenger air bag. Her contact to the center instrument panel resulted in the blunt chest trauma. As the windshield and windshield header impacted the excavator's counterweight, the front right passenger struck the intruding counterweight as well. This contact resulted in the reported blunt head trauma. The passenger came to rest partially on the seat and in the passenger foot well. She was removed from the Nissan through the front right door by the first responders. She was transported by ground ambulance to a regional trauma center and hospitalized for her injuries.

CHILD PASSENGER DEMOGRAPHICS

	Second Row Child Passengers	
Position in Vehicle:	Row 2 left	Row 2 right
Age/Sex:	8 month old/male (twins)	8 month old/male (twins)
Height:	76 cm (30 in) *per autopsy*	76 cm (30 in) *estimated from twin*
Weight:	9.2 kg (20.3 lb) *per autopsy*	10 kg (22 lb) *per medical record*
Seat Position:	Rear-facing child safety seat	Rear-facing child safety seat
Restraint Use:	5-point harness	5-point harness
Usage Source:	SCI inspection	SCI inspection
Medical Treatment:	Fatally injured	Not injured

ROW 2 LEFT CHILD PASSENGER INJURY

Injury	***Injury Severity (AIS 98 Update)***	***Injury Source***
C2/C3 dislocation with spinal cord injury, NFS	Maximum (640234.6,6)	Non-contact - Acceleration/ deceleration
Intra-ventricular hemorrhage (exact aspect unknown)	Severe (140678.4,9)	Non-contact - Acceleration/ deceleration
Subarachnoid hemorrhage (exact aspect unknown)	Serious (140684.3,9)	Non-contact - Acceleration/ deceleration

The above injuries were identified on the Radiology reports from the treating hospital and the Medical Examiner's Autopsy Report.

ROW 2 LEFT CHILD PASSENGER KINEMATICS

At the time of the crash, the 8 month old male was restrained by the 5-point harness system of the CSS in a rear-facing mode. Upon impact, the child responded to the 12 o'clock direction of the impact by initiating a forward trajectory. The child loaded the harness straps with his shoulders and his torso loaded the back of the CSS shell. The inertial loading of the shell and harness caused the CSS (shell and base) to translate forward and pitch downward due to its restraint at the seat bight by the LATCH webbing and vehicle safety belt. The seat cushion of the Row 2 left seat compressed. During this kinematic pattern, the carrier handle of the CSS contacted and interacted with the back of the left front seat. This interaction was evidenced by the identified seat back contact and the stressed carrier handle.

During the later stage of the impact, the seat cushion unloaded and the CSS rebounded (rearward with respect to the vehicle). The child (with his back being loaded by the shell) initiated a rebound trajectory. However, as the CSS reached its maximum rearward excursion and decelerated, the child continued rearward and loaded the internal harness straps of the CSS with his shoulders and chest. As the child's torso decelerated, the inertia of the child's (unrestrained) head caused the neck to flex forward beyond its anatomical limits. This kinematic pattern resulted in the C2/C3 dislocation and associated spinal cord injury. The acceleration/deceleration of the head during the rebound resulted in the identified brain hemorrhages. The child came to rest secured within the CSS shell still restrained by its harness system.

The first responders removed the CSS from the Nissan by cutting the vehicle and LATCH restraints. The CSS was handed to a police officer responding to the crash. The officer was also a trained Child Safety Seat Technician. The officer/technician noted the harness straps appeared to be tight and the harness retainer clip was at an appropriate level. The child was unresponsive at that time. Resuscitation was initiated and the child was emergently transported to a regional trauma center. However, medical intervention was not able to revive the child and he was pronounced deceased 185 minutes post-crash.

ROW 2 RIGHT CHILD PASSENGER INJURY

The Emergency Room Records for this 8 month old child indicated that this occupant was not injured in the crash.

ROW 2 RIGHT CHILD PASSENGER KINEMATICS

The kinematics of the Row 2 right child would have been similar to the kinematics of the Row 2 left child. However, during the rebound phase of the ride-down, the child was not injured. His rebound was not as violent. He came to rest secured in the CSS and was not injured.

DISCUSSION

The major difference in the kinematics and ultimately the injury outcome of the child occupants are rooted in the unknown differences in the dynamic impact accelerations transmitted through the vehicle and the dynamic intrusion. In the left offset impact, the dynamic acceleration and intrusion will not be evenly distributed laterally across the vehicle. The magnitude of those properties will be greater in the left rear than in the right rear. The respective occupant's kinematic response in-turn will be driven by the profile and magnitude of that acceleration. The greater acceleration transmitted through the left rear occupant space resulted in a greater kinematic response and rebound of the left rear occupant. Additionally, the dynamic intrusion reduced the survival space for the left CSS and probably altered the interaction between the CSS and the front seat. The combined differences in the method/tightness of the restraints, the CSS angle and (respective) front seat position may also have been factors that contributed to the difference in injury outcome.

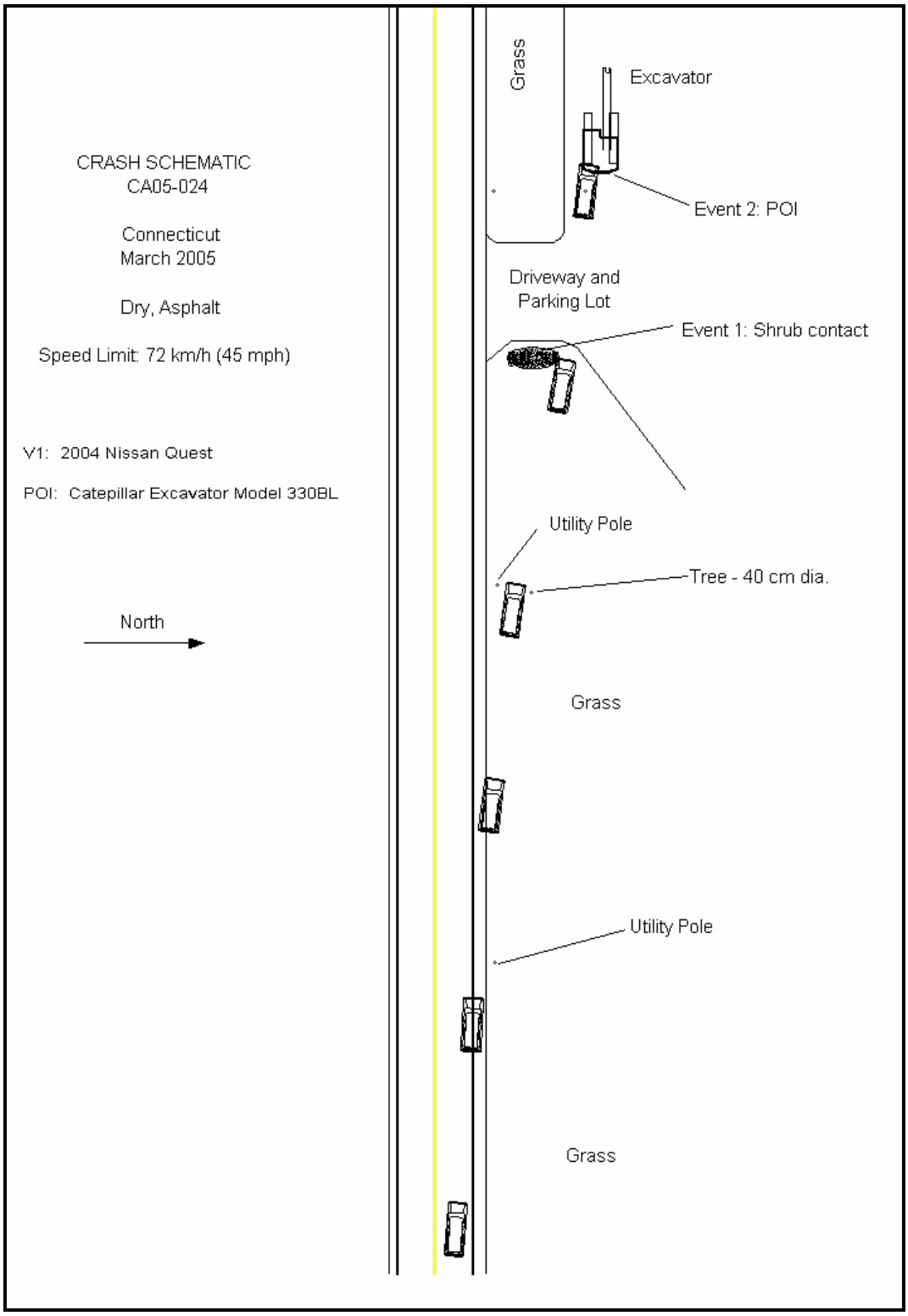

Figure 23: Crash Schematic.