TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

Veridian Engineering
Buffalo, New York 14225

VERIDIAN ON-SITE AIR BAG DEPLOYMENT/CHILD FATALITY INVESTIGATION

CASE NO. CA00-001

VEHICLE - 1997 NISSAN SENTRA

LOCATION - VIRGINIA

CRASH DATE - DECEMBER 1999

Contract No. DTNH22-94-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, DC 20590

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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 of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* CA00-001	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
		4. Weights	
5. *Title and Subtitle* Veridian On-site Air Bag Deployment/Child Fatality Investigation Vehicle - 1995 Hyundai Sonata Location - North Carolina		6. *Report Date*: February 2000	
		7. *Performing Organization Code*	
8. *Author(s)* Crash Research Section		9. *Performing Organization Report No.*	
10. *Performing Organization Name and Address* Transportation Sciences Crash Research Section Veridian Engineering P.O. Box 400 Buffalo, New York 14225		11. *Work Unit No.* CO1115 0259-(0000-9999)	
		12. *Contract or Grant No.* DTNH22-94-D-07058	
13. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, DC 20590		14. *Type of Report and Period Covered* Technical Report Crash Date: December, 1999	
		15. *Sponsoring Agency Code*	
16. *Supplementary Notes*:			

17. *Abstract*

This on-site investigation focused on a single vehicle/fixed object crash that involved a 1997 Nissan Sentra. The vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front right passenger air bags. The 26 year old female driver became distracted by her 4 month old daughter, originally seated in a rear facing Child Safety Seat (CSS) positioned in the front right seat. The driver reportedly reached over, removed the child from the CSS and was cradling the child across her chest. The driver failed to maintain directional control and allowed the Nissan to impact and mount a 15 cm (6 in) raised median. The force of the impact to the left front suspension was of sufficient magnitude to cause the deployment of the vehicle's frontal air bags. The child was stuck by the deploying driver air bag resulting in fatal closed head injuries.

The Special Crash Investigations team at Veridian/Calspan was informed of the crash by the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) on January 5, 2000. NHTSA subsequently assigned an on-site investigation of the crash to Veridian SCI the same day. Cooperation with the local police authorities was established and details regarding the on-site investigations were coordinated. Virginia's State Multi-disciplinary Crash Team participated in the on-site inspection.

18. *Key Words* Supplemental Restraint System, Air bag deployment Unrestrained, Skull fracture, Brain hemorrhages		19. *Distribution Statement* General Public	
20. *Security Classif. (of this report)* Unclassified	21. *Security Classif. (of this page)* Unclassified	22. *No. of Pages* 10	23. *Price*

TABLE OF CONTENTS

ONSITE AIR BAG DEPLOYMENT/CHILD FATALITY INVESTIGATION
VERIDIAN CASE NO: CA00-001

VEHICLE: 1997 NISSAN SENTRA
LOCATION: VIRGINIA
CRASH DATE: DECEMBER, 1999

BACKGROUND

This on-site investigation focused on a single vehicle/fixed object crash that involved a 1997 Nissan Sentra. The vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front right passenger air bags. The 26 year old female driver became distracted by her 4 month old daughter, originally seated in a rear facing Child Safety Seat (CSS) positioned in the front right seat. The driver reportedly reached over, removed the child from the CSS and was cradling the child across her chest. The driver failed to maintain directional control and allowed the Nissan to impact and mount a 15 cm (6 in) raised median. The force of the impact to the left front suspension was of sufficient magnitude to cause the deployment of the vehicle's frontal air bags. The child was stuck by the deploying driver air bag resulting in fatal closed head injuries.

The Special Crash Investigations team at Veridian/Calspan was informed of the crash by the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA) on January 5, 2000. NHTSA subsequently assigned an on-site investigation of the crash to Veridian SCI the same day. Cooperation with the local police authorities was established and details regarding the on-site investigations were coordinated. Virginia's State Multi-disciplinary Crash Team participated in the on-site inspection.

SUMMARY

Crash Site

This single vehicle crash occurred during the early morning hours of December, 1999, in a suburban area of a major metropolitan city. At the time of the crash, it was dark with street lights on and the weather was misty. The road surfaces were wet. The crash occurred at the 4-leg intersection of a four lane east/west road and two lane north/south road. The intersection was controlled by a standard (green/amber/red) traffic signal. **Figure 1** is a pre-crash trajectory view approximately 45 m (150 ft) east of the intersection. The primary roadway was in transition from a three lane undivided asphalt road (east of the intersection) to a four lane divided asphalt road

Figure 1: Westbound trajectory view approaching the intersection.

(west of the intersection). At the intersection, the road was configured with three westbound lanes and 1 wide eastbound lane. The inboard westbound lane was for left turning traffic, the center lane continued through the intersection and the outboard lane was for straight and/or right turning traffic. Note, the overhead signs in Figure 1. The opposing travel lanes (west of the intersection) were divided by a 15 cm (6 in) raised concrete median that measured 127 cm (50 in) in width. There was a gradual left curve in the westbound direction throughout the crash scene.

Figure 2 is a pre-crash trajectory view of the median, the point of impact. Note, the tire and scrape marks that developed as the vehicle mounted and overrode the median. The median appeared to have been struck numerous times by other vehicles. The divided traffic warning sign that marked the end of the median was missing. There appeared to be four different mounting locations for the warning sign. The sign was missing a the time of the crash. The speed limit in the area of the crash was 56 km/h (35 mph).

Figure 2: View of the raised median, west of the intersection.

Pre-Crash

The driver of the 1997 Nissan Sentra was an unrestrained 26 year old female. The driver's 4 month old daughter was the front right passenger. She was riding in a Century "Smart-fit Plus" Infant Child Safety Seat (CSS) positioned in a rear facing mode in the front right passenger seat. The investigating officer reported it was "loosely restrained" by the vehicle's seat belt. The seat belt was routed across the CSS. The vehicle's switchable seat belt retractor was being utilized. **Figure 3** is a post-crash view of the Child Seat's installation taken by the investigating officer. The CSS was given away after the crash and was not available for inspection.

Figure 3: Post-crash view of the Child Safety Seat installation.

The driver reportedly carried the infant from her home and placed her in the CSS, which was already positioned in the front right of the Nissan. She reportedly fastened the child into the CSS with its integral harness. The occupants of the Nissan were en-route to a hospital located approximately 1.6 km (1 mile) west of the crash site. They were traveling to the facility to check on the status of the child's father, who had just been admitted.

The Nissan Sentra was in the inboard westbound lane on the approach to the intersection. The vehicle was traveling within the 56 km/h (35 mph) speed limit. The driver was negotiating the left curve. The vehicle had traveled approximately 3.2 km (2 miles) prior to reaching the crash scene. The child began to whimper and cry. It was the driver's habit to pick-up the child whenever she began to cry or get fussy. She would breast feed the child on demand.

Approximately 183 m (600 ft) from the intersection, the driver reached to her right and removed the child from the CSS. Reportedly, she reached over with her left arm, unbuckled the child from the CSS and lifted her out of the seat. She was steering the vehicle with her knees. The driver bought the child across to the left front position and was cradling the child in her left arm, across her chest. She was face was up, looking toward the ceiling. Her feet were to the right of the driver. It was the driver's intension to comfort and soothe the child by nursing her. The driver reported she had nursed the child while driving on other occasions.

During the driver's distraction and inattention, the Nissan had entered and was traversing through the intersection. The vehicle had drifted to the left from its travel lane. The vehicle's trajectory was directed toward the nose of the raised concrete median, which began on the west side of the intersection. Refer to the crash schematic **Figure 4**.

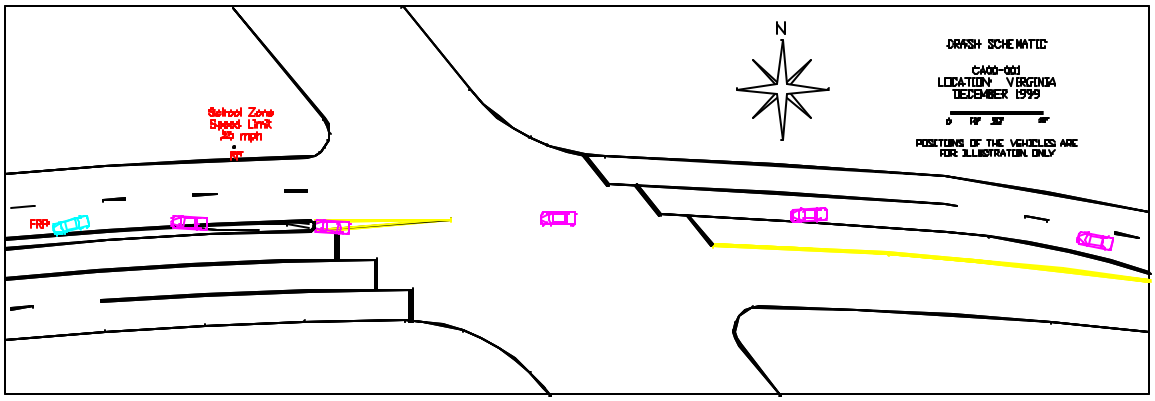

Figure 4: Crash Schematic

Crash

Immediately prior to the median impact, the driver had just returned her attention to straight ahead. In her interview, she indicated that she looked up, saw something (she did not know what it was) and the impact occurred. There were no pre-impact avoidance maneuvers. The force of the left front suspension impact with the concrete median caused the deployment of the vehicle's frontal air bags. The position of the child in the across the driver's chest placed the child directly in the path of the deploying driver air bag. The expanding driver air bag contacted the exposed left parietal aspect of the infants's head resulting in a skull fracture, massive brain hemorrhages and bilateral evulsion of the optic nerves. The driver was not injured.

The impact deformed the lower control arm of the left front suspension and bent the interior surface of the left front rim. The left front tire deflated. There were also contacts to the vehicle's engine cradle, transmission and oil pan. Refer to the Vehicle Exterior Damage Section of this report. The vehicle's left side tires mounted and traversed the median. Tire marks and rim scrapes across the median's surface defined the vehicle's trajectory. The vehicle traveled across the median a distance of 19 m (63 ft). The Nissan then re-entered the inboard westbound lane. The vehicle's trajectory was directed northwestward, approximately 7 degrees right relative to the road. The vehicle rolled to rest approximately 34 m (111 ft) from the point of impact facing southwestward. The left front tire was in contact with the median. During this post-crash phase, the vehicle traversed a counterclockwise arcing path. A combination of the drag caused by the deflated left front tire and the driver's possible counterclockwise (left) steering redirected the vehicle to the left.

Post-Crash

The driver exited the vehicle with the child in her arms and proceeded back to the service station in the northeast quadrant of the intersection. As she was in the process of calling 911, a police officer, en-route to the hospital (west of the crash site) on another matter, passed by. He stopped and immediately transported the driver and child to the facility. The child was admitted through the Emergency Room to the Pediatric Intensive Care Unit of the hospital and placed on life support. Surgical intervention was declined by the facilities neurosurgeons due the extent of the infant's head injuries. She was then transferred to a Level 1 Trauma Center approximately 3 hours post-crash. Surgical intervention was again declined due to the extent of the trauma. The child was maintained on life-support until the details regarding organ donation could be completed. The child was removed from life support approximately 17 hours post-crash and all of the child's viable organs were reportedly donated. An external examination by the Office of the Chief Medical Examiner was conducted the day after the crash.

After the police investigation was complete, the Nissan was removed from the crash scene by a flatbed truck. The vehicle was transported to the property of a friend of the driver. It remained there until it was inspected by the SCI team, 16 days post-crash.

AIR BAG VEHICLE DATA

The 1997 Nissan Sentra, 4-door sedan, was identified by a Vehicle Identification Number (VIN): 1N4AB41DXVC (production sequence deleted). The date of manufacture was 5/97. The vehicle was equipped with a Supplemental Restraint System that consisted of driver and front right passenger air bags. The power train consisted of a 1.6 liter, I4 engine linked to a 4-speed automatic transmission. The vehicle's brakes were a standard hydraulic front disc/rear drum system. The vehicle was not equipped with an anti-lock braking system (ABS). The vehicle was registered to the driver and had been her personal vehicle since 11/97. The odometer reading at the time of inspection was 84,640 km (52,594 miles).

The front interior consisted of cloth covered, manually adjustable bucket seats with reclining seat backs. The driver's seat was adjusted to a mid-to-rear track position. The position measured 4.6 cm (1.8 in)

forward of full-rear. The total seat track travel was 21.1 cm (8.3 in). The front right seat was adjusted to a mid-track position and measured 8.9 cm (3.5 in) forward of full rear.

The front seat belts were standard 3-point lap and shoulder belts, with a sliding latch plate. The front left retractor was a dual mode locking retractor, both webbing and vehicle sensitive. The adjustable D-ring was 2.5 cm (1.0 in) below full up. The total adjustment range was 7.5 cm (3.0 in). Evidence of historical use was found on both the latch plate and webbing. However, the SCI inspection found no contact evidence to support restraint usage in this crash. The driver also admitted she was not restrained.

The front right retractor was a switchable retractor specifically designed to restrain a Child Safety Seat (CSS). The locking mode was activated by fully extending the webbing, properly securing the CSS and then ratcheting the excess webbing back in the retractor. The appropriate warning labels and instructions were fixed to the webbing near the outboard anchor. The locking mode, reportedly, was in use at the time of the crash.

VEHICLE EXTERIOR DAMAGE

Figure 5 is an overall left front view of the Nissan Sentra. There was no direct contact nor damage to the vehicle's exterior body panels or uni-body structure. The vehicle's engine started and ran properly. The vehicle did sustain a direct impact to the left front wheel/suspension and associated contact to center and left regions of the undercarriage. The measurement of left wheelbase dimension indicated there was 5 cm (2 in) of residual rearward displacement. **Figure 6** is a view of the left front wheel depicting the deformation.

Figure 5: Left front view of the 1997 Nissan Sentra.

Figure 6: View of the left wheelbase displacement.

Upon completion of the exterior vehicle inspection, the Nissan was transported via a flatbed to a local garage. The vehicle was placed on a hydraulic lift in order to inspect the suspension and undercarriage. Removal of the left front tire revealed direct impact damage to the interior surface of the rim, **Figure 7**. The rim deformation caused the left front tire to deflate. Simultaneously with the rim impact, the lower control arm and forward undercarriage also impacted and overrode the median curb.

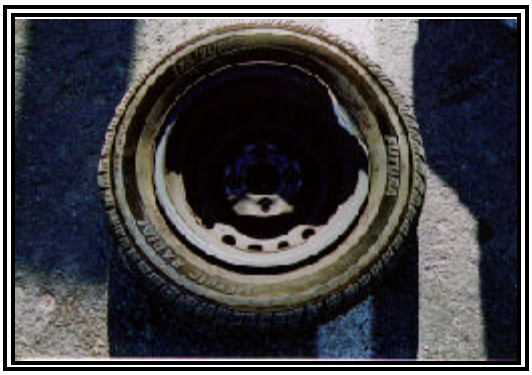

Figure 7: Left front rim deformation.

Figure 8 is an overall view of the forward undercarriage. Scraping-type damage was noted to the oil pan, exhaust system, engine cradle and transmission pan. The transmission was also note to have been leaking and was void of fluid. There was direct contact damage noted on the box-structure supporting the lower control arm. Refer to the top aspect of **Figure 9.** Surface stresses were noted on the exterior surfaces of trailing arm (refer to the arrow in center of Figure 9). These stresses developed due to the bending moment induced by the offset impact force on the left front rim. Concrete residue was observed throughout this area and on the surfaces of the lower control arm

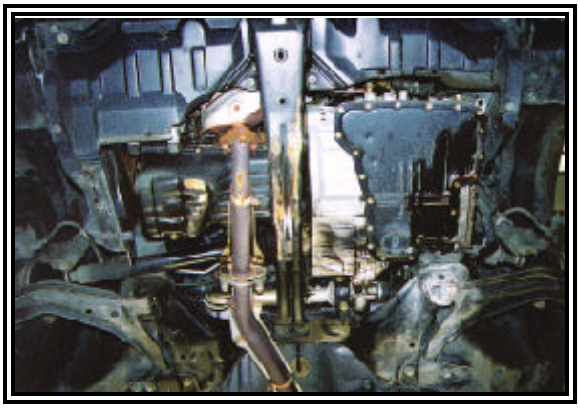

Figure 8: Overall view of the forward undercarriage.

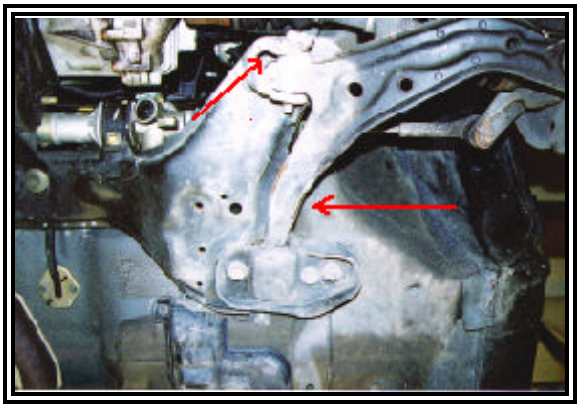

Figure 9: View of the lower control arm of the left front suspension.

The Collision Deformation Classification (CDC) of the damage was 12-UFYW-01. A crash severity/delta V analysis for the Nissan was not possible using the traditional Crash Models (i.e. WINSMASH). The nature of the Nissan's undercarriage damage was not applicable as a model input. Forensic analysis based on SCI experience indicated the delta V experienced in the crash was approximately 8 to 16 km/h (5 to 10 mph). However, the magnitude and duration of the impact's deceleration was above the deployment threshold criteria of the Nissan's Supplemental Restraint System. The above threshold condition properly commanded deployment of the vehicle's frontal air bags.

VEHICLE INTERIOR DAMAGE

There was no interior damage to the vehicle that could be directly related to the forces of the crash. The windshield and side glazings were not fractured and were free of defects. The surfaces of the driver knee bolster did not exhibit any contact evidence. There was no deformation of the steering wheel rim nor loading of the steering column shear capsules. The vehicle was equipped with a tilt steering column adjusted to the full upright position. The only interior vehicular damage was the deployment of the driver and front right passenger air bags.

SUPPLEMENTAL RESTRAINT SYSTEM

The 1997 Nissan Sentra was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front right passenger air bags. The SRS consisted of a single point sensing system controlled by a Diagnostic Sensor Unit located in the occupant compartment, under the center console. There were no remote satellite sensors in the engine compartment.

The driver air bag was configured in the typical manner in the center hub of the steering wheel. It deployed from an H-configuration module. The module's cover flap measured 14.0 cm (5.5 in) in width. The height of the upper and lower flaps were 10 cm (4.0 in) and 3.8 cm (1.5 in), respectively. There was no contact evidence identified on either cover flap.

The diameter of the deflated driver air bag measured 66 cm (26 in). It was vented by two, 5 cm (2 in) diameter, ports located in the 11/1 o'clock sectors on the back side of the bag. The bag was tethered by four 6.4 cm (2.5 in) wide straps sewn to the face of the bag. The surfaces of the air bag fabric were free of any contact evidence. Refer to **Figure 10.** The following nomenclature was located on the back side of the bag in its 12 o'clock sector:

Nissan HF
98570-89911-C1
0005076
04 04 97

The front right passenger air bag, **Figure 11**, was a top-mount design located in the typical manner in the right aspect of the instrument panel. The H-configuration module cover flaps were constructed of vinyl. The cover flaps center seam measured 125 cm (10 in). The height of the upper and lower flap measured 5.0 cm (2.0 in) and 4.6 cm (1.8 in), respectively. The passenger bag was not tethered. It was vented by two, 6.4 cm (2.5 in) diameter, ports located on the side panels of the bag. The face of the bag measured 38 cm x 40 cm (15 in x 16 in), width by height, and extended 50 cm (20 in) from the module, in its deflated state. No contact evidence was identified on the surfaces of the air bag.

Figure 10: Driver air bag.

Figure 11: Front right passenger air bag.

OCCUPANT DEMOGRAPHICS

	Driver	***Front Right Passenger***
Age/Sex:	26 year old/female	4 month old/female
Height:	178 cm (70 in)	58 cm (23 in)
Weight:	73 kg (160 lb)	7.1 kg (15.6 lb)
Restraint Usage:	Unrestrained	None, cradled by the driver
Usage Source:	SCI inspection	Driver statement/SCI investigation
Medical Treatment:	None	Transported to local hospital and transferred to Level 1 Trauma Center

OCCUPANT INJURIES

Driver

The driver of the Nissan was not injured in the crash.

Front Right Passenger Injuries

Injury	***Injury Severity (AIS 90)***	***Injury Mechanism***
Sub-arachnoid hemorrhage	Serious (140684.3,9)	Driver air bag
Intra-parenchymal hemorrhage	Severe (140638.4,9)	Driver air bag

Injury	*Injury Severity (AIS 90)*	*Injury Mechanism*
Sub-dural hemorrhage	Severe (140650.4,9)	Driver air bag
Cerebral edema (left side)	Serious (140668.3,2)	Driver air bag
Vault fracture (left parietal)	Moderate (150400.2,2)	Driver air bag
Edema of the Occiput	Serious (140454.3,6)	Driver air bag
Bilateral evulsion of the Optic nerve	Moderate (130608.2,3)	Driver air bag

Note: the above injuries were identified in Medical Examiners Investigative Report. All injuries were diagnosed by CT Scan.

OCCUPANT KINEMATICS

The 26 year old female driver was unrestrained and seated in a mid-to-rear track position consistent with her stature. The 4 month old female child was initially seated in a rear facing Child Safety Seat (CSS), improperly restrained in the front right passenger seat. The vehicle was westbound in the inboard lane. The vehicle was traversing a gradual left curve and approaching the subject intersection. The occupants had traveled approximately 3.2 km (2 miles) since the beginning of the trip. Their destination was a hospital located approximately 1 mile west of the crash. The child was whimpering and began to cry.

Approximately 183 m (600 ft) from the intersection, the driver became distracted and turned to her right to comfort the child. She reported that she reached over with her left arm and removed the child from the CSS. She was steering the vehicle with her knees. The driver brought the child over into her lap. She indicated she was cradling the child with her left arm across her chest. It was her intent to begin to nurse the child. The investigating officer reported the driver had said she had previously nursed the baby while driving.

During this distraction, the driver had relinquished directional control, thus allowing the vehicle to drift to the left from its intended lane of travel. The vehicle was traveling through the intersection on its pre-crash trajectory in-line with the 15 cm (6 in) raised concrete median. The distracted driver returned her attention to straight ahead, stated she saw "something" (she did not recall what it was) and the impact occurred. There were no pre-crash avoidance maneuvers.

The left front suspension and forward undercarriage of the Nissan struck and mounted the median. The force of the 12 o'clock direction of the impact was of sufficient magnitude to command the deployment of the vehicle's Supplemental Restraint System. The driver and front right passenger air bags deployed. The cover flaps of the driver air bag module rotated open and the expanding driver air bag struck the child, now

cradled in front of the driver, early during its inflation. The air bag struck the exposed left parietal aspect of the infant's head and expanded across the child and driver's chest. The impact and expansion of the driver air bag to the child's fragile head resulted in a skull fracture, massive brain hemorrhages and bilateral evulsion of the optic nerves.

The unrestrained driver responded to the 12 o'clock direction of the impact force by initiating a forward trajectory. Her motion may have been modulated (minimized) by her right arm and/or lower extremities due to the (relatively) low deceleration level of the impact. Any forward motion by the driver would have increased the load applied to the child. The driver contacted the expanded air bag and then rebounded back into her seat with the child still cradled in her right arm.