TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

Veridian Engineering
Buffalo, NY 14225

VERIDIAN REMOTE AIR BAG RELATED CHILD PASSENGER FATALITY INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

VERIDIAN CASE NO. CA01-015

VEHICLE - 1994 PLYMOUTH VOYAGER

LOCATION - STATE OF GEORGIA

CRASH DATE - NOVEMBER 1998

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 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 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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* CA01-015	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* Veridian Remote Air Bag Related Child Passenger Fatality Investigation Vehicle: 1994 Plymouth Voyager Location: State of Georgia		5. *Report Date*: October 2001 6. *Performing Organization Code*	
7. *Author(s)* Crash Data Research Center		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Sciences Crash Data Research Center Veridian Engineering P.O. Box 400 Buffalo, New York 14225		10. *Work Unit No.* C01115.0333.(0000-0009) 11. *Contract or Grant No.* DTNH22-94-D-07058	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		13. *Type of Report and Period Covered* Technical Report Crash Date: November 1998 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* Remote investigation of a front-to-rear crash that resulted in the deployment of the frontal air bag system in a 1994 Plymouth Voyager and the death of the 4-year-old front right child passenger.			
16. *Abstract* This remote investigation focused the injury mechanisms for an unrestrained 4-year-old male front right passenger who was seated in a 1994 Plymouth Voyager that was equipped with frontal air bags for the driver and front right passenger positions. The 4-year-old unbuckled the manual restraint prior to the crash, and the driver became distracted while trying to restrain the child. The Voyager impacted a 1985 Chevrolet S-10 Blazer in a front-to-rear configuration which was sufficient to deploy the Voyager's frontal air bag system. The restrained 30-year-old female driver initiated a forward trajectory and loaded the manual restraint and the deployed driver's air bag. She did not sustain injury and did not receive medical treatment. The unrestrained 4-year-old was shielding his body and had his right arm extended forward. He was struck in the arm by the air bag cover flap which resulted in a right forearm contusion. His legs struck the lower instrument panel which resulted in lower extremity contusions. He initiated a forward trajectory and was struck by the deploying front right passenger's air bag. The air bag expanded against his arms, face, and anterior neck which resulted in extensive contusion involving the face and neck, rupture of the ligamentous attachments between the base of the skull and C1 and C2 resulting in severe subluxation and spinal cord impingement, severe diffuse subarachnoid hemorrhage of soft tissues and musculature at the base of the skull, severe cerebral edema, extensive cerebral subarachnoid hemorrhage, focal small cortical contusions, and focal scalpular contusions. Contact with the air bag also resulted in extensive abrasions to the right upper chest and shoulder, extensive bilateral pulmonary contusions with right lung collapse, extensive mediastinal and paravesicular hemorrhage, and extensive abrasions and contusions of the upper extremities. The child came to rest on the floor pan area. He was transported by ambulance to a local hospital where he was pronounced dead 1.5 hours after the crash. A 9-year-old male child was reportedly lying laterally, unrestrained on the right position of the second seat. He sustained a forehead contusion and was transported by ambulance to a local hospital. His admission status was not reported.			
17. *Key Words* Frontal air bags Child passenger fatality		18. *Distribution Statement* General Public	
19. *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 15	22. *Price*

TABLE OF CONTENTS

REMOTE AIR BAG RELATED CHILD PASSENGER FATALITY INVESTIGATION
SCI SUMMARY TECHNICAL REPORT
VERIDIAN CASE NO. CA01-015
SUBJECT VEHICLE - 1994 PLYMOUTH VOYAGER
LOCATION - STATE OF GEORGIA
CRASH DATE - NOVEMBER 1998

BACKGROUND

Figure 1. Interior view of 1994 Plymouth Voyager

This remote investigation focused the injury mechanisms for an unrestrained 4-year-old male front right passenger who was seated in a 1994 Plymouth Voyager **(Figure 1)** that was equipped with frontal air bags for the driver and front right passenger positions. The 4-year-old unbuckled the manual restraint prior to the crash, and the driver became distracted while trying to restrain the child. The Voyager impacted a 1985 Chevrolet S-10 Blazer in a front-to-rear configuration which was sufficient to deploy the Voyager's frontal air bag system. The restrained 30-year-old female driver initiated a forward trajectory and loaded the manual restraint and the deployed driver's air bag. She did not sustain injury and did not receive medical treatment. The unrestrained 4-year-old was shielding his body and had his right arm extended forward. He was struck in the arm by the air bag cover flap which resulted in a right forearm contusion. His legs struck the lower instrument panel which resulted in lower extremity contusions. He initiated a forward trajectory and was struck by the deploying front right passenger's air bag. The air bag expanded against his arms, face, and anterior neck which resulted in extensive contusion involving the face and neck, rupture of the ligamentous attachments between the base of the skull and C1 and C2 resulting in severe subluxation and spinal cord impingement, severe diffuse subarachnoid hemorrhage of soft tissues and musculature at the base of the skull, severe cerebral edema, extensive cerebral subarachnoid hemorrhage, focal small cortical contusions, and focal scalpular contusions. Contact with the air bag also resulted in extensive abrasions to the right upper chest and shoulder, extensive bilateral pulmonary contusions with right lung collapse, extensive mediastinal and paravesicular hemorrhage, and extensive abrasions and contusions of the upper extremities. The child came to rest on the floor pan area. He was transported by ambulance to a local hospital where he was pronounced dead 1.5 hours after the crash. A 9-year-old male child was reportedly lying laterally, unrestrained on the right position of the second seat. He sustained a forehead contusion and was transported by ambulance to a local hospital. His admission status was not reported.

This crash was identified through a search of the Fatality Analysis Reporting System (FARS) for child fatalities that occurred in vehicles equipped with air bags. The crash occurred in November 1998 and was assigned to the Veridian Special Crash Investigations Team on January 29, 2001 as a remote investigation effort. Police photographs, a police crash report, an autopsy report and autopsy photographs were obtained which provide the basis for this narrative report.

SUMMARY

Crash Site

This crash occurred during the nighttime hours of November 1998 on a two-lane city roadway **(Figure 2)** east of a four-leg intersection. At the time of the crash, it was dark with no roadway illumination. The weather was clear and the asphalt roadway surface was dry. The east/west roadway consisted of two travel lanes separated by a center left turn lane. The roadway was also configured with right turn lanes on the outboard aspects and bordered by concrete curbs. The roadway was straight and had a level grade. The roadside environment consisted of commercial buildings and parking lots. The posted speed limit was 72 km/h (45 mph). A three phase traffic signal controlled traffic flow through the intersection west of the crash site.

Figure 2. Eastbound view of crash scene

Pre-Crash

According to the driver's statement, the 4-year-old male child had been previously restrained in an integral child safety seat located in the second seat of the Plymouth Voyager. The 9-year-old child had been seated in the front right position restrained by the manual restraint. After a brief stop where the occupants had exited the vehicle, the 4-year-old verbalized that the integral harness system was too tight and uncomfortable. The 30-year-old female driver restrained the 4-year-old in the front right seat with the manual 3-point lap and shoulder belt and told the 9-year-old to sit on the second bench seat in the van.

As the driver of the Voyager was operating the vehicle in an easterly direction on the two-lane city roadway, the 4-year-old began to fidget on the seat in an attempt to see out of the right front side window. When the Voyager approached the four-leg intersection, the driver detected that the 4-year-old had released the buckle of the manual restraint system. The driver reached with her right hand and turned her head to the right, in an attempt to re-buckle the manual restraint. Due to the distraction, she failed to detect the Chevrolet S-10 Blazer straddling the center left turn lane ahead of the Voyager. The Blazer was stopped and waiting to turn left into a parking lot. There did not appear to be any avoidance maneuvers, however, it was likely that the driver of the Voyager applied the brakes upon recognition of the impending crash. This was evidenced by the forward position of the front right child passenger at impact.

Crash

The front aspect of the Plymouth Voyager impacted the rear of the Chevrolet Blazer. The probable directions of force were in the 12 o'clock and 6 o'clock sectors for the Voyager and Blazer, respectively. There were no available photographs of the Voyager's exterior damage and a crush profile could not be accurately estimated for the Blazer. Therefore, the crash could not be reconstructed using the damage algorithm of the WinSMASH program. Based on air bag deployment in the Voyager and limited photographs of the Blazer, the Voyager's delta-V was probably in the 16 - 24 km/h (10 - 15 mph) range. The Blazer was deflected forward and to the left from the impact. It traveled onto the center left turn lane

in a tracking mode and came to rest facing east. The Voyager was deflected to the right and traveled across the eastbound lane and onto the adjacent right turn lane. A single tire mark was visible in the on-scene police photographs in the post-crash trajectory of the Voyager. The Voyager came to rest in the eastbound right turn lane facing southeast.

Post-Crash

Witness reports and statements taken by police were the basis for post-crash events. After the Voyager came to rest, the 4-year-old was found on the front right floor area of the vehicle. The female driver removed him from the floor and exited the vehicle with the unresponsive child in her arms. She placed the child on the roadway where passers-by initiated first aid prior to the arrival of police and rescue personnel. The 9-year-old male child exited the Voyager under his own power. The driver of the Voyager was uninjured and accompanied both children to the hospital. The 9-year-old child passenger sustained a minor injury and was transported by ambulance to a local hospital, however, his admission status was not reported. The unresponsive 4-year-old child passenger sustained severe closed head injuries and C-spine injuries and was transported by ambulance to a local hospital where he was pronounced dead 1.5 hours following the crash.

VEHICLE DATA - 1994 Plymouth Voyager

The 1994 Plymouth Voyager was identified by the Vehicle Identification Number (VIN): 2P4GH2532RR (production sequence omitted). The vehicle was a three-door mini-van that was equipped with a 3.0 liter, 6 cylinder engine, front-wheel drive, an automatic three-speed transmission, cruise control, power brakes, and power steering. Interior features included tinted glazing, a tilt steering wheel, rigid plastic knee bolster, and two integrated child restraints in the second bench seat. The tilt steering wheel appeared to be between the mid position and full-down position in the police photographs. The vehicle's exact mileage was not reported, however, based on an oil change reminder sticker affixed to the windshield that was one month overdue, the mileage was approximately 74,000 km (46,000 miles).

Based on interior photographs of the front seat positions in the Plymouth Voyager and vehicle specifications, the Voyager seating was configured with box-mounted front bucket seats and second and third bench seats. The inboard aspects of the front bucket seats were configured with arm rests, and a forward sliding storage drawer was present under the right front seat. Both front bucket seats appeared to be in the mid-track position in the police photographs. Two integrated child safety seats with five-point harness systems, new for the 1994 model year, were present in the outboard positions of the second bench seat. Based on vehicle specifications, the seat back of the second seat was equipped with a two-position recline feature that allowed an additional 22 degree recline position for enhanced sleeping comfort of children restrained in the integral child safety seats.

VEHICLE DAMAGE

Exterior Damage - *1994 Plymouth Voyager*

There were no available photographs of the exterior of the 1994 Plymouth Voyager. The police reported extensive damage to both vehicles.

Interior Damage - *1994 Plymouth Voyager*

Interior damage to the 1994 Plymouth Voyager appeared to be minor and was attributed to occupant contact. There did not appear to be any intrusions. The top left windshield laminate was fractured **(Figure 3)** from probable contact from the driver's left hand. Transfers on both air bag membranes were noted in the police photographs from occupant contact. Additional contacts could not be determined from the available photographs.

Figure 3. Fractured windshield

Exterior Damage - *1984 Chevrolet Blazer*

The 1984 Chevrolet Blazer sustained moderate damage as a result of the rear impact with the Plymouth Voyager **(Figure 4)**. The direct damage began at the centerline on the rear lift gate and extended laterally to the right bumper corner. The combined direct and induced damage involved the entire rear width of the Blazer. The bumper and lift gate were crushed forward on the right side, and the right rear quarter panel sustained induced buckling. A crush profile could not be estimated from the available photographs. The Collision Deformation Classification (CDC) for the impact with the Voyager was 06-RZEW with an unknown extent zone.

Figure 4. Damaged 1984 Chevrolet Blazer

MANUAL RESTRAINT SYSTEM - 1994 Plymouth Voyager

The front seating positions in the Plymouth Voyager were configured with manual 3-point lap and shoulder belts with lightweight locking latch plates. Both positions of the second bench seat and the outboard positions of the third bench seat were equipped with manual 3-point lap and shoulder belts with lightweight locking latch plates. The center position of the third bench seat was configured with a lap belt.

Two integral child safety seats were configured in the second bench seat back. The forward aspect of the seat back folded forward to expose the 5-point harness system and acted as the seat cushion for the child safety seat. The harness straps were configured with a plastic harness retainer clip.

FRONTAL AIR BAG SYSTEM - *1994 Plymouth Voyager*

The 1994 Plymouth Voyager was equipped with frontal air bags for the driver and front right positions. The driver's air bag **(Figure 5)** was housed in the center of the steering wheel. The air bag deployed from H-configuration module cover flaps that were symmetrical in shape. There did not appear to be any damage or occupant contact with the driver's module cover flaps. The driver's air bag was circular in shape. It could not be determined if the air bag was vented by external ports or tethered. A probable makeup transfer from the driver's face was located on the center aspect of the driver's air bag membrane **(Figure 6)**.

Figure 5. Driver's air bag

Figure 6. Probable makeup transfer on driver's air bag

The front right passenger's air bag deployed from a top-mount module **(Figure 7)** with a single cover flap design hinged at the forward aspect. The cover flap was rectangular in shape. It could not be determined if the air bag was vented or tethered from the available photographs. What appeared to be a red and blue fabric transfer **(Figure 8)** was identified on the front right passenger's air bag from the 4-year-old's shirt. A probable tissue transfer from the child's exposed neck was also noted on the top center aspect of the air bag membrane.

Figure 7. Front right passenger's air bag

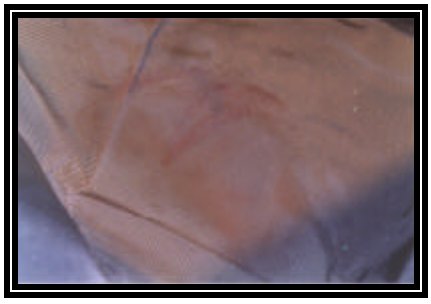

Figure 8. Transfer on front right passenger's air bag

OCCUPANT DEMOGRAPHICS - 1994 Plymouth Voyager

Driver

Age/Sex:	30-year-old female
Height:	163 cm (64")
Weight:	45 kg (100 lb)
Seat Track Position:	Mid-track in police photographs
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Police report
Eyewear:	Unknown
Type of Medical Treatment:	Not injured and accompanied children to the hospital in the ambulance

Driver Kinematics

The 30-year-old female driver was restrained by the manual 3-point lap and shoulder belt. She was leaning to the right with her right arm extended laterally, attempting to buckle the manual restraint for the 4-year-old child in the front right position. She regained an upright posture prior to the impact. At impact, the driver's air bag deployed and she initiated a forward trajectory. She loaded the manual restraint and the deployed driver's air bag with her face, evidenced by a makeup transfer on the center aspect of the air bag membrane. There were no police reported injuries, although a fracture of the windshield laminate on the upper left aspect of the windshield suggests a possible fling contact from the left hand as a result of the hand deflection from the steering wheel from air bag expansion. She exited the vehicle under her own power and removed the front right child passenger. She refused medical treatment at the scene and accompanied the children in the ambulance to a local hospital.

Front Right Child Passenger

Age/Sex:	4-year-old male
Height:	107 cm (42")
Weight:	17 kg (38 lb)
Seat Track Position:	Mid-track in police photographs
Manual Restraint Use:	Unrestrained
Usage Source:	Injury data, driver's statement, police report
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local hospital and was pronounced dead 1.5 hours following the crash

Front Right Child Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
3.0 cm (1.0") diameter region of subarachnoid hemorrhage about the pituitary stalk	Critical (140210.5,8)	Front right passenger's air bag
Severe brain edema with marked flattening of the sulci and gyri with a mild degree of softening	Critical (140666.5,9)	Front right passenger's air bag
Extensive bilateral pulmonary contusion with right lung collapse	Severe (441410.4,3)	Front right passenger's air bag
Extensive subarachnoid hemorrhage of superior surface of cerebral hemispheres	Serious (140466.3,6)	Front right passenger's air bag
0.2 cm (0.1") diameter contusion in the cortex of the inferior surface of the mid-portion of the right temporal lobe	Serious (140606.3,1)	Front right passenger's air bag
Right and left subarachnoid hemorrhage over the parietal regions, each approximately 5.0 cm (2.0") in diameter	Serious (140684.3,1) Serious (140684.3,2)	Front right passenger's air bag
Subluxation of C1 and C2 with the dens of C2 protruding into the foramen magnum with severe impingement upon the upper cervical spinal cord and disruption of ligamentous attachment between the base of the skull and C1 with extensive hemorrhage of surrounding soft tissue and musculature	Serious (650206.3,6)	Front right passenger's air bag
2.0 cm (0.8") diameter left temporal scalp contusion	Minor (190402.1,2)	Possible fling from left hand or driver's right hand

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
15.0 cm (5.9") in length, large, irregular, triangular abrasion that began over the suprasternal notch, extended superiorly and to the right beneath the right ear and extended across the right cheek, right side of the chin, and across the right jaw line	Minor (290202.1,1) Minor (290202.1,1) Minor (290202.1,8) Minor (390202.1,5) Minor (490202.1,1)	Front right passenger's air bag
2.0 x 5.0 cm (0.8 x 2.0") purple contusion on the mid-portion of the upper lip	Minor (290402.1,8)	Front right passenger's air bag
Right upper chest contusion at the top of the shoulder extending to below the clavicle	Minor (490402.1,1)	Front right passenger's air bag
Discontinuous right arm abrasion measuring 25.0 x 5.0 cm (9.8 x 2.0") from the shoulder to the wrist	Minor (790202.1,1)	Front right passenger's air bag
Two superficial abrasions on the anterior left forearm	Minor (790202.1,2)	Front right passenger's air bag
7.0 cm (2.8") diameter contusion on the dorsal surface of the right hand	Minor (790402.1,1)	Right A-pillar
Right anterior forearm contusion	Minor (790402.1,1)	Front right passenger's air bag cover flap
5.0 cm (2.0") diameter contusion on the left upper arm	Minor (790402.1,2)	Front right passenger's air bag
1.0 cm (0.4") diameter contusion on the lateral aspect of the right knee and a 1.5 cm (0.6") diameter contusion on the anterior right lower leg midway between the knee and ankle	Minor (890402.1,1)	Front right lower instrument panel

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
1.0 cm (0.4") diameter contusion on the anterior superior iliac crest	Minor (890402.1,2)	Unknown

Injury source: Autopsy report, autopsy photographs

Front Right Child Passenger Kinematics

The 4-year-old front right child passenger was initially seated upright and restrained by the manual 3-point lap and shoulder belt. Prior to the impact, he began to fidget on the seat in an attempt to see out of the right front side window. He unbuckled the manual restraint and most likely moved forward on the seat cushion to allow his lower legs to clear the leading edge. The driver detected the removal of the seat belt, and attempted to re-secure the manual restraint prior to the crash. As the driver detected the impending collision, she regained an upright posture. Based on the child's injuries and position, his arms were extended forward in an effort to brace. The probability of pre-crash braking displaced the child further forward into the path of the front right passenger's air bag and placed his right arm forearm parallel to, and above, the leading edge of the cover flap and his head above the leading aspect of the module.

At impact, the frontal air bag system deployed and he initiated a forward trajectory. His legs struck the lower instrument panel which resulted in a 1.0 cm (0.4") diameter contusion on the lateral aspect of the right knee and a 1.5 cm (0.6") diameter contusion on the anterior right lower leg midway between the knee and ankle. The cover flap struck the anterior aspect of his right forearm which produced a right anterior forearm contusion. The air bag deployed from the top-mount module and projected his right hand into the right A-pillar which resulted in a 7.0 cm (2.8") diameter contusion on the dorsal surface of the right hand from the right A-pillar. He also sustained a 2.0 cm (0.8") diameter left temporal scalp contusion from the possible deflection of his left hand or the possible deflection of the driver's right hand. The air bag expansion against the child's arms resulted in a discontinuous right arm abrasion measuring 25.0 x 5.0 cm (9.8 x 2.0") from the shoulder to the wrist, and two superficial abrasions on the anterior left forearm. The contact of the air bag with the child's head caused a 3.0 cm (1.0") diameter region of subarachnoid hemorrhage about the pituitary stalk, severe brain edema with marked flattening of the sulci and gyri with a mild degree of softening, extensive subarachnoid hemorrhage of superior surface of cerebral hemispheres, a 0.2 cm (0.1") diameter contusion in the cortex of the inferior surface of the mid-portion of the right temporal lobe, right and left subarachnoid hemorrhage over the parietal regions, each approximately 5.0 cm (2.0") in diameter, and a 2.0 x 5.0 cm (0.8 x 2.0") purple contusion on the mid-portion of the upper lip. The expansion of the air bag hyper-extended the child's neck and resulted in a subluxation of C1 and C2 with the dens of C2 protruding into the foramen magnum with severe impingement upon the upper cervical spinal cord and disruption of ligamentous attachment between the base of the skull and C1 with extensive hemorrhage of surrounding soft tissue and musculature. Based on the soft tissue injuries to the face and neck, it appears the child's head may have been rotated counterclockwise (CCW).The expansion of the air bag also produced a 15.0 cm (5.9") in length, large, irregular, triangular abrasion that began over the suprasternal notch, extended superiorly and to the right beneath the right ear and extended across the right cheek, right

side of the chin, and across the right jaw line, a right upper chest contusion at the top of the shoulder extending to below the clavicle, an extensive bilateral pulmonary contusion with right lung collapse, and a 5.0 cm (2.0") diameter contusion on the left upper arm. The child was redirected rearward and fell onto the front right floor area.

The unresponsive 4-year-old child was removed from the vehicle by the driver and placed on the roadway. First aid was administered by passers-by until rescue personnel arrived on-scene. He was transported by ambulance to a local hospital and remained in respiratory and cardiac arrest on arrival. The child did not respond to advanced medical intervention and was pronounced dead 1.5 hours following the crash.

Second Seat Right Child Passenger

Age/Sex:	9-year-old male passenger
Height:	Not reported
Weight:	Not reported
Seat Track Position:	Fixed
Manual Restraint Use:	Unrestrained
Usage Source:	Statement from child in witness statement
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a local hospital, however, his admission status was not reported.

Second Seat Right Child Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Moderate forehead contusion	Minor (290402.1,7)	Possibly front left or front right seat back

Injury source: Police report, witness statements

Second Seat Right Child Passenger Kinematics

The 9-year-old male was positioned in the second seat of the Plymouth Voyager. He stated to EMS personnel that he had been lying on the seat prior to the crash. His exact orientation was not reported. At impact, he initiated a forward trajectory. Depending on his orientation, his head probably struck the front left or front right seat back, which resulted in a moderate forehead contusion. He stated that he came to rest on the floor area in front of the seat. He exited the vehicle under his own power and was treated by EMS personnel at the scene. He was transported by ambulance to a local hospital, however, his admission status was not reported.