Remote, Redesigned Air Bag Special Study
On-scene Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS99001
1998 Chevrolet Blazer
Maryland
September 1998

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. Abstract

This three vehicle crash occurred during the night hours of a weekend in September 1998. At the time of the crash it was dark and there were no street lights. The crash occurred in the south-bound travel lane of a two-lane north/south rural roadway. The posted speed limit for the area was 72 km/h (45 mph).The first other vehicle, a 1987 Nissan Pulsar with three occupants, was being driven north, negotiating a right turning curve in the northbound travel lane. As the Pulsar exited the curve (approximately 70 m [230 ft] south of the crash scene) it was in a left yaw. It appears that the driver over-steered to the left in an attempt to control the yaw, and the vehicle yawed right as it crossed the center line into the southbound travel lane and the travel path of the second other vehicle, a 1988 Chevrolet Camaro. The Camaro was being driven south, in the southbound travel lane approximately 61 to 76 m (200 to 250 ft) ahead of the the case vehicle, at an undetermined speed. The right front plane of the Pulsar impacted the left front plane of the Camaro. After impact, the Camaro appears to have been brought to a controlled stop at the west edge of the southbound travel lane approximately 11 m (35 ft) south of the point of impact (POI). After impact with the Camaro, the Pulsar began a counterclockwise rotation of approximately 270^0, while moving northwest approximately 24 m (80 ft), and the left rear corner impacted a small dirt embankment immediately adjacent to the west edge of the roadway. At impact with the embankment it appears that the left rear occupant of the Pulsar was ejected through the back window/hatchback. Disengaging the embankment, the Pulsar continued the counterclockwise rotation for an additional 180E while moving north approximately 17 m (55 ft). During this rotation it appears that the driver was ejected through the left front window/door onto the east shoulder of the roadway. The case vehicle was being driven south, in the southbound travel lane. The driver observed the Pulsar rotating in his travel path; he braked and steered right in an attempt to avoid the Pulsar. The right front and rear wheels of the case vehicle departed the west edge of the roadway and entered a shallow, stone lined drainage ditch. With the left wheels in the southbound travel lane and the right wheels in the shallow ditch, the case vehicle continued south approximately 17 m (55 ft) where the right front wheel impacted a large rock imbedded in the ditch. The front of the case vehicle was deflected left by the rock impact, and the right side plane of the Pulsar impacted the front plane of the case vehicle in a right angle configuration. The case vehicle came to final rest, facing south, at the POI. The Pulsar rotated counterclockwise an additional 50E and came to final rest, facing south, with the right side plane maintaining contact with the left front side plane of Vehicle 1. The right front occupants of the case vehicle and the Pulsar were fatally injured in this crash.

17. Key Words	18. Distribution Statement
Air bag, deployment, injury, accident, fatality, passenger, redesigned, RABSS,	

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Dynamic Science, Inc.
Accident Investigation
Case Number: DS99001

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BACKGROUND:

Description: This on-scene investigation focused on the redesigned air bag system deployment of a 1998 Chevrolet Blazer. The case vehicle, a 1998 Chevrolet Blazer, was equipped with a Supplemental Restraint System (SRS) that consisted of depowered driver and right front passenger air bags that deployed in the crash. The driver of the case vehicle sustained major injuries consisting of fractures, dislocations, contusions and abrasions; maximum AIS = AIS-3. The front right occupant sustained fatal chest injuries of an unknown nature. The two rear seat occupants were reported, by police, to have sustained minor injuries of an unknown nature or severity. NHTSA was notified of this crash through the Crash Injury Research and Engineering Network on January 8, 1999. NHTSA assigned this investigation to the DSI Special Crash Investigations team on January 8, 1999. The on-site inspection, which occurred within 24 hours of notification, had been completed on September 14, 1998.

Investigation Type: On-Scene

Crash Location: Maryland
Crash Date: September 1998
Notification Date: January 8, 1999
Field Work Completed: September, 1998

SUMMARY:

This three vehicle crash occurred during the night hours of a weekend in September 1998. At the time of the crash it was dark and there were no street lights. The weather was clear, there was no precipitation and the road surface was dry and free of defects. The crash occurred in the south-bound travel lane of a two-lane north/south rural roadway. At the crash scene, the roadway was straight with a 4% upgrade for southbound traffic. The roadway was 8 m (26 ft) in width and was edged on the east by a 0.9 m (3 ft) asphalt shoulder. The travel lanes were delineated by white fog lines and a double yellow center line. The posted speed limit for the area was 72 km/h (45 mph).

Figure 1. Path of case vehicle to area of impact.

According to the police report, and scene evidence, the crash occurred in the following manner. The first other vehicle, a 1987 Nissan Pulsar with three occupants, was being driven north, negotiating a right turning curve in the northbound travel lane, at a speed estimated to have been between 113 and 121 km/h (70 and 75 mph). The radius of the curve was 85 m (280 ft), and the computed critical speed was 89.9 km/h (55.9 mph)[1]. As Vehicle 2 exited the curve (approximately 70 m [230 ft] south of the crash scene) it was in a left yaw. It appears that the driver over-steered to the left in an attempt to control the yaw, and the vehicle yawed right as it crossed the center line into the southbound travel lane and the travel path of the second other vehicle, a 1988 Chevrolet Camaro. The second other vehicle was being driven south, in the southbound travel lane approximately 61 to 76 m (200 to 250 ft) ahead of the Vehicle 1, at an undetermined speed. The right front plane of the Pulsar impacted the left front plane of the Camaro. After impact, the Camaro appears to have been brought to a controlled stop at the west edge of the southbound travel lane approximately 11 m (35 ft) south of the point of impact (POI).

Figure 2. Exterior, case vehicle

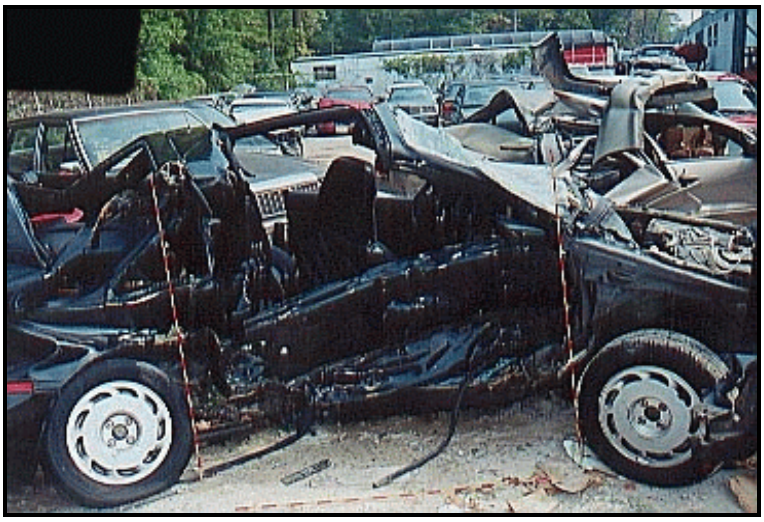

Figure 3. Exterior, Nissan Pulsar

After impact with the Camaro, the Pulsar began a counterclockwise rotation of approximately 270^0, while moving northwest approximately 24 m (80 ft), and the left rear corner impacted a small dirt embankment immediately adjacent to the west edge of the roadway. At impact with the embankment it appears that the left rear occupant of the Pulsar was ejected through the back window/hatchback.

Disengaging the embankment, the Pulsar continued the counterclockwise rotation for an additional 180E while moving north approximately 17 m (55 ft). During this rotation it appears that the driver was

[1]See Attachment 1

ejected through the left front window/door onto the east shoulder of the roadway.

The case vehicle was being driven south, in the southbound travel lane, at a speed estimated to have been between 64 and 72 km/h (40 and 45 mph) when the driver observed the Pulsar rotating in his travel path. The driver of Vehicle 1 braked and steered right in an attempt to avoid the Pulsar. The right front and rear wheels of the case vehicle departed the west edge of the roadway and entered a shallow, stone lined drainage ditch. With the left wheels in the southbound travel lane and the right wheels in the shallow ditch, the case vehicle continued south approximately 17 m (55 ft) where the right front wheel impacted a large rock imbedded in the ditch. The front of the case vehicle was deflected left by the rock impact, and the right side plane of Vehicle 2 impacted the front plane of the case vehicle in a right angle configuration. The case vehicle came to final rest, facing south, at the POI. The Pulsar rotated counterclockwise an additional 50E and came to final rest, facing south, with the right side plane maintaining contact with the left front side plane of the case vehicle. The right front occupants of the case vehicle and the Pulsar were fatally injured in this crash.

The forces involved in this crash exceeded the manufacturer's SRS threshold in the case vehicle and the driver's side and passenger's depowered air bags deployed.

Scene Diagram

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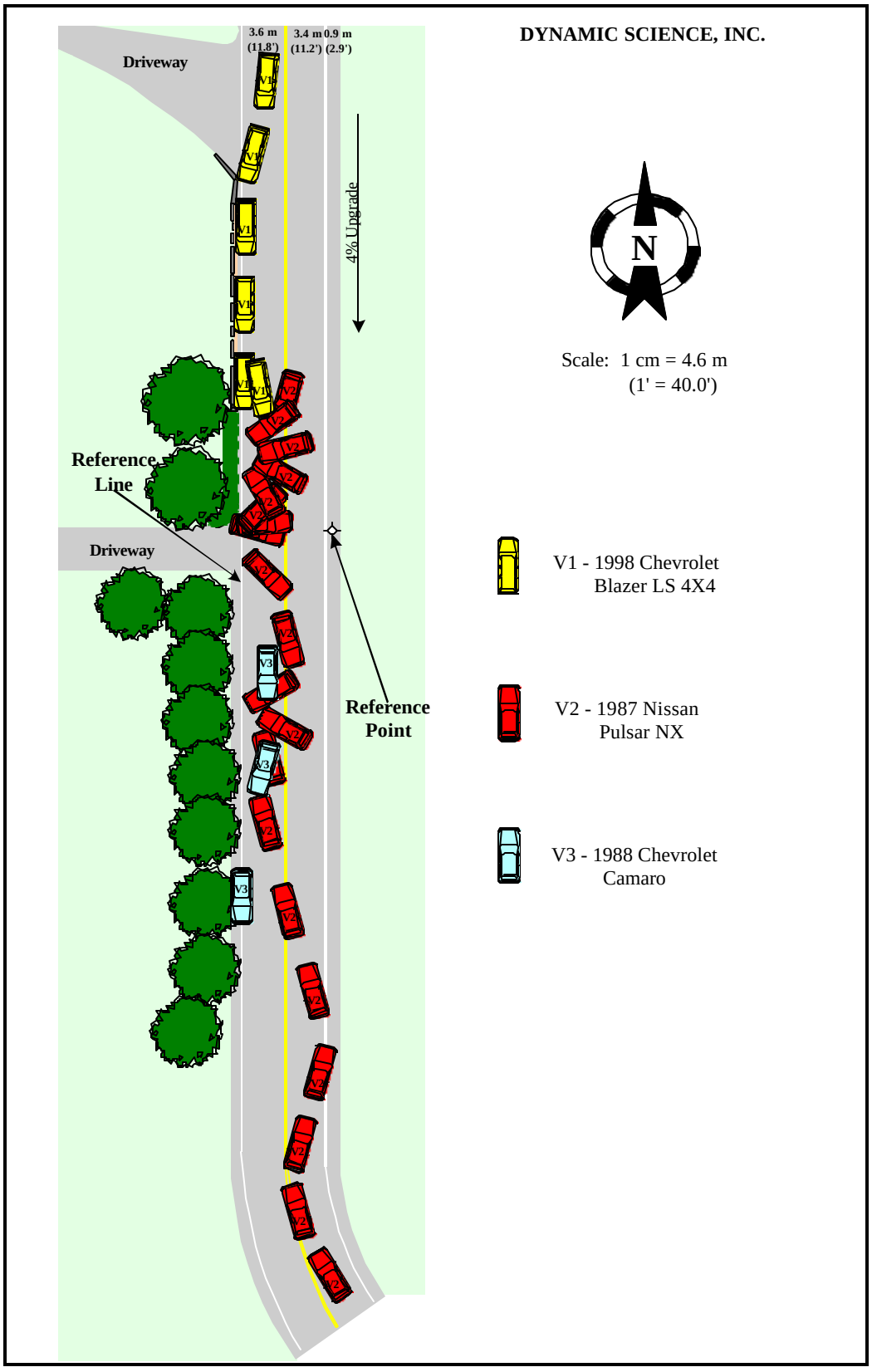

Figure 4. Scene diagram

DETAILED INFORMATION

Vehicles

Case vehicle

Description:	1998 Chevrolet Blazer LS 4-door 4x4	
VIN:	1GNDT13W9WKxxxxxx	
Odometer:	Unknown	
Engine:	4.3 liter V6	
Reported Defects:	None noted	
Cargo:	Wheel chair	
Damage Description:	The damaged components included the front bumper, hood, grille, left front fender, right front fender, left front door and the front suspension. The windshield was cracked full width by impact forces, and there was intrusion into the left floor/toe pan. The left front and rear doors were jammed shut, but the front door had been pried open for extrication at the crash scene. All four tires remained inflated. The only wheel damage was minor scratching of the right front wheel.	
CDC:	12FDEW2	
Delta V:	Total	32.1 km/h (20 mph)
	Longitudinal	-31.6 km/h (19.6 mph)
	Latitudinal	5.6 km/h (3.5)

The Blazer was a four-wheel drive, ½ ton multi-purpose vehicle equipped with a four-speed automatic transmission. The vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of depowered driver and right front passenger air bags. The vehicle was also equipped with a four-wheel anti-lock braking system.

The manual restraint system consisted of 3-point lap/shoulder restraints for the four outboard seating positions and a 2-point manual lap restraint for the center rear seating position. Each of the 3-point restraints consisted of a single retractor located at the base of the "B", or "C", pillar and a single, one-piece, webbing with a sliding latch plate. The four outboard "D" rings were not adjustable and did not reveal evidence of loading marks or abrading. However, the restraint webbing at all four outboard seating positions contained moderate load marks and abrasions. The left front and right front restraints

were equipped with Energy Management Loops (EML) that were extended at both seating positions. Based upon the above, and the reported injuries, all four occupants of the case vehicle were properly restrained at the time of the crash.

Figure 5. Exterior, case vehicle.

The vehicle's interior was fabric, gray in color. The front seats were box mounted bucket seats with reclining seat back rests and integral head rests. Both front seats were manually adjustable. The right front seat was located at the middle seat track position and the back rest was reclined approximately 15E. The left front seat was also adjusted to the middle seat track position and the back rest was deformed forward at an approximate 20E angle (this deformation appears to have been caused by the left rear occupant bracing for the crash by placing his feet on the back surface of the back rest).

Figure 6. Exterior, case vehicle.

The vehicle's steering column was a tilt column adjusted to the center position. The four spoke steering wheel rim was deformed approximately 2 cm (1 in) forward on its upper half.

The driver air bag module was located in the center of the steering wheel. The "I" type cover flaps opened as designed during the deployment sequence. The symmetrical flaps measured approximately 10 cm (4 in) vertically by 7 cm (3 in) horizontally. The driver's air bag was a tethered bag, approximately 60 cm (24 in) in diameter. The two internal tether straps, sewn to the center of the bags front surface, were located at approximately the 3:00 and 9:00 o'clock positions. During inspection, the tether straps allowed the deflated bag to extend approximately 28 cm (11 in) from the module. There were two 2.5 cm (1 in) diameter vent ports located at the 1:00 and 11:00 o'clock positions on the back side of the bag. The lower half of the air bag had several drops of post-crash blood, but there was no residual evidence of occupant contact with the bag.

Figure 7. Interior, case vehicle.

The passenger air bag module was a mid-mount housed in the right side of the instrument panel. The single module flap measured 31 cm (12 in) in width and 13 cm (5 in) in height, and was hinged at the bottom (opened outward and downward). The flap opened as designed during the deployment sequence. In its deflated state, the bag measured approximately 55 cm (22 in) in width and approximately 50 cm (21 in) in height at it's extended face. The air bag extended approximately 58 cm (21 in) outward from the module. The air bag was not tethered, and was vented by two 5 cm (2 in) diameter vent ports located at the 9:00 and 3:00 o'clock positions on the bag's side panels. There were abrasions/fabric transfers on the air bag fabric located on the face panel in the center-right quadrant. In addition, while not damaged, the face of the module flap was abraded indicating probable contact with the right front passenger during the deployment sequence.

Other vehicle

Description:	1987 Nissan Pulsar NX SE 3-door	
VIN:	JN1EN34S3HMxxxxxx	
Odometer:	181,537 km (112,805 miles)	
Engine:	I4 1.6 L	
Reported Defects:	None noted	
Cargo:	None	
Damage Description:	Extensive right side crash and extrication damage with a maximum crush depth of approximately 86 cm (34 in) at the right "B" pillar (maximum side extension)	
CDC:	03RPEW4	
Delta V:[2]	Total	58.8 (36.5 mph)
	Longitudinal	15.2 km/h (9.4 mph)
	Latitudinal	-56.8 km/h (-35.3 mph)

Figure 8. Exterior, Nissan Pulsar

[2] The total Delta V was computed, using WinSMASH 1.2.1 - CDC only.

Other vehicle

Description:	1988 Chevrolet Camaro	
VIN:	1G1FP21S5Jlxxxxxx	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Unknown	
CDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Occupants

Case vehicle	Occupant 1	Occupant 2
Age/Sex:	68/Male	72/Female
Seated Position:	Front left	Front right
Seat Type:	Box mounted bucket seat	Box mounted bucket seat
Height:	180 cm (71 in.)	Unknown
Weight:	104 kg (230 lbs.)	Unknown
Occupation:	Unknown	Unknown
Pre-existing Medical Condition:	Insulin dependent diabetes, arthritis, hypertension	Unknown medical condition which required the use of a wheelchair
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Unknown	NA
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Right foot presumed to be on brake	Unknown
Restraint Usage:	Lap and shoulder belt used properly	Lap and shoulder belt used properly
Air bag:	Deployed	Deployed

Case vehicle	Occupant 3	Occupant 4
Age/Sex:	11/Male	4/Female
Seated Position:	Rear left	Rear right
Seat Type:	Split bench with folding back	Split bench with folding back
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	NA	NA
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	NA	NA
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt used properly	Lap and shoulder belt used properly

Nissan Pulsar	Occupant 1	Occupant 2	Occupant 3
Age/Sex:	19/Male	31/Female	20/Male
Seated Position:	Front left	Front right	Rear left
Seat Type:	Bucket with folding back	Bucket with folding back	Bench with folding back
Height:	Unknown	Unknown	Unknown
Weight:	Unknown	Unknown	Unknown
Occupation:	Unknown	Unknown	Unknown
Pre-existing Medical Condition:	Unknown	Unknown	Unknown
Alcohol/Drug Involvement:	Had been drinking (no test result)	NA	NA
Driving Experience:	Unknown	NA	NA
Body Posture:	Unknown	Unknown	Unknown
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:	None used	None used	None used

Chevrolet Camaro	Occupant 1	Occupant 2	Occupant 3
Age/Sex:	18/Male	20/Male	17/Male
Seated Position:	Front left	Front right	Rear left
Seat Type:	Unknown	Unknown	Unknown
Height:	Unknown	Unknown	Unknown
Weight:	Unknown	Unknown	Unknown
Occupation:	Unknown	Unknown	Unknown
Pre-existing Medical Condition:	Unknown	Unknown	Unknown
Alcohol/Drug Involvement:	None	NA	NA
Driving Experience:	Unknown	NA	NA
Body Posture:	Unknown	Unknown	Unknown
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:			

Injuries and Injury Mechanisms

Case vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Left neck abrasion	390202.1,2	910.0	Seat belt
	Bilateral upper chest abrasions	490202.1,3	911.0	Seat belt
	Left arm contusion	790402.1,2	923.10	Left interior side surface
	Left hand contusion	790402.1,2	923.20	Left IP
	Right distal radius fracture	752802.1,1	813.44	Left IP
	Right distal ulna fracture	753202.1,1	813.44	Left IP
	Right upper quadrant abdominal contusion	590402.1,1	822.2	Steering wheel rim
	Rectal sheath hematoma	543610.2,8	863.40	Seat
	Left posterior hip dislocation	850610.2,2	835.01	Left IP
	Left acetabular fracture	852602.2,2	808.0	Left IP
	Left femoral head fracture	851808.3,2	802.09	Left IP
	Bilateral leg abrasions	890202.1,1 890202.1,2	916.0 916.0	Left IP
FR Occupant: (fatally injured)	Large contusion, center of chest	490402.1,4	922.1	Air bag
	Minor lacerations to both arms	790600.1,3	884.0	Possibly air bag
RL Occupant:	Police investigators reported that he sustained “possible” injuries of an unknown nature or severity.			
RR Occupant:	Police investigators reported that she sustained non-incapacitating injuries of an unknown nature or severity.			

Occupant Kinematics

There were a total of four occupants in the case vehicle. The vehicle was driven by a 68 year old male who was 180 cm (71 in) in height and weighed 104 kg (230 lbs). The driver sustained major injuries consisting of fractures, dislocations, contusions and abrasions; maximum AIS = AIS-3. He was not entrapped, but did require assistance to exit the vehicle due to his injuries. He was transported, by air, to a regional trauma center where he was admitted for treatment. The right front occupant was a 72 year old female of unknown height or weight. This occupant suffered from an unknown medical condition that required a wheel chair for mobility (the folded wheel chair was located in the case vehicle's cargo area at the time of the crash) and was reported to be oxygen dependent. The right front occupant was not entrapped, but expired at the scene from injuries to her chest.

The left rear occupant was an 11 year old male of unknown height or weight. Police investigators reported that he sustained "possible" injuries of an unknown nature or severity. He was not entrapped. He was transported, method not reported, to a regional children's trauma center for an unknown course of treatment. The right rear occupant of the vehicle was a 4 year old female of unknown height or weight. Police investigators reported that she sustained non-incapacitating injuries of an unknown nature or severity. She was not entrapped. She was transported, by air, to a regional children's trauma center for an unknown course of treatment.

Figure 9. Interior, Vehicle 1. Driver position.

Figure 10. Interior, case vehicle. Knee contact.

Figure 11. Driver side front air bag.

Inspection of the vehicle indicated that all four occupants were properly restrained by the available 3-point manual lap/shoulder restraints. At impact, it appears that the driver was fully braced with both hands on the steering wheel rim, his left foot on the floor/toe pan and his right foot on the brake pedal. The left rear occupant appears to have braced for the impact by placing his feet against the left front seat back rest. The postures of the right front and right rear occupants could not be determined.

Figure 12. Passenger front air bag.

Upon impact with the Pulsar, the Blazer's occupants were projected forward, and approximately 10E left, in response to the 12 o'clock (350E) direction of impact forces. The forces involved in this crash exceeded the manufacture's SRS threshold in the case vehicle, and the driver's and right front passenger's depowered air bags deployed. All four occupants of the case vehicle loaded their respective lap/shoulder restraints, and the front seat occupants loaded the deployed depowered air bags. There was no evidence of occupant contact on the driver's air bag, but there were abrasions/fabric transfers on the face of the passenger's air bag that were likely due to the chest contact.

Attachment 1. Calculations

CASE NUMBER: DS99001

Comments: critical speed for roadway curve

*** * CRITICAL SPEED W/ COEFF. OF FRICTION AND RADIUS * ***

$S = 3.86 \times \sqrt{R \times (\mu \pm e)}$

$S = 3.86 \times \sqrt{280.00 \times (0.75 - 0.00)}$

$S = 3.86 \times \sqrt{280.00 \times 0.75}$

$S = 3.86 \times \sqrt{210.00}$

$S = 3.86 \times 14.49$

$S = 55.93$

S = The Speed in MPH.
3.86 = A Constant.
R = The Radius in Feet.
μ = The Coeff. of Friction, Level Surface.
e = The Superelevation.

INPUTS:	
The Level Surface Coeff. of Friction is:	0.75
The Radius in Feet is:	280.00
The Percentage of Superelevation is:	0.00

RESULTS:	
The Speed in MPH is:	55.93
The Velocity in FPS is:	81.99