

Remote, Redesigned Air Bag Special Study
FOR NHTSA'S INTERNAL USE ONLY
Dynamic Science, Inc., Case Number (DS99023)
1998 GMC Suburban
California
July 1998

Technical Report Documentation Page

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16. Abstract <p>This remote investigation focused on the redesigned air bag system deployment of a 1998 GMC Suburban. The case was generated through the Fatal Accident Reporting System. It was conducted as a remote investigation. This crash occurred during the early evening hours in July, 1998. The crash occurred on a straight, two-lane, two-way undivided roadway. Just prior to the crash location there is a right-hand curve. A rock embankment borders the roadway on the left side. There is a downhill slope on the right side of the roadway. The weather was clear and the bituminous roadway was dry and free of defects. There is a downhill grade at this location. The speed limit is 89 km/h (55 mph).</p> <p>The case vehicle, a 1998 GMC Suburban driven by an unrestrained 17-year-old male (178 cm/70 in., 68 kg/150 lbs.), was traveling southbound at an estimated pre-braking travel speed of 97 km/h (60 mph). The front right seat was occupied by an unrestrained 14-year-old female. This occupant indicated that she had begun the trip with the seat belt on with the seat in a reclined position. Just prior to the crash, she removed the seat belt in order to move the seat to the upright position. The crash occurred while she was in the process of raising the seat. The driver of the case vehicle allowed his vehicle to drift off the right side of the roadway at the conclusion of the right hand curve. The driver of case vehicle began braking and steered his vehicle to the left, re-entering the roadway. The case vehicle crossed into the opposite lane and the driver steered to the right and then to the left. This maneuver caused the vehicle to begin a clockwise rotation. The case vehicle crossed into the opposing lane of travel and departed the roadway, striking the rock embankment with its front end (12FDEW1). The case vehicle sustained a longitudinal delta v of -22.9 km/h (-14.2 mph) and a latitudinal delta v of -4.0 km/h (-2.5 mph). Both frontal air bags likely deployed at this point. The case vehicle rotated sharply in a counterclockwise direction 180E. The left front rim dug into the roadway surface and tripped the vehicle causing it to rollover laterally onto its left side. As the vehicle rolled over, the driver was partially ejected and his head was crushed between the left side roof rail and the ground. The vehicle then came to rest on its left side in the northbound lane facing southwest.</p> <p>The driver was declared dead at the scene. The front right occupant was found outside of the vehicle shortly after the crash. The police and witnesses do not know if she was ejected or had exited the vehicle on her own. This occupant does not recall anything after the initial impact. She was air lifted from the scene to a local hospital for treatment.</p>					
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Summary

This remote investigation focused on the redesigned air bag system deployment of a 1998 GMC Suburban. The case was generated through the Fatal Accident Reporting System. It was conducted as a remote investigation. This crash occurred during the early evening hours in July, 1998. The crash occurred on a straight, two-lane, two-way undivided roadway. Just prior to the crash location there is a right-hand curve. A rock embankment borders the roadway on the left side. There is a downhill slope on the right side of the roadway. The weather was clear and the bituminous roadway was dry and free of defects. There is a downhill grade at this location. The speed limit is 89 km/h (55 mph).



Figure 1. Approach to impact with rock embankment.

Crash Events

The case vehicle, a 1998 GMC Suburban driven by an unrestrained 17-year-old male (178 cm/70 in., 68 kg/150 lbs.), was traveling southbound at an estimated pre-braking travel speed of 97 km/h (60 mph)¹. The front right seat was occupied by an unrestrained 14-year-old female. This occupant indicated that she had begun the trip with the seat belt on with the seat in a reclined position. Just prior to the crash, she removed the seat belt in order to move the seat to the upright position. The crash occurred while she was in the process of raising the seat.



Figure 2. Impact area and final rest (south).

The driver of the Suburban allowed his vehicle to drift off the right side of the roadway at the conclusion of the right hand curve. The driver began braking and steered his

¹Calculated using pre-impact braking and delta v

vehicle to the left, re-entering the roadway. The case vehicle crossed into the opposite lane and the driver steered to the right and then to the left. This maneuver caused the case vehicle to begin a counterclockwise rotation. The case vehicle crossed into the opposing lane of travel and departed the roadway, striking the rock embankment with its front end (12FDEW1). The case vehicle sustained a longitudinal delta v of -22.9 km/h (-14.2 mph) and a latitudinal delta v of -4.0 km/h (-2.5 mph)². Both frontal air bags likely deployed at this point. The case vehicle rotated sharply in a counterclockwise direction 180E. The left front rim dug into the roadway surface and tripped the vehicle causing it to rollover laterally onto its left side. As the vehicle rolled over, the driver was partially ejected and his head was crushed between the left side roof rail and the ground. The vehicle then came to rest on its left side in the northbound lane facing southwest.

The driver was declared dead at the scene. The front right occupant was found outside of the vehicle shortly after the crash. The police and witnesses do not know if she was ejected or had exited the vehicle on her own. This occupant does not recall anything after the initial impact. She was air lifted from the scene to a local hospital for treatment.

Table 1. Delta V

	Case Vehicle	
	km/h	mph
Total	23.2	14.4
Longitudinal	-22.9	-14.2
Lateral	-4.0	-2.5

²Calculated using WinSmash, CDC only. Stiffness values were derived from NCAP database.

Exterior of Case Vehicle

Table 2. Vehicle Information

Model year, make and model	1998 GMC Suburban
VIN	1GKEK13R4WS
CDC #1	12FDEW1
CDC #2	00LDA02

Table 3. Crush Measurements

Plane of Impact	Field L cm/in.	C1 cm/in.	C2 cm/in.	C3 cm/in.	C4 cm/in.	C5 cm/in.	C6 cm/in.
Bumper	188	unk	unk	unk	unk	unk	unk
	74	0	0	0	0	0	0



Figure 3. Exterior, case vehicle - impact #1 to front



Figure 4. Exterior, case vehicle. Show rollover contact to entire left side.

Interior of Case Vehicle

The interior of the GMC Suburban was not inspected; however, police photos show that the driver's head contacted the exterior surface of the top frame of the driver's side window. The left front window was found in the down position and was not damaged. The case vehicle was equipped with front bucket seats. There was no indication of any intrusion. It appears that one of the rear doors may have opened during the rollover.

Case Vehicle Occupant Protection Systems

The GMC Suburban was equipped with a redesigned air bag system which consisted of front left and front right air bag modules which housed air bags and depowered inflator units. Both air bags deployed as a result of the initial impact.

The front left air bag was housed in the steering wheel hub and was concealed by symmetrical I-configuration cover flaps which do not appear to have been damaged in the crash. The front right air bag was housed in the mid-instrument panel position and was concealed by dual rectangular cover flaps which did not appear to have been damaged in the crash.



Figure 5. Interior, case vehicle

Case Vehicle Occupant Demographics

	Occupant 1	Occupant 2
Age/Sex:	17/Male	14/Female
Seated Position:	Front left	Front right
Seat Type:	Bucket	Bucket
Height (cm/in):	178 70	Unk 0
Weight (kg/lbs):	68 150	Unk 0
Pre-existing Medical Condition:	None noted	None noted
Body Posture:	Normal, upright	Somewhat reclined—seat was being returned to upright position as crash occurred
Hand Position:	Unknown	Unknown
Foot Position:	Right presumably on brake pedal	Unknown
Restraint Usage:	Lap and shoulder belts available, not used	Lap and shoulder belts available, not used
Air bag:	Deployed during collision	Deployed during collision

Occupant Injuries

Table 4. Injuries (Driver)

Injury	Injury Severity (AIS)	Injury Mechanism
Extensive fractures of skull with multiple lacerations and loss of brain tissue	6	Roof rail/window frame and ground
Contusion, right eyebrow - 1/4 x 1/4 in.	1	Unknown, possibly occupant #2
Contusion, right side of face 1 x 6 in.	1	Unknown, possibly occupant #2
Contusion, left knee - 1/2 x 1/2 in.	1	Instrument panel
Contusion, right knee - 1/2/ x 1/2 in.	1	Instrument panel
Contusion, left side of face - 3/4 x 3/4 in.	1	Ground
Contusion, left upper back - 1/2 x 5 in.	1	Ground
Contusion, left arm - 1/2 x 3 in.	1	Ground

Table 5. Injuries (Front right occupant)

Injury	Injury Severity (AIS)	Injury Mechanism
Contusion, right cheek bone and eyebrow area	1	Side interior surface
Contusion, left knee	1	Instrument panel
Contusion, right knee	1	Instrument panel

Occupant Kinematics

The driver (case occupant) of the GMC Suburban was seated in a normal upright posture in the front left position of the vehicle. He was not wearing the available manual lap/shoulder restraint. There was considerable pre-impact braking, as well as multiple evasion maneuvers.

At impact, the driver reacted to the 10 degree principle direction of force by moving forward and slightly right, engaging the deploying air bag. While the air bag protected his torso and face, he under-rode it to some degree and he struck the lower instrument panel with both knees—causing contusions to both. After impact, the vehicle began rotating violently in a counterclockwise fashion. This rotation would have shifted this occupant to the right even further. After rotating 180E, the left front tire/rim loaded heavily, digging into the asphalt road surface, and then tripping the vehicle. The abrupt cessation of rotation caused this occupant to pitch to the left and he was partially ejected through the side window. As the vehicle overturned, the driver's head was outside of the vehicle and at the level of the roof rail and was crushed between the rail and the ground. This occupant's skull was crushed. After this contact between the roof rail and the ground, the curved surface of the vehicle caused it to rock back so there was now some distance between the rail and the road surface. The driver was not pinned by the vehicle.

The front right occupant was seated in a somewhat reclined position and was not using the available lap and shoulder belts. At impact, this occupant reacted to the 10 degree principle direction of force by moving forward and slightly right, engaging the deploying air bag. While the air bag protected her torso and face, she under-rode it to some degree and she struck the lower instrument panel with both knees—causing contusions to both. After impact, the vehicle began rotating violently in a counterclockwise fashion. This rotation would have shifted this occupant to the right even further. This occupant was found outside of the vehicle shortly after the crash. The police and witnesses do not know if she was ejected or had exited the vehicle on her own. This occupant does not recall anything after the initial impact. It is this investigator's opinion that she likely came to rest on the left side of the interior surface and exited out the back of the vehicle.

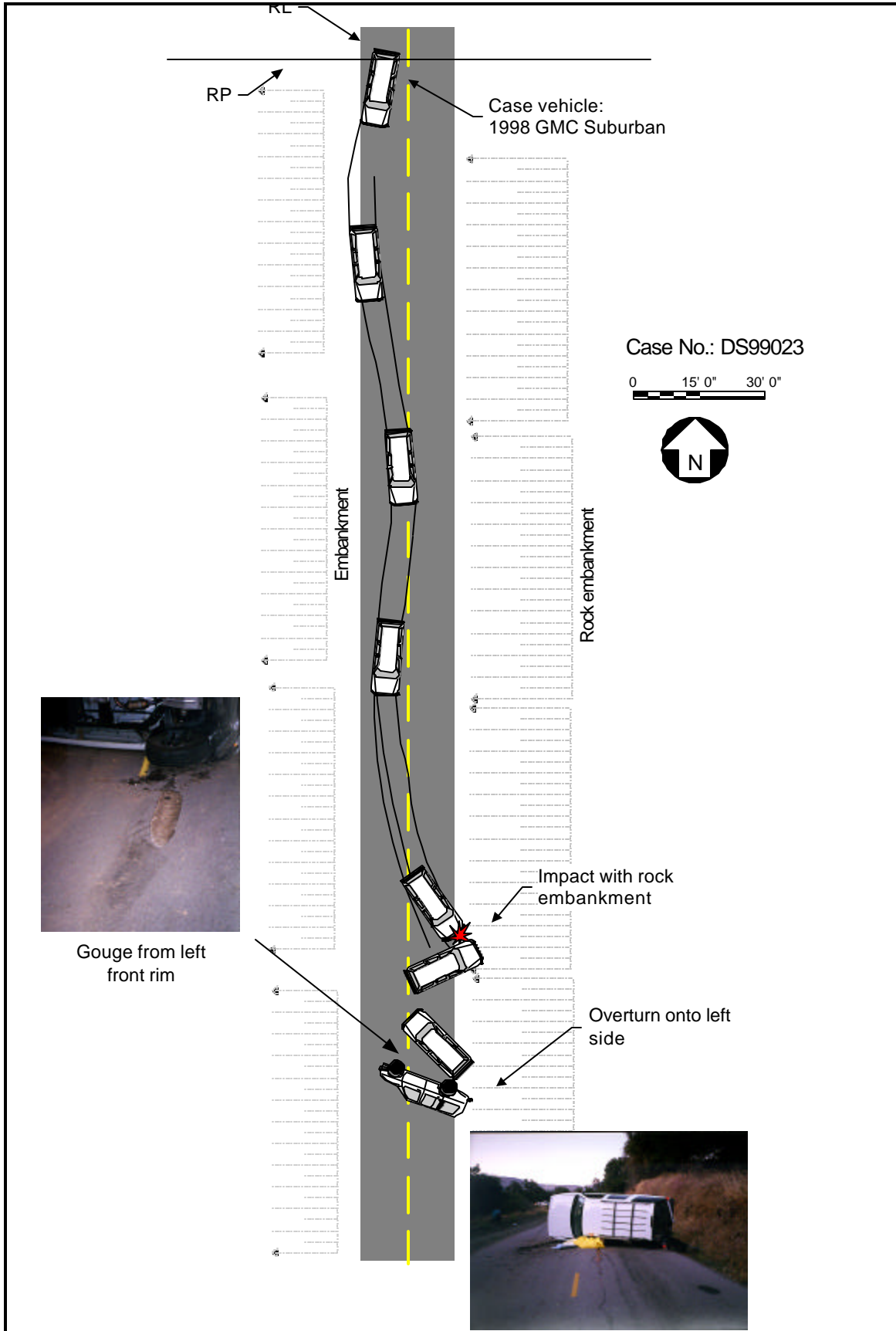


Figure 6. Interior surface of roof rail



Figure 7. Exterior view of roof rail/side glass rail

Scene Diagram



COLLISION MEASUREMENTS						
Reference point:	Station line from nearest cross street					
Reference line:	West road edge					
Data Point	Distance/Direction from RL			Distance/Direction from RP		
	ft	m	d	ft	m	d
1. Right front tire	0	0	o	11	3.4	S
2. Right front tire	1.5	0.5	W	16.76	5.1	S
3. Right front tire	2.9	0.9	W	25.2	7.7	S
4. Left front tire	3.2	1	E	24.7	7.5	S
5. Right front tire	2.5	0.8	W	37.4	11.4	S
6. Left front tire	3.4	1	E	36.5	11.1	S
7. Right front tire	0	0	o	58.2	17.7	S
8. Right front tire	10.5	3.2	E	81.4	24.8	S
9. Left front tire	12	3.7	E	107	32.6	S
10. Right front tire	6.8	2.1	E	104.1	31.7	S
11. Left front tire	10.3	3.1	E	122.9	37.5	S
12. Right front tire	3.5	1.1	E	139.1	42.4	S
13. Right front tire	11.1	3.4	E	162.2	49.4	S
14. Right front tire	9.2	2.8	E	175.4	53.5	S
15. Right front tire	10.3	3.1	E	180	54.9	S
16. Left rear tire	10.3	3.1	E	186.8	56.9	S
16b. Right rear tire	10.7	3.3	E	198.9	60.6	S
17. Left front tire	21.5	6.6	E	193.8	59.1	S
18. Left rear tire	15.6	4.8	E	201.6	61.4	S
19. Right front tire	21.3	6.5	E	204.2	62.2	S
20. Right rear tire	15.9	4.8	E	208.1	63.4	S
21. White paint transfer front end	26.8	8.2	E	203.6	62.1	S
22. Left front tire	10.8	3.3	E	222.1	67.7	S
23. Begin gouge in asphalt	10	3	E	225	68.6	S

24. End gouge in asphalt	9.8	3	E	228.8	69.7	S
24b. Point of rest left front wheel	10	3	E	230.3	70.2	S
25. Point of rest left rear wheel	19.4	5.9	E	233.1	71	S
26. Groin came to rest	12.2	3.7	E	235.6	71.8	S
27. Head came to rest	19.4	5.9	E	238.2	72.6	S

CASE NUMBER: ds9923

Comments: Pre-impact braking

**** MINIMUM SPEED W/ KNOWN DRAG FACTOR ****

$$S = \sqrt{30 \times D \times f}$$

$$S = \sqrt{30 \times 185.00 \times 0.65}$$

$$S = \sqrt{3607.50}$$

$$S = 60.06$$

S = The Speed in MPH.

30 = A Constant.

D = The Distance in Feet.

f = The Adjusted Accel/Drag Factor.

INPUTS:	
The Acceleration/Drag Factor is:	0.65
The Distance in Feet is:	185.00

RESULTS:	
The Speed in MPH is:	60.06
The Velocity in FPS is:	88.04

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CASE NUMBER: ds9923

Comments: Combined speeds using delta v

**** COMBINED MINIMUM SPEEDS W/ KNOWN SPEEDS ****

$$S = \sqrt{S^2(1) + S^2(2) + \dots + S^2(n)}$$

$$S = \sqrt{(14.40)^2 + (60.60)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2}$$

$$S = \sqrt{207.36 + 3672.36 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00}$$

$$S = \sqrt{3879.72}$$

$$S = 62.28$$

S = The Speed in MPH.

S² = The Individual Min. Speed.

(1), (2), (n) = The # of the individual speed.

INPUTS:		RESULTS:	
Speed #1 in MPH is:	14.40	The Speed in MPH is:	62.28
Speed #2 in MPH is:	60.60	The Velocity in FPS is:	91.30

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