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CRASH RESEARCH SECTION**

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CALSPAN REMOTE AIR BAG DEPLOYMENT INVESTIGATION

CALSPAN CASE NO. CA98-054

VEHICLE #1 - 1990 CHRYSLER LEBARON

LOCATION - STATE OF VIRGINIA

CRASH DATE - MARCH, 1994

Contract No. DTNH22-94-D-07058

Prepared for:

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

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

<p>1. <i>Report No.</i> CA98-054</p>	<p>2. <i>Government Accession No.</i></p>	<p>3. <i>Recipient's Catalog No.</i></p>	
<p>4. <i>Title and Subtitle</i> Veridian Engineering Remote Air Bag Deployment Investigation Vehicle #1 - 1990 Chrysler LeBaron Location - State of Virginia</p>		<p>5. <i>Report Date:</i> August 1999</p>	
		<p>6. <i>Performing Organization Code</i></p>	
<p>7. <i>Author(s)</i> Accident Research Group</p>		<p>8. <i>Performing Organization Report No.</i></p>	
<p>9. <i>Performing Organization Name and Address</i> Transportation Research Group Crash Research Section Veridian Engineering P.O. Box 400 Buffalo, New York 14225</p>		<p>10. <i>Work Unit No.</i> 1115 (8800-8809)</p>	
		<p>11. <i>Contract or Grant No.</i> DTNH22-94-D-07058</p>	
<p>12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590</p>		<p>13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: March, 1994</p>	
		<p>14. <i>Sponsoring Agency Code</i></p>	
<p>15. <i>Supplementary Notes</i> Remote investigation of an air bag deployment crash that resulted in critical injuries to the driver.</p>			
<p>16. <i>Abstract</i></p> <p>This crash involved a 1990 Chrysler LeBaron driven by an unrestrained 58 year old female which departed the left side of the rural roadway in the afternoon hours and struck a tree with the frontal plane resulting in a Collision Deformation Code (CDC) of 12-FLEW-2 with a WinSMASH computed delta V of 28.0 km/h (17.4 mph). The unrestrained driver, who was 162.6 cm (64.0") tall, was sitting close to the steering wheel when the air bag system deployed. The police noted that the driver seat was adjusted in a full forward position which was consistent with her family's description that she preferred to sit forward.</p> <p>The driver suffered fractures of C1 and C2 resulting in quadriplegia, bruises of the knees, and bruises the head and chest. The driver survived the crash, however, after extended stays at medical treatment facilities was released to her home where she has remained on a ventilator.</p> <p>The police report theorized that the driver was in close proximity to the steering wheel prior to the crash and moved forward during the onset of the impact with the tree. Due to the counterclockwise rotation of the vehicle just prior to impact, the driver was probably right of center with respect to the center of the air bag. She moved forward and was subsequently contacted by the expanding front left driver air bag which resulted in hyperextension of her neck. She continued forward as the vehicle's counterclockwise rotation was accelerated by the impact sequence with the tree. The rapid rotation allowed her to subsequently move to the right and come to rest in the right front occupant seat and partially on the floor.</p>			
<p>17. <i>Key Words</i> Front left driver air bag deployment Delta V 28.0 km/h (17.4 mph) 58 year old female driver AIS-5 (Critical)</p>		<p>18. <i>Distribution Statement</i> General Public</p>	
<p>19. <i>Security Classif. (of this report)</i> Unclassified</p>	<p>20. <i>Security Classif. (of this page)</i> Unclassified</p>	<p>21. <i>No. of Pages</i></p>	<p>22. <i>Price</i></p>

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Veridian Engineering Case No. CA98-054
Front Left Air Bag Related Driver Injury
State of Virginia
March, 1994

Background

The Field Operations Branch (FOB) of NHTSA was notified by the Virginia State Police of a single vehicle crash in which the driver reportedly sustained disabling injuries resulting from contact with the deploying front left driver air bag. Veridian Engineering team (formerly Calspan Operations of Veridian) was directed to conduct a remote investigation into the relationship between the driver's injuries and the air bag system.

Summary

This crash involved a 1990 Chrysler LeBaron driven by an unrestrained 58 year old female which departed the left side of the rural roadway in the afternoon hours and struck a tree with the frontal plane. The unrestrained driver, who was 162.6 cm (64.0") tall, was sitting close to the steering wheel when the air bag system deployed. The police noted that the driver seat was adjusted in a full forward position which was consistent with her family's description that she preferred to sit forward.

A paramedic happened to be in the vicinity at the time of the crash and at first observation noted that the driver was not breathing and her complexion had turned blue. He administered mouth to mouth resuscitation which sustained her until rescue arrived. She was subsequently life flighted to a trauma hospital.

The driver suffered fractures of C1 and C2 resulting in quadriplegia, bruises of the knees, and bruises the head and chest. The driver survived the crash, however, after extended stays at medical treatment facilities was released to her home where she has remained on a ventilator.

The police noted that prior to the crash the driver was traveling westbound on a two lane, undivided, dry asphalt roadway with a speed limit of 88 km/h (55 mph) and traveled through a left curve which had a police measured superelevation of 17.7 percent. The roadway width measured 6.7 m (22.0') with narrow gravel shoulders.

Upon exiting the left curve, the vehicle crossed over into the oncoming lane and departed the left side of the roadway at a police determined departure angle of 4 degrees. The roadway at this point had a police measured -9.4 percent slope. The driver apparently initiated a right steer avoidance maneuver and re-entered the roadway at an 8 degree angle (**refer to Figures 1&2**). From the tire marks noted along the shoulder, the vehicle was in a clockwise yaw as it re-entered the roadway.



Figure 1 View of the vehicle's trajectory at the point of the first departure



Figure 2 View of the vehicle's roadway re-entry



Figure 3 View of the vehicle's trajectory from the re-entry showing the oversteer to the left leading to the second departure

The vehicle was proceeding back across the roadway when the driver apparently oversteered to the left. The vehicle subsequently reversed the rotational pattern to a counterclockwise yaw as noted by the heavy tire scuff/skid marks noted in police scene photographs (**refer to Figures 3&4**).

As the vehicle departed the left side of the roadway a second time, the driver appeared to again countersteer to the right as the lateral gap between the right front and right rear tire pattern appeared to narrow (**refer to Figures 5&6**). The left front bumper of the vehicle contacted a large tree resulting in an estimated Collision Deformation Code (CDC) of 12-FLEE-2 with a WinSMASH computed delta V of 28.0 km/h (17.4 mph). The vehicle rotated counterclockwise 145 degrees where it came to the final rest position (FRP) on the roadside parallel to the roadway edge and 11 m (36') beyond the tree (**refer to the police scene diagram in Figure 7**).



Figure 4 Reverse trajectory showing the counterclockwise scuff marks prior to the second roadway departure



Figure 5 View showing the vehicles's counterclockwise rotation prior to the second roadway departure



Figure 6 Reverse view illustrating the vehicle's heading at the point of impact with the 73.7 cm diameter tree and the roadway profile prior to the crash

The police report theorized that the driver was in close proximity to the steering wheel prior to the crash and moved forward during the onset of the impact with the tree. Due to the counterclockwise rotation of the vehicle just prior to impact, the driver was probably right of center with respect to the center of the air bag. She moved forward and was subsequently contacted by the expanding front left driver air bag which resulted in hyperextension of her neck. She continued forward as the vehicle's counterclockwise rotation was accelerated by the impact sequence with the tree. The rapid rotation allowed her to subsequently moved to the right and come to rest in the right front occupant seat position and partially on the floor.

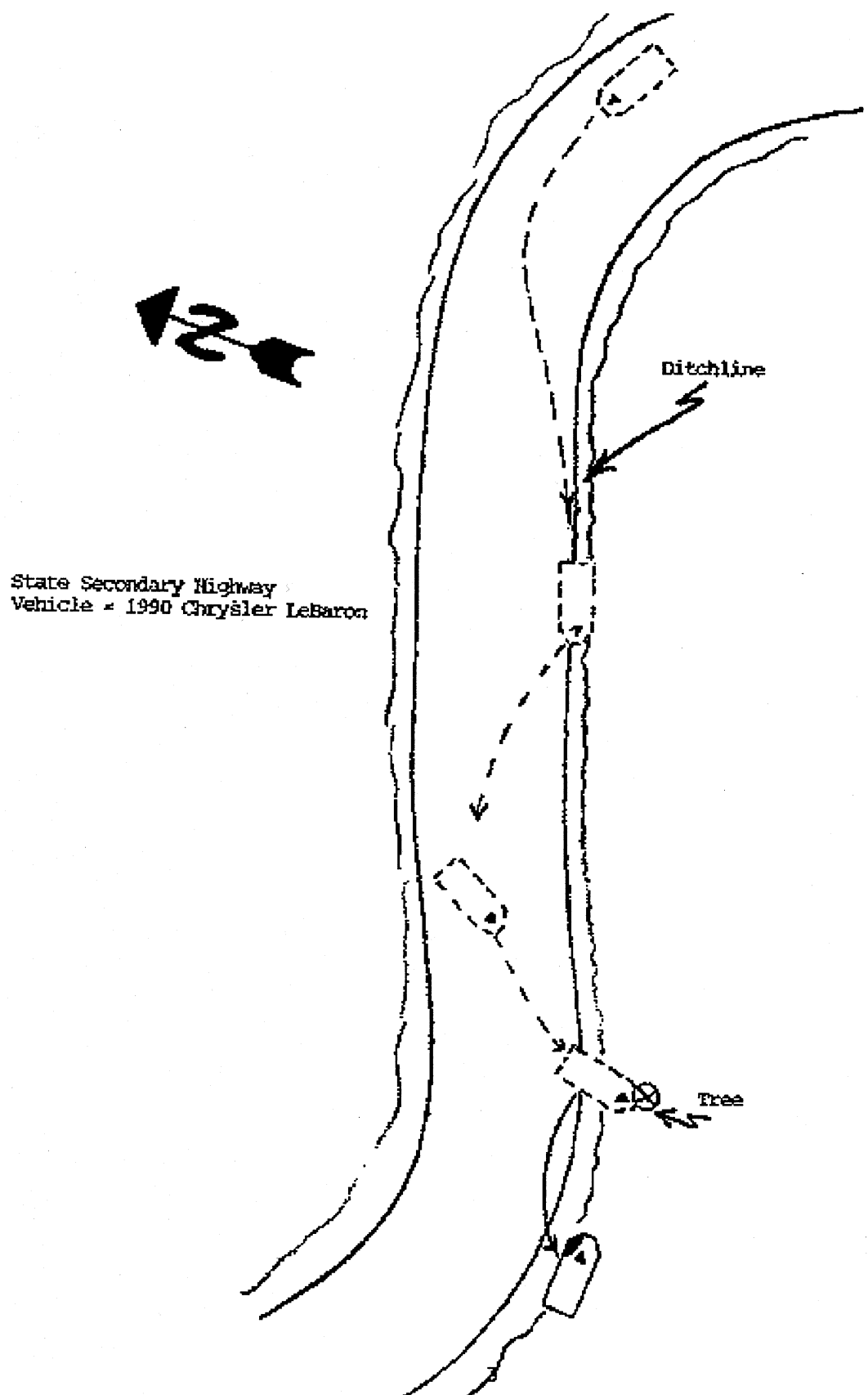


Figure 7. Police Scene Diagram

VEHICLE DATA

Exterior -1990 Chrysler LeBaron

The 1990 Chrysler LeBaron was equipped with a front left driver air bag which deployed as the result of the impact with a large tree measured by police at 73.7 cm (29.0") in diameter. Exterior damage to the vehicle involved the front bumper, left parking light, left headlight assembly, grille, hood, left front fender, and left front wheel. The 43.2 cm (17.0") contact pattern began at the left front bumper corner and extended to just inboard of the left front parking light. The contact appeared to continue along the surface of the left front fender and ending forward of the left front axle. The left front axle was displaced rearward 7.1 cm (2.8"). The windshield was cracked along the left side which was attributed to impact forces and not occupant contact. The CDC was **12FLEW2**.



Figure 8 Corner view of the vehicle showing the area of direct contact damage at the left front corner



Figure 9 Lateral view of the vehicle while at the scene showing the longitudinal crush pattern and the displacement of the left front axle

Crush values in the following table were determined from police documentation and photographs(**refer to Figures 8 &9**).

Vehicle #1 Crush		
Impact with tree 73.7 cm (29.0") diameter	$C_1 = 38.1 \text{ cm (15.0")}$	$C_2 = 27.2 \text{ cm (10.7")}$
	$C_3 = 9.4 \text{ cm (3.7")}$	$C_4 = 0$

Interior - 1990 Chrysler LeBaron

The front interior area of the 1990 Chrysler LeBaron (from the limited view provided by police photographs) revealed limited visible/discernable damage from driver contact. The lower portion of the steering wheel rim appeared to be deformed forward an estimated distance of 0.6 cm (0.25"). This was attributed to driver contact during the impact sequence. The steering wheel according to police was adjusted one notch up from the full down position (**refer to Figure 10**).

The front seat was design as a split bench with fold down center armrests. The armrest were in the down position as shown in **Figure 10**. The police investigative report indicated that the driver's seat was in

a full forward position at the time of the crash with the rear portion of the seat cushion located 49.5 cm (19.5") rearward from the steering wheel. In **Figure 10**, the driver's seat appeared to be forward of the right front seat an estimated distance of 5 cm (2").

The driver side manual restraint belt was a continuous loop lap and shoulder belt design. The belt was intact and fully retracted as shown in **Figure 10**.

SPEED RECONSTRUCTION

The WinSMASH speed reconstruction algorithm was used to compute relative delta V values and impact speed. The output from the damage routine indicated that the vehicle experienced a total delta V of 28.0 km/h (17.4 mph) as shown in the following table. This value was considered an approximation due to the visually estimated maximum crush of 38.1 cm (15.0") at the left front fender corner. This output value appeared reasonable especially in light of the 7.1 cm (2.8") rearward displacement of the left front axle.



Figure 10 Lateral view of the vehicle interior taken from the right side illustrating the relative seat track positions, the steering wheel adjustment, the air bag, and the restraint belt

The police using a critical curve scuff formula calculated the on-roadway just prior to the point of impact (POI) travel speed of 58 km/h (36 mph). According to police, the travel speed slowed to 45 km/h (28 mph) at POI with the tree. The WinSMASH using the damage and spinout routine computed the impact speed at 62.9 km/h (38.9 mph).

WinSMASH Speed Reconstruction Algorithm	
Impact Speed	62.9 km/h (38.9 mph)
Total delta V	28.0 km/h (17.4 mph)
Longitudinal delta V	-27.6 km/h (-17.1 mph)
Lateral delta V	-4.9 km/h (-3.0 mph)
Energy dissipated	43,958 joules (32,439 ft-lb)
Barrier equivalent speed	28.0 km/h (17.4 mph)

SUPPLEMENTAL RESTRAINT SYSTEM (SRS)

The supplemental restraint system (SRS) comprised of a front left driver air bag module only. The module cover opened in the usual symmetrical "H" configuration. Typically, Chrysler installed nontethered air bags with vent ports located at the 3&9 o'clock positions in vehicle models which included 1990 vehicles. In the 1990 vehicle model year, however, tethered air bags and vent ports in the 12 o'clock position were introduced. From the available data in this crash, the air bag design could not be determined.

Injury Data

The driver, who was 162.6 cm (64.0") tall, moved forward and to the right as a result of the counterclockwise pre-impact rotation of the vehicle. During the impact sequence, it was theorized that she was within the expansion zone of the air bag and was subsequently contacted by the expanding air bag. The air bag contacted her head and chest resulting in the hyperextension of her neck. She sustained fractures of C1 and C2 with resulting quadriplegia which was attributed to this contact mechanism.

Immediately following the crash, a passerby who happened to be a volunteer rescue squad member, stopped and notified authorities to dispatch a rescue unit. When the passerby approached the vehicle, he noted that the driver was not breathing and had a blue complexion. He implemented rescue procedures and restored her breathing pending the arrival of rescue. Rescue requested a helicopter which transported her to a trauma hospital located 64 km (40 miles) from the crash scene.

The following table summarizes injuries identified in the police in-depth crash report along with the respective AIS-90 injury code and correlating injury source.

INJURY	AIS-90	INJURY SOURCE	
		Component	Certainty
1. Fractures of C1 and C2 resulting in quadriplegia	640220.5,6	Front left driver air bag	Probable
2-3. Bruises of the knees	890402.1,1 890402.1,2	Knee bolster Knee bolster	Certain Certain
4. Bruises of the head	190402.1,0	Front left driver air bag	Probable
5. Bruises of the chest	490402.1,0	Front left driver air bag	Probable
6. Circle type bruise on mid upper abdomen	590402.1,7	Steering wheel rim	Probable
<i>Supplemental discussion: There were no facial burn marks or scuffing of the face, and no bruising from a restraint belt,</i>			

OCCUPANT KINEMATICS

The driver was returning home after working her normal eight hour work shift. She, however, had a recent history of working extended work weeks with 6-eight hour days. According to the in-depth police report, there was a possibility that the driver may have experienced sleepiness which they listed as a contributing factor in the crash. She had driven approximately 11 km (7miles) from her place of employment and was within 5 km (3 miles) of her home at the time of the crash.

The driver's seat was reported by the police to have been adjusted in the full forward track position. Members of her family apparently indicated that she preferred to sit very close to the steering wheel.

Scene evidence indicated that when the vehicle departed the left side of the roadway, the driver reacted by steering to the right. The vehicle re-entered the roadway in a clockwise rotation and traveled a short distance when the driver subsequently reversed the steering and overcorrected to the left. This action resulted in the vehicle reversing its rotation to a counterclockwise yaw. As the vehicle departed the left side of the roadway for the second time, the driver appeared to have attempted to steer back to the right.

The vehicle struck the tree with an estimated 10 degree slip angle. The driver, who was not wearing the manual lap and torso restraint belt, moved forward and slightly to the right. It was theorized that she was within close proximity of the air bag module at the time of the air bag actuation sequence and was contacted in the chest and head by the expanding air bag. Her head was subsequently propelled rearward which resulted in a hyperextension of the neck. Her knees contacted the knee bolster resulting in contusions of both knees. Due to the fact that the driver may have been right of center to the air bag (i.e., due to the counterclockwise yaw), her forward movement probably compressed the air bag allowing her mid upper abdominal area to load the steering wheel rim resulting in a circle type contusion.

The driver continued forward and to the right as the vehicle rotated rapidly in a counterclockwise direction due to the left front corner impact with the tree. The driver came to rest partial on the right front seat and partially on the floor.