TRANSPORTATION RESEARCH GROUP
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VERIDIAN REMOTE AIR BAG RELATED ADULT DRIVER FATALITY INVESTIGATION

VERIDIAN CASE NO. CA99-012

VEHICLE - 1998 BUICK REGAL GS

LOCATION - STATE OF PENNSYLVANIA

CRASH DATE - DECEMBER, 1998

Contract No. DTNH22-94-D-07058

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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.

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16. *Abstract*

This single vehicle crash involved a 1998 Buick Regal GS which departed the right side of the roadway and struck the end of a concrete bridge railing with the left frontal plane. The impact resulted in the deployment of the redesigned frontal air bag system. The vehicle rotated counterclockwise after the impact and came to the final rest position (FRP) 5.8 m (19.0') off roadway after traveling down an embankment. The unrestrained 80 year old female driver suffered fatal injuries and was pronounced at the scene by the Coroner. The crash occurred in the month of December, 1998 in the mid afternoon hours.

The 80 year old female driver, who was 170.2 cm (67.0") tall and weighed 79.4 kg (175.0 lbs.), was not restrained by the three point manual lap and shoulder belt. She was found at the FRP laying across the right front seat with her mid body wedged between shift lever and the center console and her feet located forward of the driver seat cushion. She sustained multiple fractures of the left ribs (AIS-3), laceration of the heart (AIS-6), contusion of both lungs (AIS-4) which were attributed to contact with the deploying front left driver air bag and open comminuted fractures of both ankles (AIS-2) from axile loading of the lower legs against the floor pan, and multiple soft tissue injuries. The cause of death was listed as blunt chest trauma. The driver was pronounced deceased on-scene by the corner approximately 1.5 hrs after the crash.

The vehicle damage was located left of the vehicle centerline and was assigned a collision deformation classification (CDC) code of 12-FYEN-2. The WinSMASH algorithm computed the total delta V as 30.0 km/h (18.6 mph) which was sufficient to actuated the supplemental restraint system (SRS).

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TABLE OF CONTENTS

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DECEMBER, 1998

Background

Veridian Engineering (formerly Calspan Operations of Veridian) was notified of a single vehicle crash involving a 1998 Buick Regal GS by the Field Operations Branch (FOB) of the National Highway Traffic Safety Administration (NHTSA) which occurred in December, 1998. The Veridian Engineering investigation team was requested to conduct a remote investigation to determine the relationship between the vehicle's deployed redesigned air bag system and fatal injuries sustained by the 80 year old female driver.

Summary

This single vehicle crash involved a 1998 Buick Regal GS which departed the right side of the roadway and struck the end of a concrete bridge railing with the left frontal plane. The impact resulted in the deployment of the redesigned frontal air bag system. The vehicle rotated counterclockwise after the impact and came to the final rest position (FRP) 5.8 m (19.0') off roadway after traveling down an embankment. The unrestrained 80 year old female driver suffered fatal injuries and was pronounced at the scene by the Coroner. The crash occurred in the month of December, 1998 in the mid afternoon hours.

The 80 year old female driver, who was 170.2 cm (67.0") tall and weighed 79.4 kg (175.0 lbs.), was not restrained by the three point manual lap and shoulder belt. She was found at the FRP laying across the right front seat with her mid body wedged between shift lever and the center console and her feet located forward of the driver seat cushion. She sustained multiple fractures of the left ribs (AIS-3), laceration of the heart (AIS-6), contusion of both lungs (AIS-4) which were attributed to contact with the deploying front left driver air bag and open comminuted fractures of both ankles (AIS-2) from axile loading of the lower legs against the floor pan, and multiple soft tissue injuries. The cause of death was listed as blunt chest trauma. The driver was pronounced deceased on-scene by the corner approximately 1.5 hrs after the crash.

The travel direction of the vehicle suggested that the driver was en route to her residence which was located approximately 4 km (2.5 miles) north of the crash scene. The roadway was designed with one travel lane in each direction (north/south) which were separated by a continuous median left-turn lane and a posted speed limit of 64 km/h (40 mph). The asphalt surface was dry, level, with good lane and roadway edge lines **(refer to Figure 1)**.

At the point of departure, the roadway transitioned from a straight segment to a left curve **(refer to Figure 2)**. The vehicle traversed a paved shoulder, a stone driveway apron, and an adjacent grass shoulder a police reported distance of 25.6 m (84.0') before impacting the blunt end of an unprotected concrete bridge railing **(refer to Figure 3)**. The contact on the vehicle was located between the left front bumper corner and the centerline of the vehicle. Maximum crush was estimated at 51 cm (20'') by the police. The vehicle rotated approximately 45 degrees counterclockwise and traveled 1.5 m (5.0') to the FRP which was located on a negative embankment.

Figure 1 View northbound prior to the POI showing the roadway geometry

Figure 2 Look back view of the Buick's trajectory showing the point of roadway departure

Figure 3 View showing the vehicle's precrash trajectory and its final rest position

A rolling tire print in the grass was associated with the right side tires and indicated that the driver did not lockup the brakes prior the impact. The trajectory appeared to curve slightly to the left which indicated that the driver may have attempted to steer left. This maneuver was viewed more as a matter of returning to the roadway rather than avoiding the bridge wall end **(refer to scene schematic in Figure 4)**. There were no adverse weather conditions at the time with the temperature listed as 45 degrees F.

The vehicle damage was located left of the vehicle centerline and was assigned a collision deformation classification (CDC) code of 12-FYEN-2. The WinSMASH algorithm computed the total delta V as 30.0 km/h (18.6 mph) which was sufficient to actuated the supplemental restraint system (SRS).

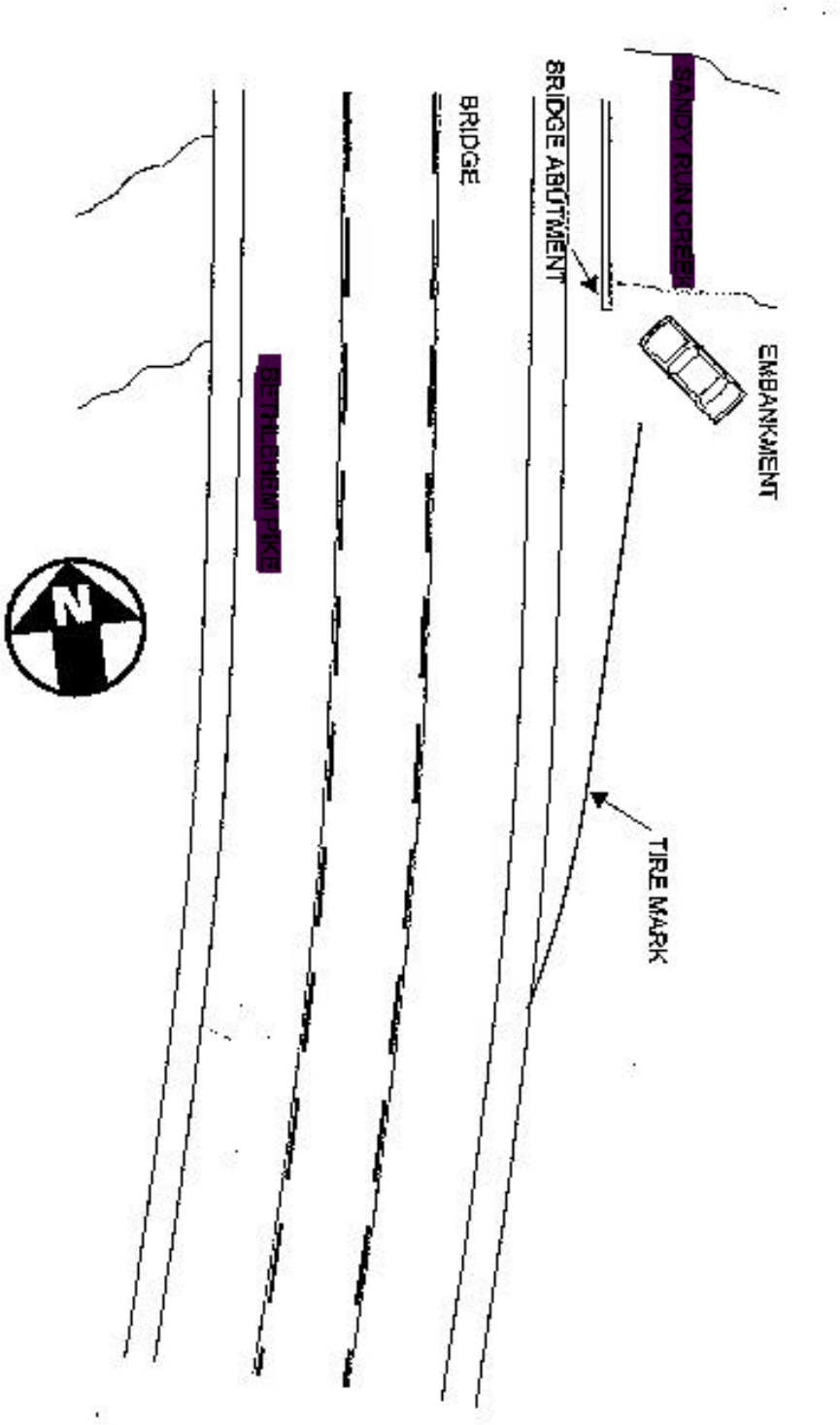

Figure 4 Police scene diagram

VEHICLE DATA

Exterior -1998 Buick Regal GS

The 1998 Buick Regal GS was equipped with a redesigned dual frontal air bag system which deployed as the result of the impact with a concrete bridge wall end. The bridge wall end measured 24.8 cm (9.75") wide and 121.9 cm (48.0") tall). Exterior damage to the vehicle involved the front bumper, left headlight assembly, grille, hood, left front fender, and windshield. The 24.8 cm (9.75") wide contact pattern began an estimated 22.9 cm (9.0") left of the vehicle centerline. The police reported a maximum crush of 50.8 cm (20.0") located an estimated 35.5 cm (14") left of the centerline **(refer to Figure 5)**. Crush values in the following table were estimated from police photographs.

Figure 5 View of the damage to the front of the Buick Regal

1998 Buick Regal GS - Crush Profile			
Impact with the 24.8 cm (9.75") wide bridge	C_1 = 50.8 cm (2.0")	C_2 = 25.4 cm (10.0")	C_3 = 50.8 cm (20.0")
	C_4 = 25.4 cm (10.0")	C_5 = 10.2 cm (4.0")	C_6 = 0

Collision Deformation Classification (CDC)

The CDC for the front impact was assigned as follows: 12-FYEN-2.

Interior - 1998 Buick Regal GS

The interior of the 1998 Buick Regal GS exhibited minor driver contact evidence which involved the headlight switch located left of the steering column and the transmission gear shift lever. The headlight switch was deformed downward which was attributed to contact by the driver's left hand **(refer to Figure 6)**. The knee bolster did not appeared to be damaged, however, there were limited views to fully evaluate contact mechanisms. There did not appear to be any deformation of the steering wheel rim **(refer to Figure 7).** The tilt steering wheel was viewed as being adjusted in a center tilt position. The police noted that the housing surrounding the console mounted transmission selector lever was slightly damaged and the shift lever was bent slightly toward the passenger side **(refer to Figure 8)**.

Figure 6 View of the left instrument panel showing the headlight switch which was deformed downward by the driver's left hand

Figure 7 View of the steering wheel assembly which shows a lack of driver related deformation

Figure 8 View of the center console mounted transmission gear selection lever as viewed from the driver's seat toward the right front instrument panel

The seat track position of the front bucket seats were adjusted such that the driver seat appeared to be in a more forward position as noted by its relative position with respect to the right front seat **(refer to Figure 9)**. The driver seat back was reclined in a normal angle with an adjustable head restraint that was in a full down position. The front restraint belts were a manual three point continuous loop lap and torso belt. The left front adjustable D-ring was in the full up position **(refer to Figure 10)**.

Figure 9 Overhead view showing the relative seat positions

Figure 10 Lateral view of the front seat area showing the frontal air bags, driver's final rest position, and the adjustment height of the D-ring for the torso belt

SPEED RECONSTRUCTION

The WinSMASH speed reconstruction algorithm was used to compute relative delta V values. The output from the damage routine indicated that the vehicle experienced a total delta V of 30.0 km/h (18.6 mph) as shown in the following table. This value was considered an approximation due to the police reported maximum crush of 50.8 cm (20.0") and visually estimated crush measurements. The total delta V result, however, appeared reasonable.

WinSMASH Speed Reconstruction Algorithm	
Total delta V	30.0 km/h (18.6 mph)
Longitudinal delta V	-30.0 km/h (–18.6 mph)
Lateral delta V	0 km/h
Energy dissipated	57,276 joules (42,270 ft-lb)
Barrier equivalent speed	30.0 km/h (18.6 mph)

SUPPLEMENTAL RESTRAINT SYSTEM (SRS)

The supplemental restraint system (SRS) comprised of dual front air bags which deployed during the crash as designed. The front left driver module cover opened in the ususal symmetrical "I" pattern. The air bag was an untethered design which did not exhibit any driver contact evidence as captured in police photographs **(refer to Figure 11)**. The front right passenger air bag was top mounted and also appeared devoid of occupant contact **(refer to Figure 12)**.

Figure 11 Lateral view of the front left driver air bag

Figure 12 View of the front right passenger side air bag

Injury Data

The unrestrained female driver, who was 170.2 cm (67.0") tall and weighed 79.4 kg (175.0 lbs.), was in close proximity to the air bag at the time of deployment and suffered thorax injuries involving the heart, ribs, and lungs which resulted in her demise. She was declared deceased on-scene by the county coroner. The following table summaries injuries identified in the autopsy report along with the respective AIS-90 injury code and correlating injury source.

INJURY	AIS-90	INJURY SOURCE	
		Component	Certainty
1,2. 0.75" superficial, irregular abrasion of the left frontal scalp located 1" left of the midline and 5" above and behind the left eyebrow associated with considerable swelling and bruising of the underlying scalp	190202.1,2 190402.1,2	Left roof side rail	Possible
3. Mottled bruising of the left chest and a 1" bruise in the Xiphoid area	490402.1,2	Front left driver air bag	Certain
4. Two tiny abrasions of the Xiphoid area	490202.1,4	Front left driver air bag	Certain
5. Fracture of the left third through ninth ribs, laterally	450230.3,2	Front left driver air bag	Certain
6. Subcutaneous, subpleural and intercostal bruising associated with the left rib fractures	450202.1,2	Front left driver air bag	Certain
7. Focal scattered contusions of both lungs	441410.4,3	Front left driver air bag	Certain
8. Laceration of the heart which measured 1.5" and which was described as an irregular sagittally oriented laceration of the anterior right ventricular wall with associated large hemoperocardium with massive hemothorax of approximately 1.5 liters	441014.6,4	Front left driver air bag	Certain
9, 10. Two irregular 1.5" rents of the pericardium and extensive superior anterior mediastinal hematoma	441602.2,4 441602.2,4	Front left driver air bag	Certain
11, 12. A 1.5" bruise of the radial border of the middle of the right forearm and a 1" irregular bruise over the metacarpophalangeal knuckle of the left middle finger	790402.1,1 790402.1,2	Instrument panel Head light control switch	Probable Certain

INJURY	AIS-90	INJURY SOURCE	
		Component	Certainty
Supplemental discussion: Several irregular , superficial mixed bruises and senile ecchymoses over both elbows, forearms, and backs of both hands measuring up to 2.5" in maximal dimension. Only a 1.5" bruise of the radial border of the middle of the right forearm and a 1" irregular bruise over the metacarpophalangeal knuckle of the left middle finger can be definitively identified as deep bruises, distinguishable from senile ecchymosis.			
13. Gaping irregular 2.5" laceration of the right knee exposing the underlying kneecap	890604.1,1	Knee bolster	Certain
14. Abrasion of the right knee, two superficial abrasions with peeled off epidermis are present on each side of the tibial tubercle of the proximal anterior right lower leg (abrasion of the right measured 2" across, abrasion on the left measured 1")	890204.1,1	Knee bolster	Certain
15. Comminuted open fracture of the right ankle with the fragmented talus and exposed distal end of the tibia protruding though a gaping, deep 5" laceration of the lateral side of the ankle	853200.2,1	Floor/toe pan	Certain
16. An irregular transverse gaping 4" laceration of the distal right lower leg immediately above the open fracture of the right ankle which extends around the anterior and lateral aspects	890602.1,1	Floor pedals	Possible
17, 18. Several superficial abrasions and accompanying faint bruising over the anterior lateral left knee cap and anterior proximal left lower leg measuring up to 2".	890202.1,2 890402.1,2	Knee bolster	Certain
19. Gaping 4" transverse laceration across the anterior middle left lower leg exposing underlying muscle and bone without fracture located immediately distal to the previous listed injury (injury 17, 18)	890602.2,2	Lower instrument panel	Probable

INJURY	AIS-90	INJURY SOURCE	
		Component	Certainty
20. Comminuted open fracture of the left ankle where the left tibial protruded through a 4" transverse laceration of the medial side of the left ankle	853200.2,2	Floor/toe pan	Certain

OCCUPANT KINEMATICS

The driver was heading in the direction of her residence at the time of the crash. The seat appeared to have been adjusted in a mid to forward position. The vehicle departed the right side of the roadway at the beginning of a left curve and traveled in a slight left curve trajectory to the impact with the end of a concrete bridge wall. The impact resulted in the deployment of the dual frontal air bag system.

The unrestrained driver given her age of 80 years old was more than likely sitting in a forward position on the seat cushion prior to the crash. In this position, she would have been in close proximity to the steering wheel at the time of the air bag actuation sequence. The deploying untethered air bag contacted her chest resulting in fractures of the left ribs, laceration of the heart, and bilateral lung contusions. There was no damage to the steering wheel rim or compression of the energy absorbing steering column observed in the police photographs. While her upper body interacted with the air bag, her lower torso moved forward with her knees contacting the knee bolster. This contact sequence resulted in abrasions of both knees and a contusion over the left knee.

Her lower torso continued forward and submarined the knee bolster resulting in a gaping laceration of her right knee and a 4" transverse laceration of the anterior aspect of the mid lower left leg as the result of contacting components underlying the instrument panel. Her feet were on the floor/toe pan and slightly to the left of the respective knee location. As the lower legs exerted a downward force as the result of her knees loading the instrument panel, the ankles fractured and rolled to the right where the right tibia protruded through the lateral aspect and the left tibia protruded through the medial aspect.

The drivers left hand moved forward and contacted the top aspect of the headlight switch as her forearm moved in an downward direction. This contact resulted in a contusion of the left middle finger. He right forearm moved forward and contacted the instrument panel resulting in a contusion.

The driver then contacted the left interior side surface of the vehicle as the vehicle rotated in a counterclockwise direction. It was likely that the left side of her head contacted the left side roof rail resulting in an abrasion and contusion of the scalp.

The driver's upper body rebounded laterally to the right with her head coming to rest on the right front seat cushion against the lower right B-pillar with her shoulders and back resting on the seat cushion. Her hip area contacted the console mounted transmission gear selector lever which resulted in the selector lever being deformed slightly to the right and being moved forward where it was found in the "reverse"

position. The police described her lower body as being wedged between the console and the gear selector at final rest. Her feet were located on the floor forward of the driver's seat.

The driver was found by police clutching head hair in her left hand. There was no description in the autopsy report to account for this somewhat unusual artifact. It was unknown whether the driver had experienced some medical event prior to the crash which resulted in this activity that lead to the roadway departure or this activity took place immediately after the crash. The medical examiner did not cite any medically related pre-impact condition as a contributing factor in the crash.