

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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**VERIDIAN ON-SITE FRONT DRIVER AIR BAG DEPLOYMENT/
FATALITY INVESTIGATION**

VERIDIAN CASE NO. CA00-006

VEHICLE - 1994 PONTIAC BONNEVILLE

LOCATION - FLORIDA

CRASH DATE - FEBRUARY 2000

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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 of the involved vehicle(s) or their safety systems.

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**ONSITE DRIVER AIR BAG DEPLOYMENT/FATALITY INVESTIGATION
VERIDIAN CASE NO: CA00-006**

**VEHICLE: 1994 PONTIAC BONNEVILLE
LOCATION: FLORIDA
CRASH DATE: FEBRUARY, 2000**

BACKGROUND

This on-site investigation focused on the single vehicle/fixed object crash of a 1994 Pontiac Bonneville and the resultant fatal injury mechanisms of the 45 year old female driver. The 1994 Pontiac Bonneville was equipped with a Supplemental Inflatable Restraint (SIR) that consisted of driver and front right passenger air bags. The air bags deployed as a result of an (above threshold) undercarriage impact with a security barrier. The barrier was a retractable security device that controlled access into a secure compound on a US military installation. The barrier properly retracted, however as the vehicle approached the barrier, it unexpectedly began to rise. The driver did not perceive and react to the lifting barrier and impacted the barrier with the forward undercarriage of the Pontiac. The driver was seated in-close proximity to the driver air bag and was struck by the bag early in its deployment sequence. The contact with the expanding driver air bag resulted in a fatal basilar skull fracture, associated head/brain trauma, chest contusions and facial abrasions.

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SUMMARY

Crash Site

This single vehicle crash occurred during the morning hours of February 2000. At the time of the crash, it was daylight and the weather was not a factor. The crash occurred at the entrance to a secure compound on a US military installation, **Figure 1**. The access road to the compound was configured with two lanes, primarily north/south in direction. Traffic entering the compound was controlled by a retractable security barrier and a green/red traffic signal. The barrier retracted into the ground after access was granted via



Figure 1: Trajectory view at the security entrance.

SUMMARY (continued)

electronic security scan at the card reader (refer to Figure 1). The traffic signal turned green after the barrier fully retracted into the ground. Standard procedure was for the vehicle to remain stationary at the card reader until the traffic light turned green. The distance from the card reader to the barrier measured approximately 20 m (67 ft).

Once the barrier was lowered, loop detectors buried in the pavement on both sides of the barrier controlled its operation. The barrier elevated to its full upright position, after the vehicle cleared the barrier and the exit loop detector. The traffic signal changed to red as soon as the barrier began to move. Refer to the Security Barrier Section of this report for more detail regarding the barrier and its operation. A surveillance camera located north of the security entrance captured the crash sequence on video tape. The tape was used to establish the time/distance relationship of the vehicle during the crash event. Unfortunately, the resolution and quality of the video tape was not adequate to view the actions and positioning of the driver.

Pre-Crash

The driver of the 1994 Pontiac Bonneville was a 45 year old female, with a reported height and weight of 158 cm (62 in) and 77 kg (170 lb), respectively. She was seated in a mid-to-forward seat track position and was restrained by the vehicle’s 3-point lap and shoulder belt system. She was en-route to a meeting at a building located within a secure compound of the base.

The vehicle approached the compound from the south and turned in a northerly direction onto the access road. Analysis of the surveillance tape revealed the subject vehicle came to a complete stop at the card reader and was stationary for a period of 41 seconds. During this period, it is assumed the driver was retrieving her security badge and scanning it through the card reader. During the last 6 seconds of the vehicle’s stationary period, the barrier lowered completely to the ground. The traffic light turned to green. The Pontiac then began to accelerate forward. The complete timing sequence from the video tape is summarized in the table below:

Action	Time (Hrs/Min/Sec)	Time Differential (Sec)
Vehicle stopped at card reader:	11:17:25	0
Barrier begins to lower:	11:18:00	35
Barrier completely lowered, Vehicle starts to accelerate:	11:18:06	41
Barrier begins to rise:	11:18:10	45
Vehicle impact to barrier	11:18:11	46
First responders to vehicle	11:18:27	62

SUMMARY (continued)

Crash

The driver accelerated the vehicle forward away from the card reader and maneuvered the vehicle through the right curve leading to the barriers, refer to the crash schematic **Figure 2** below. The vehicle was in motion for a period of 5 seconds and traveled approximately 20 m (67 ft) to impact with the barrier. A time/distance analysis based on the aforementioned parameters, assuming constant acceleration, determined the vehicle was traveling approximately 29 km/h (18 mph) at impact.

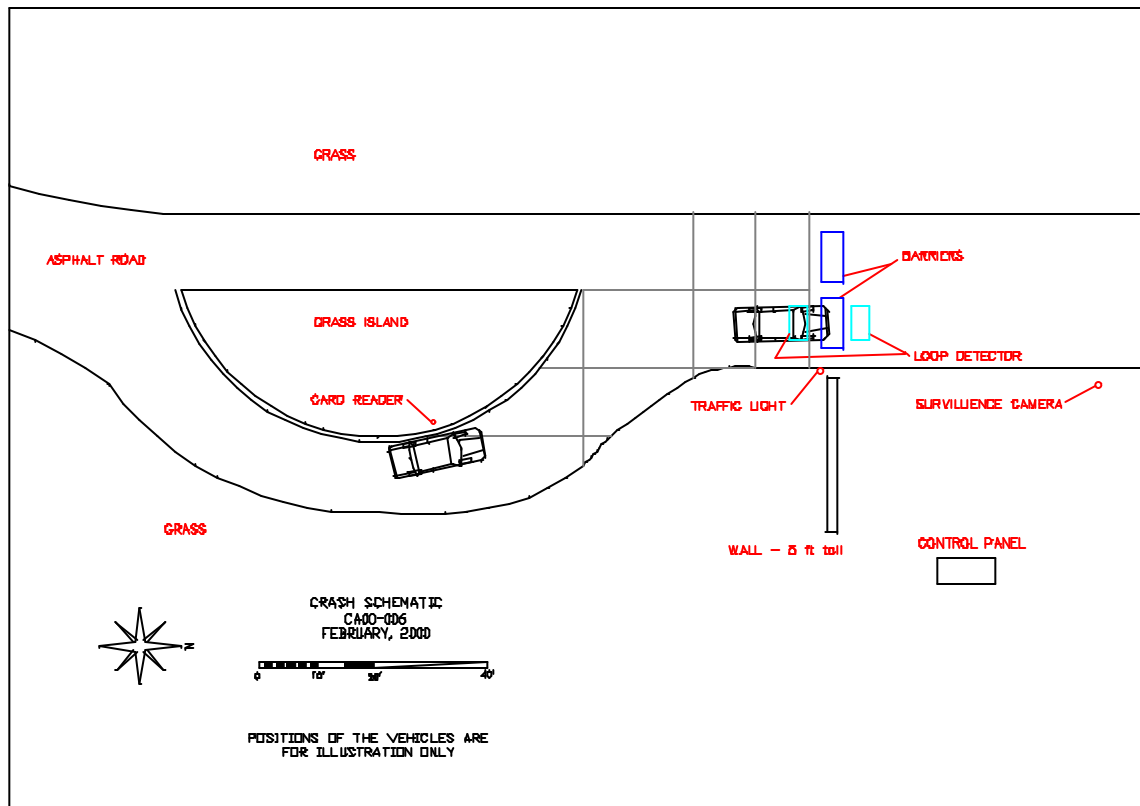


Figure 2: Schematic of the crash scene.

Approximately 1 sec prior to reaching the barrier, the barrier began to rise. Presumably, the traffic signal turned red. The vehicle's front bumper system and air dam passed over and cleared the rising barrier. However, as the vehicle continued forward and the barrier continued to rise, the forward cross-member of the Pontiac's undercarriage impacted the top plate of the barrier. The ground clearance of the Pontiac's cross-member measured 23 cm (9 in). The impact stopped the vehicle's forward momentum. The magnitude of the impact force was sufficient to warrant deployment of the Pontiac's SIR (air bag) system. The delta V of the impact was approximately (29 km/h) 18 mph.

The barrier continued to rise, unloading the vehicle's front suspension. A "feedback" loop in barrier's

SUMMARY (continued)

hydraulic system stopped its motion upon sensing the excess weight. The barrier stopped after rising an estimated 30 cm (12 in). **Figure 3** is an on-scene photograph taken of the vehicle at final rest. Inspection of the barrier revealed its top surface was constructed of 1/4 in steel diamond plate. A 56 cm (22 in) section of the top plate was deformed. The plate's maximum vertical deflection measured 4.6 cm (1.8 in).



Figure 3: On-scene view of the Pontiac at final rest.

Immediately prior to the crash, the driver was restrained in a presumed normal posture and in normal operation of the vehicle. The forward seat track position was consistent with her short stature and placed the driver in close proximity to the driver air bag module. When the barrier lifted and the traffic signal turned red, the driver possibly leaned forward and up-over the steering wheel in an effort to ascertain what was happening to the barrier system. The driver did not have time to react to the impending crash, due to the short duration of the pre-crash event. There was no pre-crash steering or braking.

At the time of impact and subsequent air bag deployment, the driver was out-of-position, over the top of the driver air bag module and impeded the bag's deployment. The deployment of the air bag contacted the driver in the head and upper chest causing a fatal basilar skull fracture, cerebral contusions cerebral sub-dural hemorrhage and associated chest contusions and facial abrasions.

Post-Crash

Landscape contractors working in the area of the security entrance ran to the vehicle and were on-scene within 30 seconds. Military security arrived on-scene within 3 minutes of the crash from the control room monitoring the surveillance camera. The control room was located in a building several hundred yards away.

The driver's door was reportedly locked and the window was up. The driver was slumped forward over the steering wheel and was reportedly bleeding profusely about the nose and mouth. Access to the vehicle's interior was achieved through the right front door and the remaining doors were subsequently unlocked. Emergency personnel removed the driver's 3-point lap and shoulder restraint by cutting the

SUMMARY (continued)

webbing at the B-pillar. The driver was removed from the vehicle via the left front door and placed on the ground. Reportedly, the tilt steering wheel had to be rotated to the full up position to provide clearance between the seat cushion and steering wheel rim for the driver's legs. The position of the steering wheel rim is again suggestive of the close proximity between the driver and the driver air bag module. Resuscitative efforts were unsuccessful due to the extent of the head trauma. She was pronounced dead at the scene.

VEHICLE DATA

The 1994 Pontiac Bonneville, 4-door sedan, was identified by a Vehicle Identification Number (VIN): 1G2HX52L0R4 (production sequence deleted), **Figure 4**. The date of manufacture was 12/93. The vehicle was equipped with a Supplemental Inflatable Restraint system that consisted of driver and front right passenger air bags. The power train consisted of a 3.8 liter, V-6 engine linked to a 4-speed automatic transmission. The vehicle's braking system was equipped with an anti-lock braking system (ABS). The odometer reading at the time of inspection was 243,511 km (151,315 miles).



Figure 4: Left side view of the Pontiac.

The front interior consisted of a cloth covered 60/40 split bench seat with reclining seat backs. The seat track position was electronically adjustable. The battery cables had been cut during the rescue operation. The seat could not be moved and was unchanged from its at-crash position. The driver's seat was adjusted to a mid-to-forward track position. The position measured 16.3 cm (6.4 in) forward of full-rear. The total seat track travel typically measures approximately 20 cm (8 in). The horizontal distance between the steering wheel hub and the seat back measured 48 cm (19 in). The measured geometry of the driver's position indicated she was seated at the outer limits of the air bag deployment zone, prior to any pre-crash forward movement. The front right seat was adjusted to a mid-to-rear track position and measured 5.7 cm (2.3 in) forward of full rear.

The front restraints were standard 3-point lap and shoulder belts. The independent lap and shoulder belt webbings spooled from separate retractors located in the B-pillar. The end of the webbings were connected at a common latch plate. The webbings had been cut during the extrication of the driver. The lengths of the lap and shoulder belt webbing measured 61 cm (24 in) and 81 cm (32 in), respectively. The belt webbings were heavily blood stained indicative of use at the time of the crash. A comfort sleeve was in-place around the shoulder belt webbing. The latch plate was still inserted in the inboard buckle anchor during the SCI inspection. The adjustable D-ring was in the full down position. The total adjustment range was 7.5 cm (3.0 in).

VEHICLE EXTERIOR DAMAGE

The Pontiac’s exterior damage consisted entirely of damage to the vehicle’s undercarriage, **Figure 5**. There was no direct damage above the level of the front bumper. The vehicle sustained direct contact damage across the full width of the forward cross-member. The greatest extent of residual displacement was biased to the left side of the cross-member and measured 10 cm (4 in). The force of the impact also caused induced damage to the left longitudinal uni-body rail, in the area of the left front suspension. **Figures 6 and 7** are views of the left front and right front suspensions, respectively. Note, the deformations of the left longitudinal rail (identified in Figure 6) as compared to the right. This deformation caused the left wheelbase dimension to be fore-shortened 4.2 cm (1.5 in), **Figure 8**. The Collision Deformation Classification (CDC) of the damage was 12-UFDW-01. The magnitude of the damage was consistent with reconstruction of the crash and warranted the deployment of the vehicle’s SIR system.

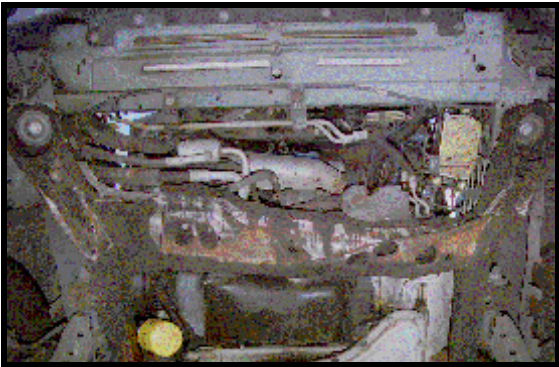


Figure 5: View of the forward undercarriage.

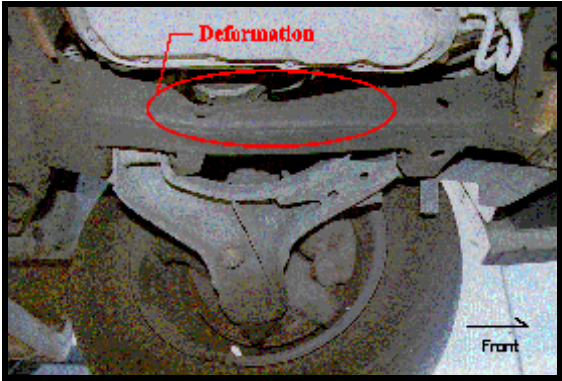


Figure 6: Left front suspension.



Figure 7: Right front suspension.



Figure 8: Close-up view of the left front wheel rearward displacement.

VEHICLE INTERIOR DAMAGE

There was no interior damage to the vehicle that could be directly related to the exterior forces of the crash. All interior damage was associated to the deployment of the driver and front right passenger air bags. The right side of the windshield was fractured by contact from the module cover of the front right passenger air bag. The side glazings were not fractured and were free of defects. The surfaces of the driver knee bolster did not exhibit any contact evidence.

The vehicle was equipped with a tilt steering wheel that had been adjusted to the full upright position during the extrication of the driver. Its at-crash position was not recorded. There was no deformation of the steering wheel rim. The wheel was rotated approximately 135 degrees clockwise (right) at inspection and did not appear to have been moved from its at-crash position. The steering column was fully displaced from its shear capsules. The compression was an estimated 2 cm (1 in). The displacement occurred due to the impeded driver air bag deployment and bag expansion - not from direct occupant loading.

SUPPLEMENTAL INFLATABLE RESTRAINT

The 1994 Pontiac Bonneville was equipped with a Supplemental Inflatable Restraint (SIR) system that consisted of driver and front right passenger air bags. The SIR was an electro-mechanical system controlled by a Diagnostic Energy Reserve Module (DERM) located under the center aspect of the instrument panel. The following nomenclature identified the DERM: *Service No - 16176558, *A13430K533365753**. The front satellite sensor was attached to the upper radiator support on the vehicle's centerline. The system's safing sensor was not identified.

The driver air bag was configured in the typical manner in the center hub of the steering wheel. It had deployed from an I-configuration module. The module's cover flaps were symmetrical and measured 7.6cm (3.0 in) by 11.4 cm (4.5 in), width by height, respectively. There was no contact evidence identified on either cover flap.

The diameter of the deflated driver air bag, **Figure 9**, measured 61 cm (24 in). It was vented by two, 2 cm (1 in) diameter, ports located in the 3/9 o'clock sectors on the back side of the bag. The bag was not tethered. The center aspect of the bag's face was heavily blood stained. Patterned vinyl transfers to the face of the bag were identified in the 8 to 11 o'clock



Figure 9: View of the driver air bag. Note, the steering wheel is rotated 135 degrees CW.

SUPPLEMENTAL INFLATABLE RESTRAINT (continued)

sector. These transfers resulted from frictional contact with the interior surfaces of the vinyl cover flaps. The frictional contact and transfers were indicative of the impeded deployment of the air bag.

The front right passenger air bag was a top-mount design located in the typical manner in the right aspect of the instrument panel. The module cover flap was rectangular and constructed of vinyl. The cover measured 34.3 cm (13.5 in) by 17.8 cm (7.0 in), width by height. The cover flap was tethered by a 20 cm (8 in) wide strap. The face of the passenger bag measured 66 cm (26 in) by 46 cm (18 in), width by height, and extended 36 cm (14 in) from the module, in its deflated state. It was tethered by two 51 cm (20 in) wide straps sewn to the face of the bag. It was vented by two, 6.4 cm (2.5 in), ports located on the side panels of the bag. No contact evidence was identified on the surfaces of the passenger air bag.

SECURITY BARRIER SYSTEM

The security barrier was a Model TT207 Hydraulic Barricade System manufactured by Delta Scientific Inc., **Figure 11**. The barrier was a 274 cm (108 in) moving wedge, (81 cm) 32 in high. The barrier was of steel construction and was crash rated. It was installed and operational in May 1998. The barrier reportedly was maintained quarterly by the manufacturer.



Figure 10: Trajectory view of the security barrier.

The barrier operated in the following manner. Access into the secure compound was granted via electronic security scan at the card reader. The card reader was located approximately 20 m (67 ft) south of the barrier. After security approval, the barrier lowered into the ground. The traffic signal turned to green after the barrier had completely lowered. The barrier’s actuation time (up/down or down/up) was 7 seconds \pm 2 sec. After the barrier lowered, control of the barrier was passed to two magnetic loop detectors buried in the ground on either side of the barrier. The loop detectors measured 2 m (6 ft) by 1 m (3 ft), width by length. The entry (south) loop was centered approximately 1.3 m (4.2 ft) from the barrier face. The center of the exit (north) loop measured 0.9 m (2.9 ft) from the north edge of the barrier, refer to Figure 2. The barrier would begin to rise only after the vehicle had passed through the entry loop, over the barrier and cleared the exit loop detector. As soon as the barrier started to rise, the traffic signal changed to red.

DRIVER DEMOGRAPHICS

	<i>Driver</i>
Age/sex	45 year old/female
Height:	158 cm (62 in)

DRIVER DEMOGRAPHICS (continued)

Weight:	77 kg (170 lb)
Restraint Usage:	Restrained - 3 point lap and shoulder belt
Usage Source:	Observations of the first responders, SCI inspection
Medical Treatment:	None

DRIVER INJURY

<i>Injury</i>	<i>Injury Severity (AIS 90)</i>	<i>Injury Mechanism</i>
Transverse basilar skull (Hinge) fracture w/ moderate distraction & fracture of sphenoid sinuses and musocal lacerations	Severe (150206.4,8)	Deploying driver air bag
Multiple cerebral contusions-bilateral	Serious (140620.3,3)	Deploying driver air bag
Sub-dural hemorrhage - right cerebral hemisphere	Severe (140652.4,1)	Deploying driver air bag
Cutaneous facial abrasions - right corner of mouth, left cheek, under side of chin (most extensive distribution)	Minor (290202.1,1) Minor (290202.1,2) Minor (290202.1,8)	Deploying driver air bag
Multiple cutaneous contusions to upper chest - bilateral	Minor (490402.1,3)	Deploying driver air bag
Bilateral lung contusions	Severe (441410.4,3)	Deploying driver air bag
Broad cluster of contusions over the superior aspect of the right shoulder	Minor (790402.1,1)	Deploying driver air bag
Moderate size contusion right arm anterior aspect	Minor (790402.1,1)	Deploying driver air bag

Note: the above injuries were identified in Medical Examiners Report of Autopsy.

DRIVER KINEMATICS

Immediately prior to the crash, the 45 year old female driver was restrained and seated in a mid-to-forward track position consistent with her short stature. The driver was seated in-close proximity to the driver air bag module during normal vehicle operation. Approximately one second before impact, the barrier began to elevate and the traffic signal changed to red. It was probable to driver began to lean forward and up-over the steering wheel in an effort to see what was happening with the barrier and/or traffic signal. There were no pre-impact avoidance maneuvers as a result of driver action.

At impact, the vehicle's air bags deployed as a result of an above threshold crash. The forward position of the driver placed her in-close proximity to the driver air bag and altered the deployment path of the bag. Additionally, the driver responded to the 12 o'clock direction of the impact force and exhibited a forward trajectory further loading the bag. Contact evidence identified on the face of the driver air bag was indicative of the impeded deployment.

The air bag impacted the driver's face/head and upper chest prior to its expansion. The expansion of the bag resulted in facial abrasions about the mouth, cheek and under the chin. The impact from the driver air bag and its expansion resulted in a complete basilar skull fracture with moderate distraction, cerebral contusions and associated sub-dural cerebral hemorrhage. Associated with the basilar fracture were fractures of the walls of the sphenoid sinuses with resultant mucosal lacerations. These lacerations resulted in extensive hemorrhage into the upper airways, observed by the first responders. The bi-lateral lung contusions and the soft tissue contusions to the upper chest and right arm also resulted from contact with the deploying air bag. Expansion of the air bag coupled with the forward kinematic pattern of the driver caused the steering column to be displaced from the shear capsule. The driver rebounded rearward in her seat and then slumped forward over the steering wheel where she was found.