CRASH DATA RESEARCH CENTER

Veridian
Engineering Division
Buffalo, New York 14225

VERIDIAN ON-SITE AIR BAG INFLATOR FAILURE INVESTIGATION

VERIDIAN CASE NO. CA00-058

VEHICLE - 1999 PONTIAC GRAND PRIX GT

LOCATION - STATE OF KENTUCKY

CRASH DATE - JULY, 2000

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 on-site investigation focused on the deployment of the redesigned frontal air bag system of a 1999 Pontiac Grand Prix GT 2-door coupe and the failure of the driver air bag inflator. The Pontiac was equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed as a result of an offset frontal collision with a 1994 Ford Mustang GT 2-door coupe. The 23 year old female driver of the Ford Mustang was operating the vehicle westbound on a two lane rural roadway when she allowed the vehicle to cross the centerline into the path of the eastbound Pontiac. As the Ford entered the eastbound lane, the front right area impacted the frontal area of the Pontiac resulting in moderately severe damage to both vehicles. As the Pontiac Grand Prix redesigned driver air bag began to deploy, the inflator and large disk-like segment separated from the module assembly and projected through the membrane of the air bag. The projectiles struck the unrestrained 17 year old female driver which resulted in a fractured right mandible and lacerations to the cheek/neck with an underlying nerve injury. Inflator particulates sprayed the driver space resulting in extensive trauma to the right eye and first degree burns across the torso and anterior extremities. She subsequently initiated a forward trajectory in response to the 11 o'clock impact force and loaded the steering wheel rim/column and sunvisor which resulted in a blunt chest trauma and closed head injury. After initial transport to a local hospital, the driver was transferred to a nearby trauma center and admitted for ten days. The unrestrained 17 year old female front right passenger of the Pontiac initiated a forward trajectory in response to the 11 o'clock impact force and loaded the deployed redesigned passenger air bag. She sustained a cervical strain which was a result of the sudden forward head movement as the kinematic response commenced (flexion). The front right passenger was transported to a local hospital for treatment and released.			
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BACKGROUND

This on-site investigation focused on the deployment of the redesigned frontal air bag system of a 1999 Pontiac Grand Prix GT 2-door coupe and the failure of the driver air bag inflator. The Pontiac was equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed as a result of an offset frontal collision with a 1994 Ford Mustang GT 2-door coupe. The 23 year old female driver of the Ford Mustang was operating the vehicle westbound on a two lane rural roadway when she allowed the vehicle to cross the centerline into the path of the eastbound Pontiac. As the Ford entered the eastbound lane, the front right area impacted the frontal area of the Pontiac resulting in moderately severe damage to both vehicles. As the Pontiac Grand Prix redesigned driver air bag began to deploy, the inflator and large disk-like segment separated from the module assembly and projected through the membrane of the air bag. The projectiles struck the unrestrained 17 year old female driver which resulted in a fractured right mandible and lacerations to the cheek/neck with an underlying nerve injury. Inflator particulates sprayed the driver space resulting in extensive trauma to the right eye and first degree burns across the torso and anterior extremities. She subsequently initiated a forward trajectory in response to the 11 o'clock impact force and loaded the steering wheel rim/column and sunvisor which resulted in a blunt chest trauma and closed head injury. After initial transport to a local hospital, the driver was transferred to a nearby trauma center and admitted for ten days. The unrestrained 17 year old female front right passenger of the Pontiac initiated a forward trajectory in response to the 11 o'clock impact force and loaded the deployed redesigned passenger air bag. She sustained a cervical strain which was a result of the sudden forward head movement as the kinematic response commenced (flexion). The front right passenger was transported to a local hospital for treatment and released.

The crash notification was provided to NHTSA's Office of Defect Investigations (ODI) on Friday, October 27, 2000 and assigned to the Veridian SCI team on Friday, November 3, 2000 as an on-site investigative effort. The on-site investigator arrived on the evening of Thursday, November 9 and concluded field activities on Friday, November 10, 2000.

SUMMARY

Crash Site

This two vehicle crash occurred during the early evening hours of July, 2000. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred in the eastbound lane of a two lane east/west (level) asphalt roadway which curved left for westbound traffic. The roadway was bordered by narrow paved shoulders with a (closed) service station located just south of the crash site **(see Figure 19 - page 13)**. No traffic control was present at the scene which had a police reported speed limit of 89 km/h (55 mph).

Pre-Crash

The 17 year old female driver of the 1999 Pontiac Grand Prix GT 2-door coupe was operating the vehicle eastbound **(Figure 1)** when she slowed for traffic ahead. As traffic ahead cleared, the Pontiac driver began to accelerate to a (driver reported) speed of 48 km/h (30 mph) when she observed the westbound Ford encroach into her lane of travel. The Pontiac driver reported no avoidance maneuvers in anticipation of the impending crash.

The 23 year old female driver of the 1994 Ford Mustang GT 2-door coupe was operating the vehicle westbound **(Figure 2)** at a (police reported) speed of 89 km/h (55 mph) when she completed a left curve in the roadway and reportedly encountered a (non-contact) westbound vehicle stopped ahead. The Ford driver maneuvered the vehicle into the eastbound lane in avoidance of the stopped vehicle ahead, and into the path of the eastbound Pontiac. Although police witnesses did not confirm the existence of the stopped (non-contact) vehicle, a possibility exists the Ford driver may have been distracted and failed to observe the stopped (non-contact) vehicle; or just improperly negotiated the previous curve, thereby overcorrecting any steering maneuvers.

Figure 1. Eastbound approach for the 1999 Pontiac Grand Prix GT.

Figure 2. Westbound approach for the 1994 Ford Mustang GT.

Crash

As the Ford Mustang entered the eastbound lane, the front right area impacted the frontal area of the Pontiac resulting in moderately severe damage to both vehicles. Although known impact and final rest positions for both vehicles were inadequate for calculation of impact speeds, the missing vehicle algorithm of the WinSMASH reconstruction program computed velocity changes of 32.2 km/h (20.0 mph) for the subject vehicle and 37.4 km/h (23.2 mph) for the striking Ford Mustang. The respective longitudinal components were -30.2 km/h (-18.8 mph) and -37.3 km/h (-23.2 mph). The speed change exceeded the threshold required for deployment, therefore the Pontiac's frontal air bag system deployed. The Pontiac's event data recorder **(see Figure 18 - page 12)** recorded a longitudinal Delta V of -45.9 km/h (-28.5 mph) which seemed somewhat high given the extent of crush and lack of intrusions to the vehicle interior. The Ford Mustang was re-directed in a southwesterly direction and came to rest approximately 17.0 meters (55.8 feet) from the point of impact in the service station parking lot facing south. The Pontiac rotated approximately 130 degrees clockwise and came to rest 5.0 meters (16.4 feet) from the point of impact straddling the south delineation line facing southwest.

Post-Crash

The driver and front right passenger of the Pontiac exited the vehicle under their own power. The exit status (and subsequent treatment) of the Ford driver was unknown. Treatment was rendered at the scene by fire department personnel and emergency medical technicians (EMTs). The occupants of the Pontiac were transported by ambulance to a local hospital for treatment. The front right passenger was treated and released. After initial assessment in the emergency room, the driver was transported to a nearby trauma center for further treatment and hospitalized for ten days. Both vehicles were towed from the crash site due to disabling damage.

VEHICLE DATA

The 1999 Pontiac Grand Prix GT was identified by the vehicle identification number (VIN): 1G2WP12K3XF (production number deleted). The driver was reported by police as the owner of the vehicle. The vehicle was a 2-door coupe equipped with four-wheel ABS, front-wheel drive and a 3.8 liter, V-6 engine. At the time of the crash, the odometer had recorded 61,585 km (38,268 miles). The seating was configured with front bucket and rear bench seats (with folding backs). The driver's father purchased the vehicle (used) in June, 2000 with an approximated odometer reading of 48,279 km (30,000 miles). Although the driver and father reported no previous crashes or maintenance on the Pontiac's frontal air bag system, the vehicle's history was unknown prior to its purchase. No cellular phone was present or in use at the time of the collision, however, a pager was present and on.

Figure 3. Frontal damage to the 1999 Pontiac Grand Prix GT.

VEHICLE DAMAGE

Exterior

The 1999 Pontiac Grand Prix GT sustained moderately severe frontal damage as a result of the impact with the Ford Mustang **(Figure 3)**. The direct contact damage encompassed the entire frontal width resulting in a combined direct and induced damage length (Field L) of 110.0 cm (43.3 in). Six crush measurements were documented at the level of the reinforcement bar *(bumper fascia separation)*: C1= 0 cm, C2= 27.5 cm (10.8 in), C3= 47.5 cm (18.7 in), C4= 48.5 cm (19.1 in), C5= 41.5 cm (16.3 in), C6= 26.5 cm (10.4 in), *maximum crush between C3 and C4= 55.5 cm (21.9 in)*. The Collision Deformation Classification (CDC) for this impact to the Pontiac was 11-FDEW-3 with a principal direction of force of (-) 20 degrees. Although the crush was concentrated mainly along the front right and center portions of the end structure, contact damage was documented across the entire front end width of the bumper cover and leading edge of the hood. An indentation was also identified to the center portion of the reinforcement bar attributed to the front right bumper corner of the opposing Ford. The hood was displaced up and rearward from the impact force. The right fender was deformed rearward which restricted the right front wheel/tire (not deflated). Bloody hand prints were noted along the (exterior) left door and window frame, attributed to the driver as she exited the vehicle post-crash. The windshield was fractured from (exterior) impact forces and the (interior) passenger air bag flap. Reduction in the right wheelbase measured 9.0 cm (3.5 in) as the left wheelbase was elongated 3.5 cm (1.4 in).

Interior

Interior damage to the Pontiac identified through the vehicle inspection was moderately severe and was attributed to occupant contact and the driver air bag inflator failure **(Figure 4)**. Scuff marks were documented to the left knee bolster. Indentations and hair strands were identified along the left roof, sunvisor and A-pillar. The left portion of the headliner was abraded with particulate burns and occupant contact scuff marks **(Figure 5)**. Steering wheel rim deformation measured 2.0 cm (0.8 in) along the top portion and 3.5 cm (1.4 in) along the right portion. Column compression measured 7.0 cm (2.8 in) which resulted in separation of the sheer capsules from the sheer plate. A heavy concentration of blood and particulate burns were noted along the left interior door panel with bloody hand prints to the (interior/exterior) door panel and upper window frame. Scuff marks were documented to the glove compartment door which was also out of place. No intrusions were found within the vehicle.

Figure 4. Interior view of the 1999 Pontiac Grand Prix GT.

Figure 5. Driver contact evidence and air bag particulate burns to the headliner.

MANUAL RESTRAINT SYSTEMS

The interior of the Pontiac Grand Prix consisted of a five passenger seating configuration with front bucket and rear bench seats (with folding backs). The driver 3-point manual lap and shoulder belt system consisted of a continuous loop belt webbing with a sliding latchplate and dual mode retractors (inertial lock/belt sensitive). The front right 3-point manual lap and shoulder belt system consisted of a continuous loop belt webbing with a sliding latchplate and a retractor equipped with an inertial and switchable lock mechanism. There was no loading evidence present on the restraint webbings or D-rings to substantiate usage by either occupant. The rear outboard seated positions were equipped with 3-point manual lap and shoulder belt systems which consisted of continuous loop belt webbings with sliding latchplates that retracted into inertial sensitive and switchable locking retractors. The center rear seating position was equipped with a 2-point manual lap belt system with a locking latchplate.

SUPPLEMENTAL RESTRAINT SYSTEMS

The 1999 Pontiac Grand Prix GT was equipped with frontal air bags for the driver and front right passenger positions. The air bags deployed as a result of the crash **(Figure 6)**. The driver air bag module was housed in the center of the steering wheel **(Figure 7)** with a vertically oriented flap tear seam (I-configuration). The flaps were

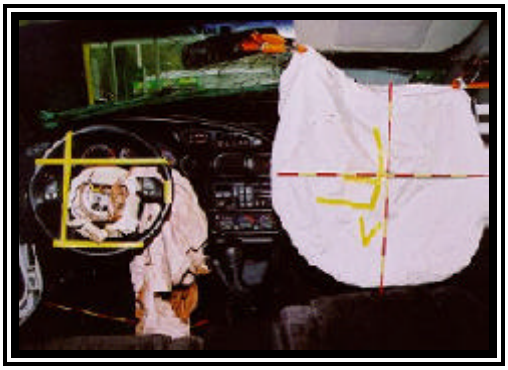

Figure 6. 1999 Pontiac Grand Prix GT deployed redesigned frontal air bag system.

symmetrical in shape and measured 7.8 cm (3.1 in) in width and 11.0 (4.3 in) in height. The module flaps and adjacent trim flaps separated from the housing and were found scattered about the vehicle interior. The air bag membrane was noted to be torn/ruptured **(Figure 8)** and partially attached to the module at the 6 o'clock sector. The diameter of the driver air bag measured approximately 68.0 cm (26.8 in) in its deflated state. The bag was vented by two ports located at the 3 o'clock and 9 o'clock sectors on the rear aspect of the air bag. No internal tether straps were present.

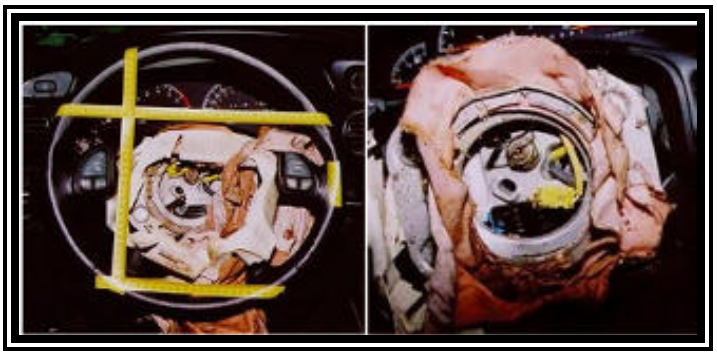

Figure 7. 1999 Pontiac Grand Prix GT deployed redesigned driver air bag module.

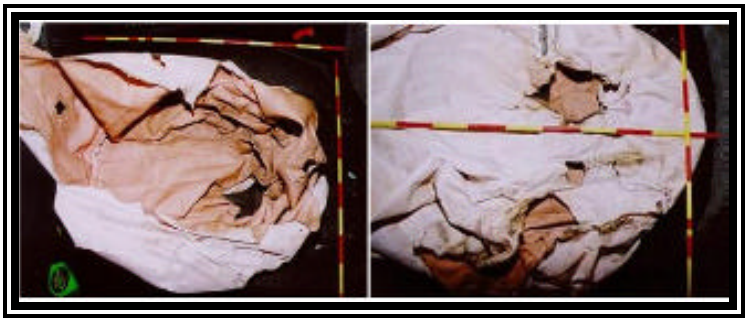

Figure 8. Deployed driver air bag (front/back).

Based on an examination of an exemplary inflator received from General Motors February 15, 2001 **(Figure 9)**, the subject inflator unit was constructed of two halves of a cast aluminum alloy metal that were threaded together with an internal thread design. The internal compartment of the inflator contained the initiator, a canister of propellant, and a series of steel mesh screens that acted as a filtering medium **(Figure 10)**. Radial ports transferred the gas from the combustion chamber, through the internal wall at the threaded union, through a second stage of filtering medium, and out the side aspect of the inflator. The base/perimeter of the alloy casting was knurled and pressed into the aluminum mounting bracket. The bracket was bolted to the module bracket and secured to the steering wheel with four bolts. At deployment, the casting failed to contain the internal burn process of the generant. As a result, the center disk-like segment of the inflator "*blew out*" of the casting **(Figure 11)**. Although initially thought to be an integral part of the inflator's design, this large disk-like segment actually separated from the top portion of the inflator. Without a metallurgical analysis of the inflator to look for certain characteristics of possible fracture sites, several possibilities exist as a reason for the inflator failure. Bad casting, too much generant, contaminates in the screen or a plugged filter screen could have produced an excessive build-up of pressure within the inflator.

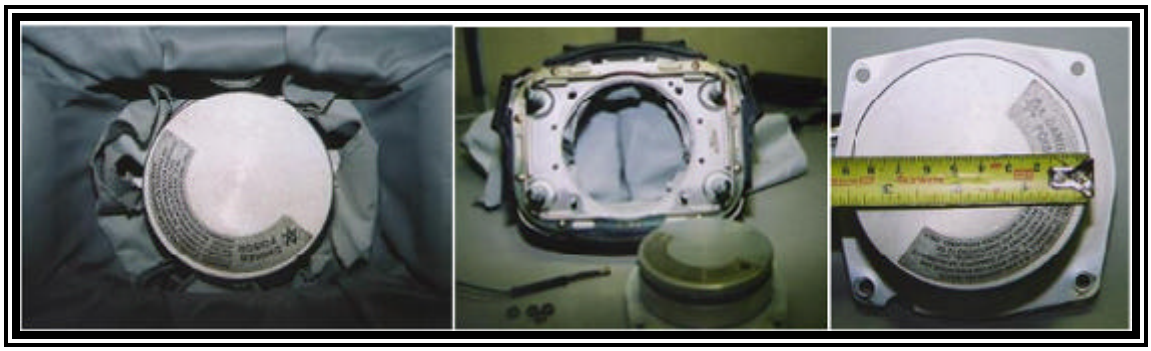

Figure 9. Exemplary deployed driver air bag module disassembled for SCI analysis.

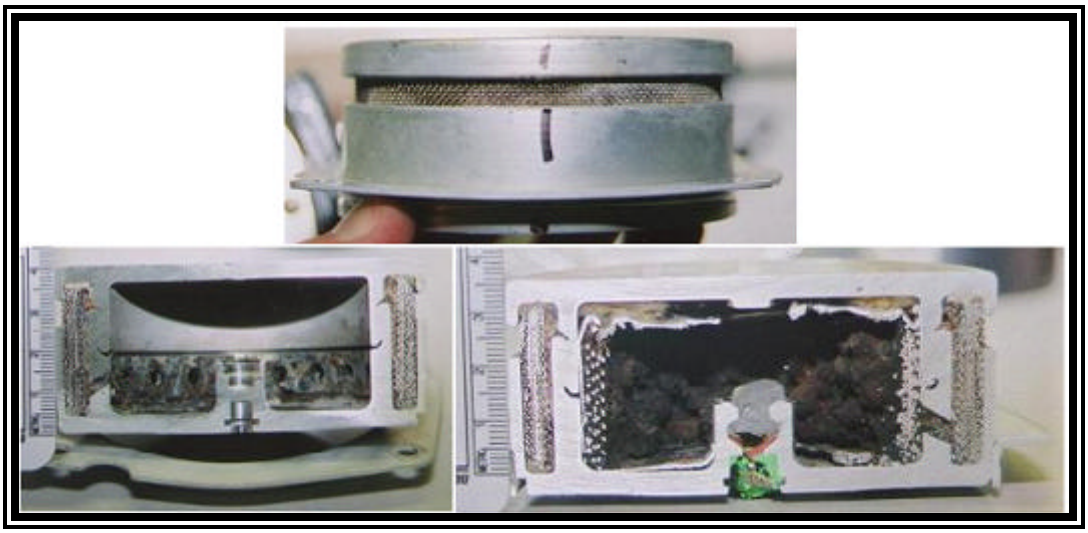

Figure 10. Exemplary inflator unit sectioned for SCI analysis (cross section view).

Figure 11. Charred disk-like segment of the failed inflator.

Although the driver air bag module part/serial numbers were unidentifiable, the separated air bag inflator and large disk-like segment **(Figure 12)** were identified by the General Motors part number: 16822766 with a bar coded lot number of: IECL0I252A1135. A discrepancy in the part number was noted between the subject inflator and the exemplary inflator received for analysis. While similar in size and design, the exemplary inflator required a 1.75 amp electrical current for deployment whereas the subject inflator required a 1.2 amp current. A third distinguishable number was identified on the back of the subject inflator unit, however, certain digits were destroyed by a recoil imprint from the steering column rim mounting bolt **(Figure 13)**. The inflator unit measured 8.7 cm (3.4 in) in diameter and 3.8 cm (1.5 in) in thickness as the large disk-like segment measured 5.7 cm (2.2 in) in diameter and 0.4 cm

(0.2 in) in thickness. The air bag inflator was later found in the rear right floor area with the igniter missing. The large disk-like segment was later found between the driver seat cushion and door burned and abraded, covered with blood and unidentifiable fabric strands. Metal shrapnel was found embedded into the rear center seat back **(Figure 14)**.

Figure 12. 1999 Pontiac Grand Prix GT failed driver air bag inflator unit and disk-like segment.

Figure 13. Recoil imprint to rear aspect of failed inflator unit.

Figure 14. Metal shrapnel from inflator unit.

The front right passenger air bag deployed from the right top instrument panel area with a single cover flap design hinged at the forward aspect. The aluminum reinforced cover flap was somewhat rectangular in shape and measured 36.4 cm (14.3 in) in width along the lower portion and 39.2 cm (15.4 in) along the upper portion. The flap measured 27.0 cm (10.6 in) in height along the left edge and 23.7 cm (9.3 in) along the right edge. Glass fragments were embedded into the aft portion of the flap attributed to the windshield impact during bag expansion. No contact evidence was identified on the exterior surface of the cover flap or surrounding instrument panel area. The passenger air bag module was identified by the General Motors part number: *16757542-57* with a bar coded lot number of: *TRAI80115853*. The passenger air bag measured 61.0 cm (24.0 in) in width and 62.5 cm (24.6 in) in height in its deflated state **(Figure 15)**. Lipstick transfers were documented to the left centered portion

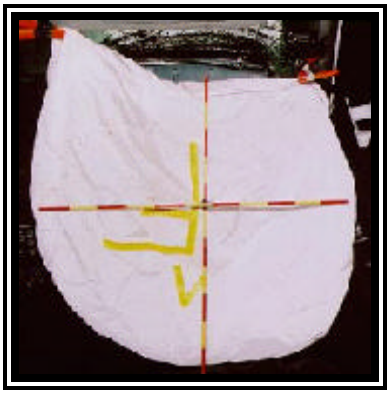

Figure 15. 1999 Pontiac Grand Prix GT deployed redesigned passenger air bag.

of the air bag face with makeup transfers surrounding the contact site. Blood spattering was noted to the upper left quadrants of the air bag face and side aspect, attributed to the driver's facial injury. Particulate burns (from the driver air bag inflator) were also noted to the upper left quadrant of the passenger air bag face and side aspect. The bag was vented by two ports located at the 10 o'clock and 2 o'clock sectors on the side aspect of the air bag. No internal tether straps were present.

DRIVER DEMOGRAPHICS

Age/Sex:	17 year old female
Height:	168 cm (66 in)
Weight:	147 kg (323 lb)
Seat Track Position:	Full rearward position
Manual Restraint Use:	None
Usage Source:	Vehicle inspection
Eyeware:	None
Type of Medical Treatment:	Transported to a local hospital, subsequently transferred to a local trauma center and admitted (10 days)

Driver Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
+Loss of consciousness (unk. duration) (with closed head injury)	Moderate (160406.2,0)	Sunvisor/roof
+Laceration left forehead (13cm)	Moderate (290604.2,7)	Sunvisor/roof
*Laceration right cheek (10cm complex/charred)	Moderate (290604.2,1)	Projectile (driver air bag inflator)
*Fracture right mandible at angle (open/comminuted)	Moderate (250612.2,1)	Projectile (driver air bag inflator)
*Facial nerve transection, 3-4cm missing (right mandibular marginal nerve)	Moderate (131604.2,1)	Projectile (driver air bag inflator)
#Dislocation right shoulder	Moderate (751030.2,1)	Steering wheel rim (indirect contact injury)
^Fracture left foot (4^{th} metatarsal near neck/displaced)	Moderate (852200.2,2)	Left toepan
^Fracture left foot (3^{rd} metatarsal distal/displaced)	Moderate (852200.2,2)	Left toepan
^Fracture left foot (2^{nd} metatarsal distal/non-displaced)	Moderate (852200.2,2)	Left toepan
+Laceration left scalp (5cm)	Minor (190602.1,2)	Sunvisor/roof
+Abrasion right cornea	Minor (240602.1,1)	Driver air bag inflator particulates

Driver Injuries (con't.)

Injury	*Severity (AIS 90)*	*Injury Mechanism*
*Laceration right neck (15cm charred)	Minor (390602.1,1)	Projectile (driver air bag inflator)
+Blunt trauma of the chest (NFS)	Unknown (415099.7,0)	Steering wheel hub/rim
*4 percent total body surface area burn (1st degree) *-Burns to face (and right ear), center chest and upper abdomen* *-Burns to right anterior upper extremity (NFS)* *-Burns to left upper extremity: anterior wrist to bicep (deep = graft)* *-Severe thermal burn to right eye: severe corneal and conjunctiva burn (with cornea opacification) complete loss of sight (now needs cornea transplant)* *-Soot on tongue and buccal mucosa* *-Soot on all four extremities* *-Both eyelashes and eyebrows singed*	Minor (992002.1,0)	Driver air bag inflator particulates
+Contusion left knee	Minor (890402.1,2)	Left knee bolster
+Contusion left foot	Minor (890402.1,2)	Left toepan

Sources:-operative report, +-history and physical report, ^-radiology report, #-driver*

Driver Kinematics

The 17 year old female driver of the 1999 Pontiac Grand Prix GT was unrestrained (3-point manual lap and shoulder belt system available), seated in an upright posture with the seat track adjusted to the full rearward position. Her right hand was placed at the 12 o'clock position on the steering wheel rim with the left hand resting on the left door armrest. Her right foot was placed on the accelerator pedal with the left foot on the floor. Restraint usage was determined by the trajectory of the occupant and the lack of loading evidence on the belt system.

As the redesigned driver air bag began to deploy, the inflator failed and the large disk-like segment separated from the main inflator unit which was projected through (ruptured) the membrane of the air bag, towards the driver. The inflator subsequently separated from the module bracket and followed the disk segment through the membrane and into the occupant space. The inflator struck the driver's right face and neck in a "glancing type blow" resulting in a open/comminuted mandible fracture and "charred" lacerations to the cheek/neck with an underlying transection of the mandibular marginal nerve. This injury mechanism was evidenced by the type and location of the injuries relative to the reported final rest position of the inflator in the rear right floor area. Metal shrapnel also found in the rear seating area was discounted as a source of the right facial lacerations given the location and severity of the fractured mandible along the angle. The large disk-like segment was found between the driver seat cushion/door area and probably struck the driver at some point, however, it was not specifically attributed to any injury sustained.

Generant particulates from the inflator sprayed the driver space which resulted in first degree burns across the torso and anterior extremities (4 percent total body surface area), evidenced by the extent of the tissue burns in conjunction with the documented circular spray-patterned singed clothing **(Figure 17)** and burned air bag membrane. Areas of heaviest concentration of particulates to the vehicle interior were noted along the headliner and left door panel. Areas of heaviest concentration to the driver's soft tissue occurred on the face, abdomen and anterior forearms. Skin grafts taken from the driver's thigh were later used to repair a severe burn to the left anterior forearm (wrist to bicep), which was placed on the door armrest pre-crash. Furthermore, medical data reported singed eyelashes/eyebrows with soot found on all four anterior extremities, with specific concentrations noted to the tongue and buccal mucosa. She also sustained a right cornea abrasion and conjunctiva thermal burn resulting in extensive corneal opacification and complete loss of sight.

Figure 17. Charred driver's clothing.

At this point, the driver initiated a forward trajectory in response to the 11 o'clock impact force and loaded through the partially inflated (torn) bag onto the steering rim/column resulting in a dislocated right shoulder and blunt chest trauma. The injury mechanism for the (indirect contact) right shoulder dislocation was evidenced by the deformation documented to the top section of the steering wheel rim relative to the driver's stated pre-crash placement of the right hand at the 12:00 position on the steering wheel rim. The injury mechanism for the blunt chest trauma was evidenced by the deformation documented to the right section of the steering wheel rim and extensive column compression identified during the SCI vehicle inspection. Loading of the knee bolster resulted in a contusion to the left knee as evidenced by the scuff marks documented on this component. She continued the kinematic response pattern as her head struck the sunvisor/roof resulting in an unspecified closed head injury and lacerations of the left forehead and scalp, evidenced by the indentation and hair strands documented on this component **(Figure 18)**. Loading of the toepan resulted in a contusion and multiple fractures of the left foot as evidenced by the location of the injury relative to the driver's stated pre-crash placement of the left foot on the floor. The medical reported a momentary loss of consciousness (duration unknown) with a closed head injury, therefore, the driver's exit from the vehicle may have been briefly delayed. After initial transport by ambulance to a local hospital, she was transferred to a

Figure 18. Contact evidence to the left sunvisor.

nearby trauma center and admitted for ten days due to the specialty oral surgery care needed. It should be noted that the driver had rods placed in her back some years ago for treatment of scoliosis. No fractures of the spine were sustained, but the right rod and middle crossing screw *(which bridges the two rods)* were also fractured and replaced during subsequent treatment. At the time of the SCI interview, she was under evaluation for a cornea transplant.

Primary restraint usage would have mitigated the head/chest trauma sustained by the driver. The *supplemental* air bag provided little if no crash protection to the unrestrained driver given the obvious damage to the air bag membrane and failure of the air bag inflator.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex:	17 year old female
Height:	165 cm (65 in)
Weight:	45 kg (100 lb)
Seat Track Position:	Full rearward position
Manual Restraint Use:	None
Usage Source:	Vehicle inspection
Eyeware:	None
Type of Medical Treatment:	Transported to a local hospital and released

Front Right Passenger Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
#Cervical strain	Minor (640278.1,6)	Non -contact injury (flexion)

Source: #-driver

Front Right Passenger Kinematics

The 17 year old female front right passenger of the 1999 Pontiac Grand Prix GT was unrestrained (3-point manual lap and shoulder belt system available) and seated in an upright posture with the seat track adjusted to the full rearward position. Restraint usage was determined by the trajectory of the occupant and the lack of loading evidence on the belt system.

At impact, the front right passenger initiated a forward trajectory in response to the 1 o'clock impact force and loaded the passenger air bag. Contact to the deployed redesigned front right passenger air bag was confirmed by the lipstick and makeup transfers documented to the left centered portion of the air bag face. She sustained a cervical strain which was a result of the sudden forward head movement as the kinematic response commenced (flexion). No other injury was reported. The front right passenger was transported by ambulance to a local hospital for treatment and released. The deployed redesigned passenger air bag provided adequate protection against contact to the instrument panel and windshield, thus preventing serious injury.

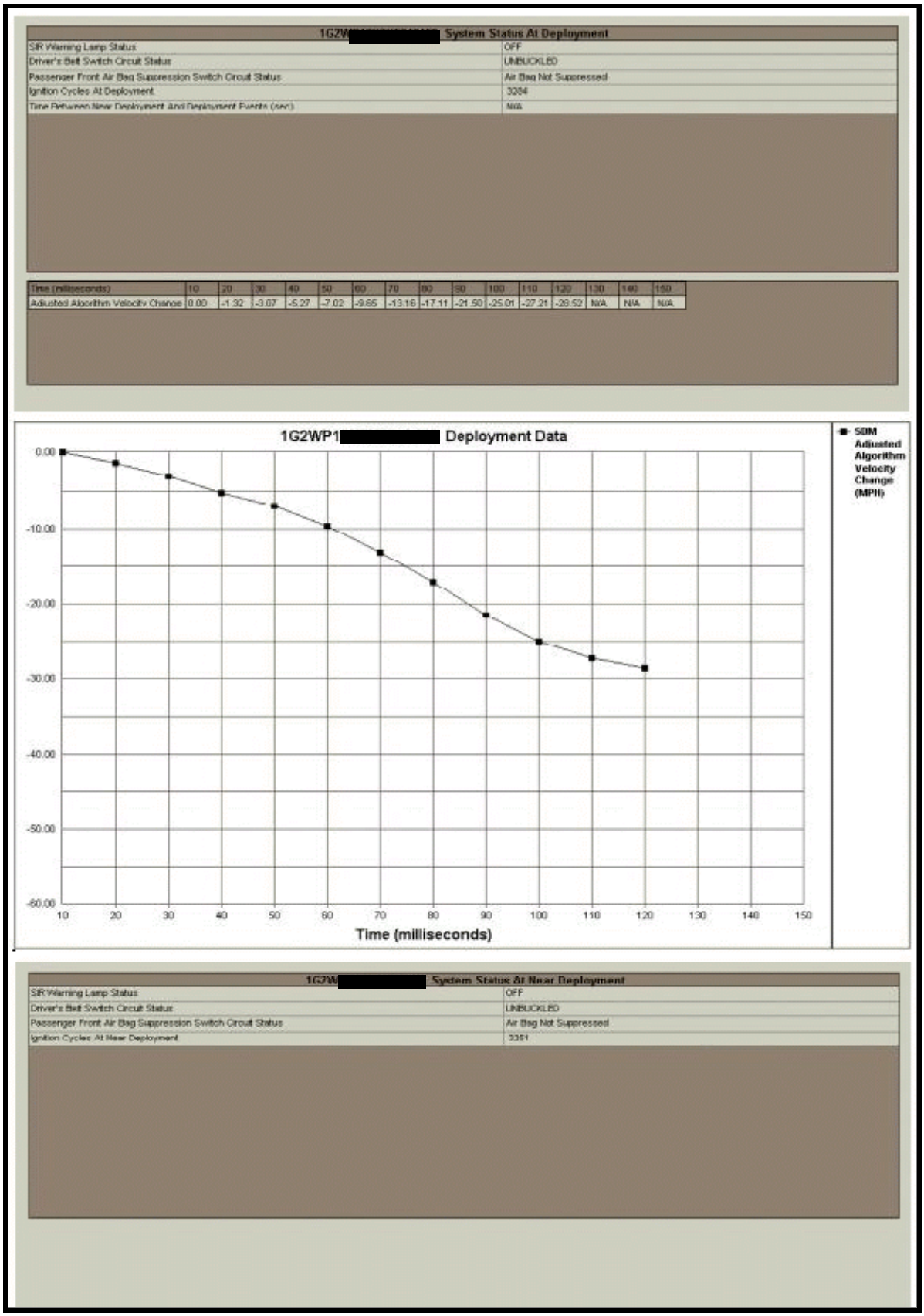

Figure 18. 1999 Pontiac Grand Prix GT EDR report.

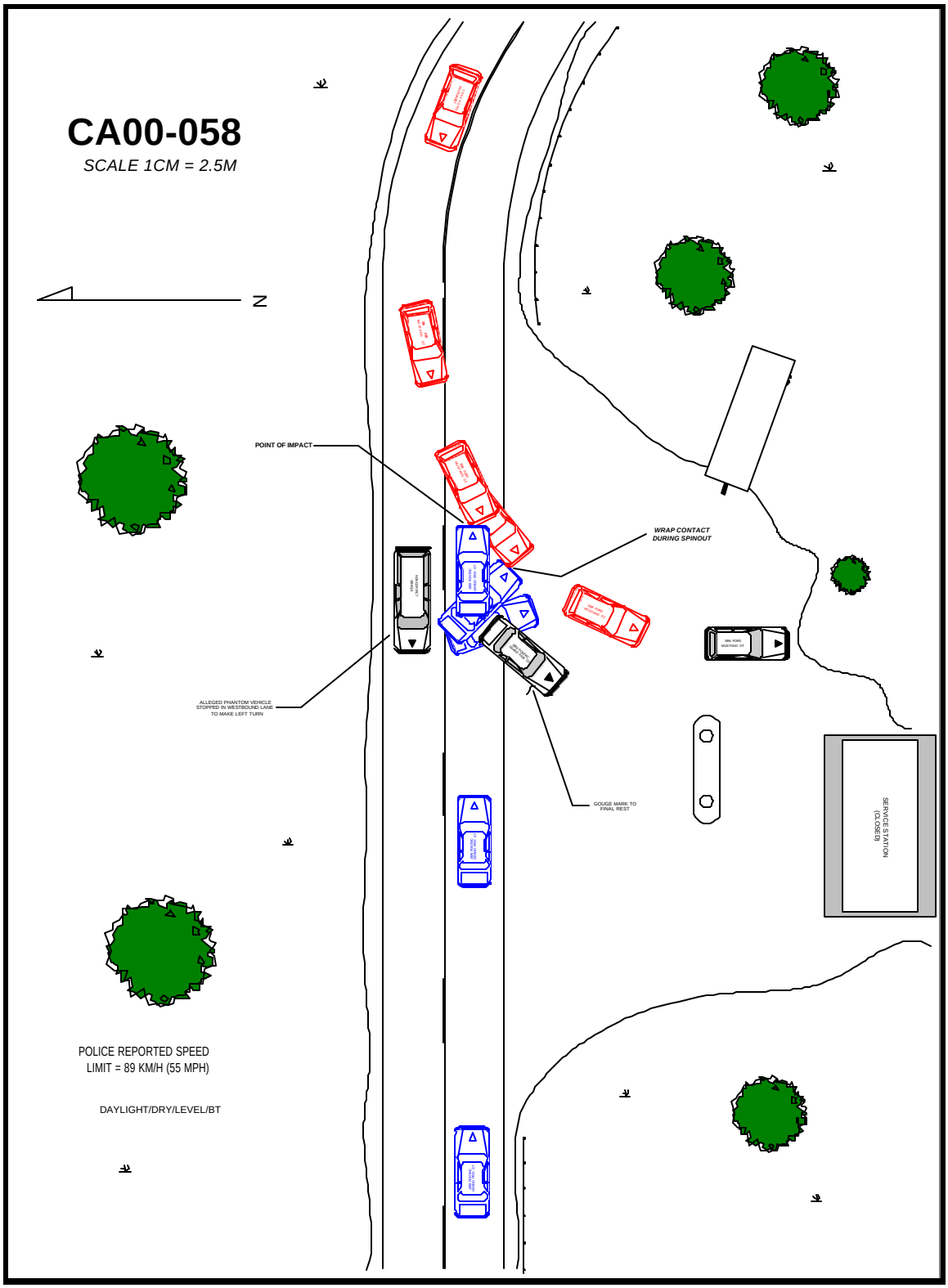

Figure 19. Scene Diagram.