TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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VERIDIAN ON-SITE SIDE IMPACT OCCUPANT PROTECTION INVESTIGATION

VERIDIAN CASE NO. CA01-047

VEHICLE - 2000 PONTIAC MONTANA

LOCATION - STATE OF MICHIGAN

CRASH DATE - OCTOBER, 2001

Contract No. DTNH22-01-C-17002

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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 performance of the side impact occupant protection system of a 2000 Pontiac Montana. The Pontiac was equipped with (seat mounted) side impact air bags for the front seating positions. The driver side impact air bag deployed as a result of a left side impact with two wooden signposts. The driver of the Pontiac was operating the vehicle southbound on a multi-lane state highway and negotiating a left curve on wet pavement when he allowed the vehicle to depart the right (west) pavement edge in a clockwise yaw. As the vehicle exited the west pavement edge, the left side surface impacted the signposts resulting in minor damage. The restrained 61 year old male driver initiated a lateral trajectory in response to the 9 o'clock impact force and loaded the deployed left front side impact air bag and interior surface. Loading of the left front door armrest resulted in multiple soft tissue injury to the left lateral chest along with associated underlying multiple (unspecified) rib fractures and splenic trauma. The driver was transported to a local hospital for treatment and admitted for five days.			
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BACKGROUND

This on-site investigation focused on the performance of the side impact occupant protection system of a 2000 Pontiac Montana. The Pontiac was equipped with (seat mounted) side impact air bags for the front seating positions. The driver side impact air bag deployed as a result of a left side impact with two wooden signposts. The driver of the Pontiac was operating the vehicle southbound on a multi-lane state highway and negotiating a left curve on wet pavement when he allowed the vehicle to depart the right (west) pavement edge in a clockwise yaw. As the vehicle exited the west pavement edge, the left side surface impacted the signposts resulting in minor damage. The restrained 61 year old male driver initiated a lateral trajectory in response to the 9 o'clock impact force and loaded the deployed left front side impact air bag and interior surface. Loading of the left front door armrest resulted in multiple soft tissue injury to the left lateral chest along with associated underlying multiple (unspecified) rib fractures and splenic trauma. The driver was transported to a local hospital for treatment and admitted for five days.

The crash notification was provided to NHTSA by the driver's son and immediately assigned to the Veridian SCI Team as an on-site investigative effort on Friday, October 19, 2001. The on-site investigator completed field activities on Tuesday, October 23, 2001.

SUMMARY

Crash Site

This single vehicle crash occurred during the morning hours of October, 2001. At the time of the crash, it was dark (street not lighted) with rainy conditions as the roads were wet. The crash occurred off the west pavement edge of a (level) multi-lane north/south state roadway **(see Figure 13 - page 8)** which curved left for southbound traffic. The concrete surfaced roadway was bordered by wide paved shoulders and divided by a thrie-beam median barrier. Environmental features also included a road sign located 7.3 meters (24.0 feet) off the west shoulder supported by three 15.2 cm x 20.3 cm (6.0 in x 8.0 in) treated posts spaced 1.3 meters (4.3 feet) apart. A chain link fence was also documented 12.4 meters (39.7 feet) off the west pavement edge with support posts spaced on 3.2 meter (10.5 feet) centers. No traffic control was present at the scene which had a posted speed limit of 113 km/h (70 mph).

Pre-Crash

The 61 year old male driver of the 2000 Pontiac Montana was en-route to work, operating the vehicle southbound **(Figure 1)** on the inboard lane of a multi-lane state roadway and negotiating a left curve at a (driver reported) speed of 105 km/h (65 mph). The vehicle's Event Data Recorder (EDR) recorded a travel speed of 105 km/h (65 mph) at the pre-crash five second interval. As the Pontiac reached the apex of the curve, the vehicle broke traction on the wet road surface and began a counterclockwise yaw. The driver reported during the SCI interview that strong cross winds may have contributed to pre-crash circumstances. Upon recognition of the impending harmful event, the driver over steered a

right avoidance maneuver which re-directed the vehicle towards the west pavement edge in a 90 degree clockwise yaw.

Figure 1. Southbound approach for the 2000 Pontiac Montana.

Crash

As the Pontiac departed the right (west) pavement edge, the vehicle traveled approximately 14.4 meters (47.2 feet) as the left side surface simultaneously impacted two signposts **(Figures 2 & 3)** resulting in minor damage. Although the impact was classified as out-of-scope *(yielding objects/simultaneous impacts)*, the damage algorithm of the WinSMASH reconstruction program computed a barrier equivalent velocity change of 11.3 km/h (7.0 mph) with a latitudinal component of 11.1 km/h (6.9 mph). Impact resulted in deployment of the Pontiac's driver side impact air bag system. The Pontiac's EDR recorded a near deployment event **(see Figure 14 - page 9)**. Fragments of the support structure subsequently struck the windshield which resulted in minor damage. At this point, the clockwise rotation continued as the vehicle proceeded in a southwesterly direction approximately 5.3 meters (17.4 feet) as the rear area struck a chain link fence resulting in minor damage. The Pontiac Montana came to rest against the chain link fence facing east.

Figure 2. Struck signposts and chain link fence.

Figure 3. Look back view from vehicle final rest showing struck signposts.

Post-Crash

Following the crash, the driver remained in the vehicle due to intense pain and attempted to "flag down" traffic by flashing his headlights (driver had no cellular phone). A passerby stopped to render assistance 30 minutes after the crash who summoned for help using a cellular phone. The tow truck was first to arrive on-scene 45 minutes following the crash as the driver's wife arrived shortly after. After a 75 minute prolonged response time by rescue personnel, the driver of the Pontiac was subsequently removed from the vehicle through the right front door with perceived serious injuries. He was transported by ambulance to a local hospital for treatment and admitted for five days. The Pontiac was towed from the scene with non-disabling damage.

VEHICLE DATA

The 2000 Pontiac Montana was manufactured in August, 1999 and identified by the vehicle identification number (VIN): 1GMDX03E3YD (production number deleted). The driver was the owner of the vehicle which was purchased as new in February, 2000. The vehicle was a 4-door minivan equipped with power windows/door locks/driver seat, front-wheel drive, anti-lock braking system (ABS), and a 3.4 liter, V-6 engine. At the time of the crash, the odometer had recorded 76,403 km (47,476 miles). The seating was configured with box-mounted (van type) bucket seats for the first and second row and a split bench (with folding backs) for the third row seating positions. The driver reported no previous crashes or maintenance on the Pontiac's side impact or frontal air bag system. No cellular phone was present in the vehicle.

VEHICLE DAMAGE

Exterior

The 2000 Pontiac Montana sustained minor left side surface damage as a result of the impact with the two signposts **(Figures 4 & 5)**. Narrow direct contact damage was identified 136.0 cm (53.5 in) forward of the left rear axle (B-pillar area) and 268.0 cm (105.5 in) forward of the left rear axle (A-pillar area) attributed to each struck post. The simultaneous and overlapping nature of these post impacts necessitated a *single direct damaged area (single crush profile)* which began 136.0 cm (53.5 in) forward of the left rear axle and extended forward 148.0 cm (58.3 in). The (*overlapping crush profile*) direct and induced damage length (Field L) began 36.0 cm (14.2 in) forward of the left rear axle and extended forward 286.0 cm (112.6 in). Six crush measurements were documented at the level of the mid-door: C1= 0 cm, C2= 4.0 cm (1.6 in), C3= 6.5 cm (2.6 in), C4= 0 cm, C5= 2.0 cm (0.8 in), C6= 0 cm. A maximum crush value of 14.0 cm (5.5 in) was documented 8.5 cm (3.3 in) aft of the C3 position. Although not inclusive of the documented crush profile, a secondary maximum crush value attributed to the A-pillar damage measured 11.0 cm (4.3 in). The Collision Deformation Classification (CDC) assigned to this *overlapping* impact to the Pontiac was 09-LYAW-2 with a principal direction of force of (-)100 degrees. Although not inclusive of CDC protocol, individual CDC's were 09-LPAN-2 and 09-LFEN-2. The left fender was deformed outward forward of the axle area as no crush or induced buckling was noted to the driver door area. Pocketing was noted to the left rear door (side tempered glazing disintegrated) as the contact damage extended vertically to the roof side rail. Induced contact damage produced minor buckling to the roof area. Pry marks were noted to the driver's door latch/striker assembly attributed to occupant extrication activities by rescue personnel post-crash. The left front tire was deflated (not restricted) with soil deposits noted in the left side wheels.

The windshield was fractured at the lower left A-pillar from exterior impact forces and the mid-center windshield was penetrated by fragments of the signpost support structure. The 18.0 cm (7.1 in) slit in the mid-windshield was attributed to a U-channel bracket that was found in the passenger compartment on the rear floor area. The CDC for this secondary (non-horizontal) impact to the Pontiac was 00-TPZW-3. Surface scratching was also noted to the rear tailgate (bumper fascia missing) and attributed to the chain link fence impact. The direct contact damage began at the rear left bumper corner (tail light area) and extended 155.0 cm (61.0 in) inboard. The CDC for this final impact to the Pontiac was 06-BDEW-1.

Figure 4. Windshield and left side surface damage to the 2000 Pontiac Montana.

Figure 5. Left side view with direct contact damage to the A-pillar and B-pillar.

Interior

Interior damage to the Pontiac was minimal and was attributed to occupant contact and component intrusions. Scratches were documented on the upper and lower portions of the left front door armrest. Small areas of concentrated scratch marks were identified on the rigid upper component and lower armrest cover panel (just above the reflector lens). Induced B-pillar damage produced rearward/lateral movement of the adjacent handle bar and pillar cover panel. Driver interaction with the deployed left front side impact air bag produced white scuff marks on the armrest and upper door panel **(Figure 6)**. Lateral intrusions into the driver space involved 7.0 cm (2.8 in) of B-pillar intrusion, 4.0 cm (1.6 in) of (left rear) handle bar intrusion, and 3.0 cm (1.2 in) of kick panel intrusion. Lateral intrusions into the left rear passenger space involved 13.0 cm (5.1 in) of door panel intrusion, 12.0 cm (4.7 in) window frame intrusion, 4.0 cm (1.6 in) of roof side rail intrusion, and 2.0 cm (0.8 in) of sill intrusion. Penetration of signpost debris into the passenger compartment (metal bracket) resulted in an approximated longitudinal intrusion >61.0 cm (>24.0 in). No vertical component intrusions were found in the vehicle.

Figure 6. Scuff marks to the driver door armrest.

MANUAL RESTRAINT SYSTEMS

The interior of the Pontiac Montana consisted of a seven passenger seating configuration with box-mounted (van type) bucket seats for the first and second row and a split bench (with folding backs) for the third row seating positions. The driver 3-point manual lap and shoulder belt system consisted of a continuous loop belt webbing with a sliding latchplate and a dual mode retractor (inertial lock/belt sensitive). Slight dimpling was noted to the shoulder portion of the driver restraint along with abrading to the latchplate and D-ring. The lack of pretensioner deployment suggested this loading evidence was crash related, however, the driver's lateral motion was minimal (he reported no previous crashes). The front right (and rear outboard) seating position was equipped with a 3-point manual lap and shoulder belt system which consisted of a continuous loop belt webbing with a sliding latchplate and a retractor equipped with an inertial and switchable lock mechanism. The third row center seat was equipped with a 2-point manual lap belt and a locking latchplate.

SUPPLEMENTAL RESTRAINT SYSTEMS

The 2000 Pontiac Montana was equipped with redesigned frontal air bags for the driver and front right passenger positions which did not deploy as a result of the crash **(Figure 7)**. The driver air bag was housed in the center of the steering wheel with a vertically oriented flap tear seam (I-configuration). The front right passenger air bag was housed in the right top instrument panel area with a single cover flap design hinged at the forward aspect.

Figure 7. 2000 Pontiac Montana non-deployed frontal air bag system.

The Pontiac was equipped with seat-mounted side impact air bags for the front seated positions **(Figure 8)**. The driver side impact air bag deployed as a result of the crash **(Figure 9)**. The air bag modules were housed in the outboard side aspect of the front seat backs [45.7 cm (18.0 in) above floor level] with a single cover flap design. No contact evidence was identified on the exterior surface of the module cover flap, however, circular patterned black vinyl transfers were noted on the air bag face from expansion within the module. A 3.0 cm (1.2 in) black fabric transfer was also documented on the mid-portion of the air bag face, and attributed to the driver's jacket. In addition, driver interaction with the deployed air bag produced the noted scuff marks to the aft aspect of the left front door panel and rigid armrest. The design of the side impact air bag placed the right lower edge corner of the membrane approximately 5.0 cm - 7.0 cm (2.0 in - 2.8 in) lower to the floor level than the left lower (inboard) edge corner; with almost no coverage of the rigid apex of the door armrest. The air bag was rectangular in shape and measured 42.5 cm (16.7 in) in width and 27.0 cm (10.6 in) in height in its deflated state. The bag was vented by one port which measured 5.0 cm (2.0 in) in diameter and located on the outboard aspect of the air bag. No internal tether straps were present. The side impact air bag sensors were located in the (lower) B-pillars. The location/severity of each damaged area on the vehicle exterior (left A-pillar and B-pillar) in this multiple impact scenario and related spacing of the sign support posts suggested the driver may have loaded through a deflated (soft) air bag. The rate of inflation and deflation through the vent port was unknown.

The front restraint systems also included buckle pretensioners mounted longitudinally alongside the seat cushions. The piston pulls a cable which lowers the height of the buckle assembly, reducing slack in both the lap and shoulder belt webbing. The buckle pretensioners did not activate as a result of the side impact crash.

Event Data Recorder (EDR)

The 2000 Pontiac Montana Sensing and Diagnostic Module (SDM) was located under the front right seat as the event data was retrieved via the J1962 connector found to the left of the steering column. The EDR records deployment and near-deployment events for the frontal air bag system. In this crash, the EDR recorded a near deployment event at ignition cycle number 3016. The system status at near deployment reflected the driver's belt switch circuit status as "buckled". As the vehicle and engine speed decreased during the five second pre-crash interval, the brake switch circuit status went from "off" to "on" three seconds prior to algorithm activation.

Figure 8. 2000 Pontiac Montana seat mounted side impact air bag.

Figure 9. 2000 Pontiac Montana deployed driver side impact air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	61 year old male
Height:	185 cm (73 in)
Weight:	79 kg (175 lb)
Seat Track Position:	Full rearward position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection, medical/police report, driver interview
Eyeware:	Prescription glasses
Type of Medical Treatment:	Transported to a local hospital and admitted for five days (three days in ICU)

Driver Injuries

Injury	*Severity (AIS 90)*	*Injury Mechanism*
#Splenic contusion (4cm)	Serious (544214.3,2)	Left front door armrest
#Splenic laceration (grade 2-3 splenic injury with high density hemoperitoneum surrounding the splenic capsule)	Moderate (544222.2,2)	Left front door armrest
*Multiple left side rib fractures (not further specified - with bilateral pleural effusions and associated bibasilar atelectasis)	Moderate (450220.2,2)	Left front door armrest
^Contusion left lateral chest (vertically oriented/ rectangular shaped)	Minor (490402.1,2)	Left front door armrest
^Contusion left lateral abdomen (flank-10cm)	Minor (590402.1,2)	Left front door armrest
^Abrasion left lateral abdomen (lower flank)	Minor (590202.1,2)	Left front door armrest

Sources: ER record/radiology report#/SCI interview including injury pictures^*

Driver Kinematics

The 61 year old male driver of the 2000 Pontiac Montana was restrained by the available 3-point manual lap and shoulder belt system, seated in an upright posture with his arms extended and hands braced at the 10 o'clock and 2 o'clock sectors on the steering wheel rim. The seat track was adjusted to the full rearward position with the seat back reclined 18 degrees off vertical. The driver stated he was belted, further evidenced by the vehicle's EDR summary. It should also be noted that the driver was wearing a short sleeve cotton shirt and a black nylon windbreaker jacket.

Figure 10. 2000 Pontiac Montana deployed driver side impact air bag.

At impact with the signposts, the driver initiated a lateral trajectory in response to the 9 o'clock impact force and loaded the deployed left front side impact air bag and interior surface. Interaction with the deployed left front side impact air bag was confirmed by the black fabric transfer documented on the air bag face **(Figure 10)**, which produced the noted white scuff marks identified on the adjacent door panel and armrest. Although preliminary SCI analysis suggested the driver's injuries were related to expansion of the side impact air bag membrane, the simultaneous nature of the post impacts indicated driver loading through a deflated (soft) air bag, or deployment late in the crash sequence. Furthermore, the nature of the injuries sustained *(rib fractures were more significant or pronounced in the lateral aspect, with associated proximal swelling)* indicated a direct loading force as opposed to an air bag expansion type injury. Air bag expansion from a seat back mounted module design would produce injury more prominent in the posterior regions, or "sideswiping the left side". However, the injuries are more prominent "in the middle of the left side" as soft tissue swelling occurred laterally, with a fractured rib just at the anterior edge of the swelling. Photographs provided by the driver (taken approximately five days following the crash) revealed a distinct left sided soft tissue contusion (in the area of the internal trauma) that initially appeared to match the location and deployment path of the expanding side impact air bag. However, further analysis implied this injury may not resemble the contact days later, and the pooling of blood masks any actual component association. That, combined with the nature of the spleen laceration, suggested these injuries were crash related and not air bag related. Loading of the left front door armrest resulted in contusions/abrasions to the left lateral chest and abdomen *(lower flank region - just above the left hip)*, along with associated underlying multiple (unspecified) rib fractures and splenic trauma. This soft tissue injury extended *only slightly* into the posterior regions, indicative of an out-of-position driver.

The driver was probably slightly out-of-position to his left due to the clockwise vehicle yaw, thus exposing the left lateral (and slightly posterior) portion of the chest and abdomen to the rigid armrest. Rotational vehicle movement, in conjunction with frictional interaction between the buttocks and seat cushion, resulted in a lateral kinematic response which exposed the left flank and pelvic areas to the

door armrest. This was evidenced by an exemplary study of the height/distance relationship to this component and a similar sized occupant **(Figures 11 & 12)**. The kinematic response into the door armrest probably redirected the air bag deployment path in a downward direction. The distinct pattern and location of the soft tissue injuries clearly placed the lateral chest region on the rigid upper structure of the armrest, and abdominal *(flank)* region against the lower cover panel *(near the reflector lens)*. These injury mechanisms were further evidenced by the scratch marks and transfers documented on these components. This mechanism also produced extensive underlying trauma which involved unspecified left side rib fractures and a splenic contusion/laceration. The driver's provisional diagnosis during emergency room treatment listed multiple left side rib fractures, however, radiology reports could not confirm the exact number or location. Subsequent analysis of driver medical records by SCI/NHTSA medical consultants revealed the (previously unspecified) fractures to be in the area of left rib #10. It should be noted that he also sustained a contusion to the descending wall of the colon, which could not be confirmed during hospitalization.

Driver Medical Treatment

After a 75 minute response time by rescue personnel, the driver was removed from the vehicle through the right front door and subsequently transported by ambulance to a local hospital for treatment and admitted for five days. Treatment involved three days of intensive care due to an episode of sinus bradycardia *(arrythmias or abnormal heartbeats)* with associated hypotension *(low blood pressure)*, which was possibly related to mesenteric stretching. A splenectomy was ruled out in lieu of a repeated drop in his blood pressure.

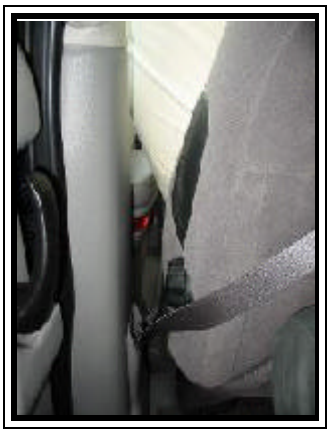

Figure 11. Exemplary view of lateral kinematic trajectory into the door armrest with a similar sized occupant (with seat friction).

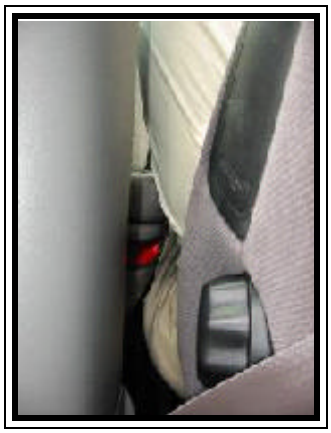

Figure 12. Exemplary view of lateral kinematic trajectory into the door armrest with a similar sized occupant (no seat friction).

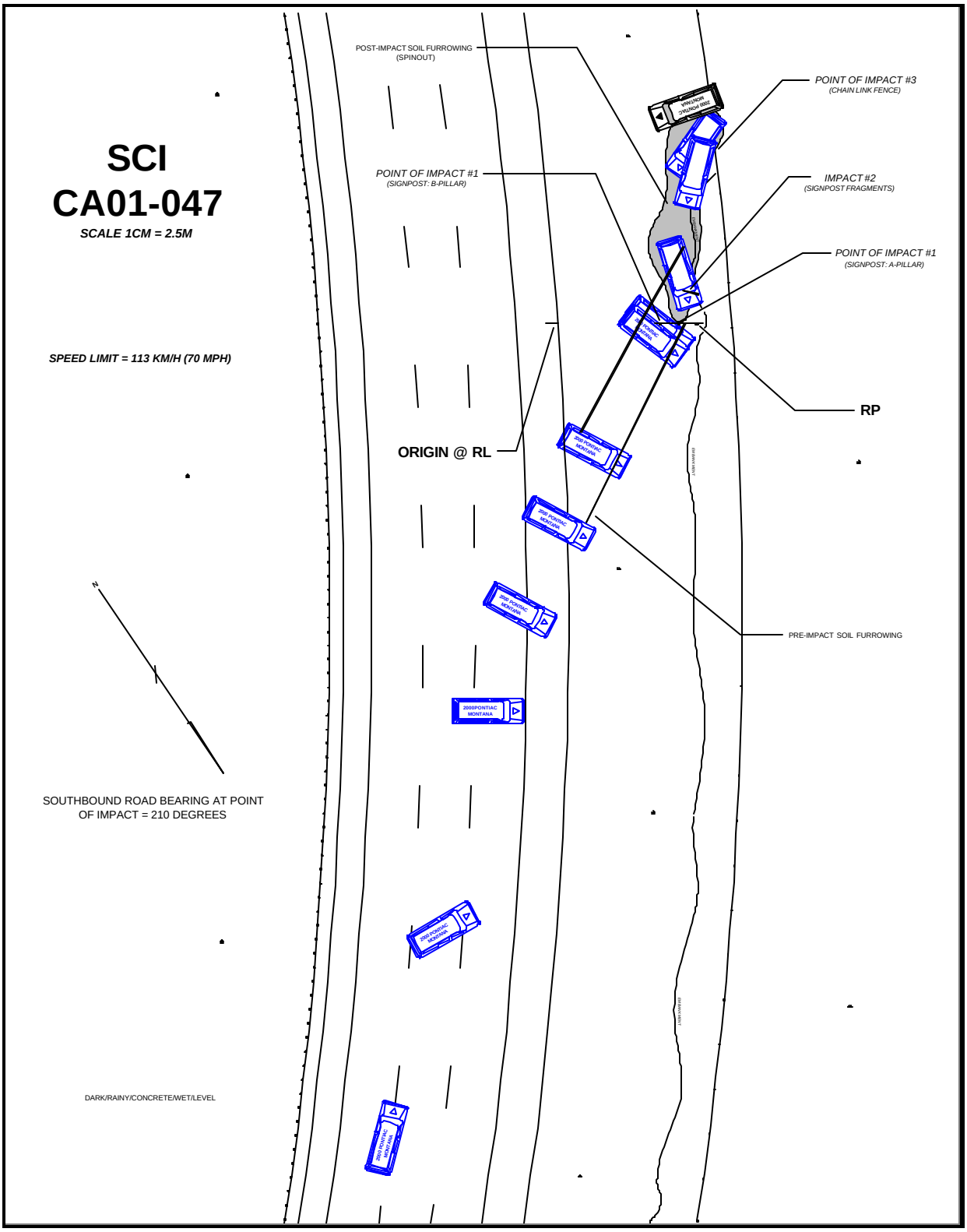

Figure 13. Scene Diagram.

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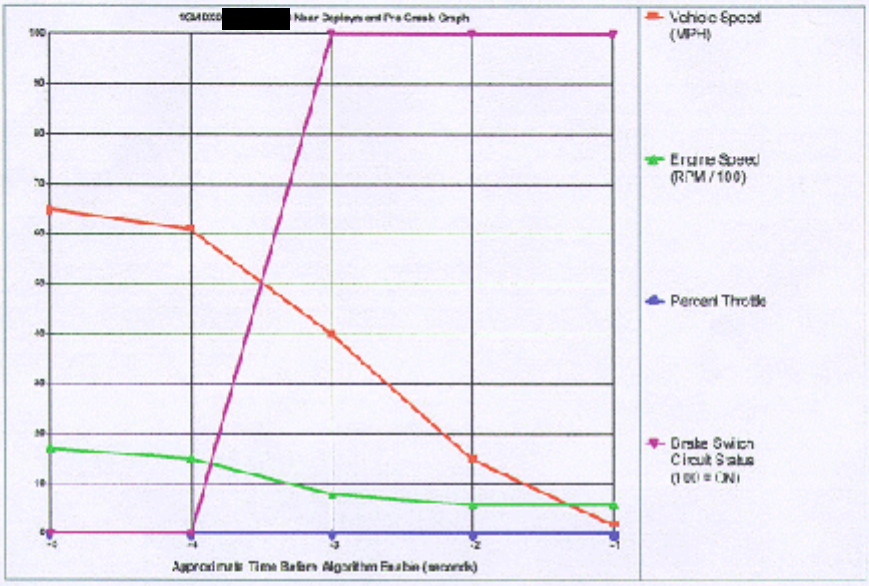
CDR CRASH DATA RETRIEVAL SYSTEM

System Status At Near Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Near Deployment	3016



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	66	1564	0	OFF
-4	61	1472	0	OFF
-3	40	832	0	ON
-2	15	576	0	ON
-1	2	640	0	ON

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Figure 14. 2000 Pontiac Montana EDR report.