TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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VERIDIAN ON-SITE AIR BAG NON-DEPLOYMENT INVESTIGATION

NASS/SCI COMBO CASE NO. 2001-12-116A

VEHICLE - 2000 GMC SONOMA PICKUP TRUCK

LOCATION - STATE OF MICHIGAN

CRASH DATE - JULY, 2001

Contract No. DTNH22-94-D-07058

Prepared for:

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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 non-deployment of the redesigned driver frontal air bag of a 2000 GMC Sonoma pickup truck. The 2000 GMC Sonoma was equipped with redesigned frontal air bags for the driver and front right passenger positions. The driver frontal air bag failed to deploy *(passenger air bag cutoff switch set to the "off" position)* as a result of an offset frontal collision with a 1989 Oldsmobile Delta 88 Royale 4-door sedan. The driver of the GMC Sonoma pickup truck was operating the vehicle southbound on a two lane rural roadway on approach to a 3-leg intersection when he failed to observe a 1995 Lincoln Mark VIII 2-door sedan slowing ahead. The initial rear-end impact resulted in minor damage to both vehicles. At this point, the GMC pickup truck entered the northbound lane and into the path of the northbound Oldsmobile Delta 88. As the GMC pickup truck entered the northbound lane, the front left area impacted the front left area of the Oldsmobile which resulted in severe damage to both vehicles. The restrained 41 year old male driver of the 2000 GMC Sonoma pickup truck initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint, knee bolster, and steering wheel hub/rim. Loading of the manual restraint and frontal components resulted in unspecified fatal injuries. Injury information was unknown as the medical report revealed no injury specifics. The GMC and Oldsmobile drivers were pronounced deceased at the scene.			
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TABLE OF CONTENTS

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LOCATION - STATE OF MICHIGAN
CRASH DATE - JULY, 2001

BACKGROUND

This on-site investigation focused on the non-deployment of the redesigned driver frontal air bag of a 2000 GMC Sonoma pickup truck. The 2000 GMC Sonoma was equipped with redesigned frontal air bags for the driver and front right passenger positions. The driver frontal air bag failed to deploy *(passenger air bag cutoff switch set to the "off" position)* as a result of an offset frontal collision with a 1989 Oldsmobile Delta 88 Royale 4-door sedan. The driver of the GMC Sonoma pickup truck was operating the vehicle southbound on a two lane rural roadway on approach to a 3-leg intersection when he failed to observe a 1995 Lincoln Mark VIII 2-door sedan slowing ahead. The initial rear-end impact resulted in minor damage to both vehicles. At this point, the GMC pickup truck entered the northbound lane and into the path of the northbound Oldsmobile Delta 88. As the GMC pickup truck entered the northbound lane, the front left area impacted the front left area of the Oldsmobile which resulted in severe damage to both vehicles. The restrained 41 year old male driver of the 2000 GMC Sonoma pickup truck initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint, knee bolster, and steering wheel hub/rim. Loading of the manual restraint and frontal components resulted in unspecified fatal injuries. Injury information was unknown as the medical report revealed no injury specifics. The GMC and Oldsmobile drivers were pronounced deceased at the scene.

The crash was identified by PSU 12 during normal sampling activities on August 13, 2001. The crash was selected as a CDS case and assigned NASS Case Number 01-12-116A. The NASS researcher was unable to download the event data recorder due to extensive vehicle damage and the accumulation of body fluids on the floor of the vehicle. The SCI investigator was conducting an on-site investigation in the area of the PSU, and traveled to the team to download the event data recorder on Friday, August 24, 2001. As a result, the event data recorder summary was obtained. Due to the non-deployment of the redesigned frontal air bags and the death of the driver, the case was assigned to the SCI team as a limited scope on-site NASS/SCI Combo Case.

SUMMARY

Crash Site

This multiple vehicle crash occurred during the early evening hours of July, 2001. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred in the north/southbound lanes of a 3-leg rural intersection between an intrastate roadway and a local street **(see Figure 9 - page 8)**. The asphalt surfaced two-lane rural intrastate roadway curved right with a negative grade for southbound traffic, and was bordered by narrow paved shoulders with wooded areas to the west. Traffic control consisted of a stop sign for westbound (turning) traffic. The posted speed limit at the crash site was 89 km/h (55 mph).

Pre-Crash

The restrained 45 year old male driver of the 1995 Lincoln Mark VIII (V3) was operating the vehicle southbound **(Figure 1)** when he slowed to a stop in preparation of a left turn (west) at the 3-leg intersection. The Lincoln driver reported to police that he paused to allow northbound traffic to clear the intersection prior to his intended left turn. The Lincoln driver reported no avoidance maneuvers in anticipation of the impending crash.

The restrained 41 year old male driver of the 2000 GMC Sonoma pickup truck (V2) was also operating the vehicle southbound (behind the Lincoln) and negotiating a right curve when he failed to observe the Lincoln stopped ahead. Upon recognition of the impending harmful event, the driver steered left and braked in avoidance, and partially entered the northbound lane prior to the initial impact.

The restrained 27 year old male driver of the 1989 Oldsmobile Delta 88 Royale (V1) was operating the vehicle northbound **(Figure 2)** on approach to the 3-leg intersection when he observed the southbound GMC cross his path of travel. Upon recognition of the impending harmful event, the driver braked in avoidance, and remained in the northbound lane prior to the secondary collision.

Figure 1. Southbound approach view for the 1995 Lincoln Mark VIII (V3) and the 2000 GMC Sonoma pickup truck (V2).

Figure 2. Northbound approach view for the 1989 Oldsmobile Delta 88 (V1).

Crash

The initial rear-end impact resulted in minor front right damage to the GMC Sonoma (V2) and minor rear left damage to the Lincoln Mark VIII (V3). The missing vehicle algorithm of the WinSMASH reconstruction program computed velocity changes of 10.6 km/h (6.6 mph) for the subject vehicle and 8.7 km/h (5.4 mph) for the struck Lincoln. Respective longitudinal components were -10.6 km/h (-6.6 mph) and 8.6 km/h (5.3 mph). The 1995 Lincoln Mark VIII came to rest in close proximity to the initial point of impact facing south. At this point, driver pre-impact steering re-directed the 2000 GMC Sonoma pickup truck into the opposing travel lane, and into the path of the northbound 1989 Oldsmobile Delta 88.

As the 2000 GMC Sonoma pickup truck entered the northbound lane, the front left area struck the front left area of the 1989 Oldsmobile Delta 88 Royale (V1) which resulted in severe damage to both vehicles. The damage algorithm of the WinSMASH reconstruction program computed velocity changes

of 65.8 km/h (40.9 mph) for the subject vehicle and 64.5 km/h (40.1 mph) for the struck Oldsmobile. Respective longitudinal components were -64.8 km/h (-40.3 mph) and -60.6 km/h (-37.7 mph). The GMC's Event Data Recorder (EDR) logged a deployment event with a longitudinal element of -38.8 km/h (-24.1 mph) at the 110 millisecond interval **(see Figures 10-12, page 9)**. Both vehicles rotated counterclockwise as the Oldsmobile subsequently came to rest in the northeast sector of the intersection facing southwest and the GMC came to rest perpendicular to the centerline facing northeast. Post-impact trajectories and final rest positions were evidenced by the gouge marks and tire marks documented at the crash site **(Figure 3)**.

Figure 3. Northeast view of the crash site showing the impact related physical evidence.

Post-Crash

Following the crash, the driver of the 1995 Lincoln Mark VIII (V3) exited the vehicle under his own power and was reported by police as uninjured in the collision. Treatment was rendered at the scene by fire department personnel and emergency medical technicians. The drivers of the 2000 GMC Sonoma pickup truck (V2) and 1989 Oldsmobile Delta 88 Royale (V1) were pronounced deceased at the crash site and remained entrapped *(by extensive frontal component intrusions)* in their respective vehicles until police investigators completed their on-scene investigation a short time later. The Lincoln was driven from the scene as the GMC and Oldsmobile were towed from the scene with disabling damage.

VEHICLE DATA

The 2000 GMC Sonoma (V2) was manufactured in August, 1999 and identified by the vehicle identification number (VIN): 1GTCS1448YK (production number deleted). The driver was reported by police as the owner of the vehicle. The vehicle was a standard cab pickup truck equipped with an automatic transmission, rear-wheel drive, and a 2.2 liter, 4-cylinder engine. The odometer reading was unknown at the time of the crash. The seating was configured with a split-bench seat (with folding backs). The NASS surrogate interview was not obtained, therefore, previous crashes or maintenance on the GMC's frontal air bag system were unknown.

VEHICLE DAMAGE

Exterior

The 2000 GMC Sonoma pickup truck (V2) sustained severe frontal damage **(Figure 4)** as a result of the impact with the 1989 Oldsmobile Delta 88 (V1). The direct contact damage began at the front left bumper corner and extended 72.0 cm (28.3 in) inboard. The impact deformed the entire front end width resulting in a combined direct and induced damage length (Field L) of 110.0 cm (43.3 in). Although contrasting damage patterns allowed for the separate and accurate assignment of Collision Deformation Classifications (CDCs), overlapping damage protocol was utilized as six crush measurements were documented at the level of the bumper: C1= 116.0 cm (45.7 in), C2= 99.0 cm

(39.0 in), C3= 78.0 cm (30.7 in), C4= 67.0 cm (26.4 in), C5= 38.0 cm (15.0 in), C6= 18.0 cm (7.1 in). *Inconsistencies were identified in NASS field documentation of the subject vehicle, which may explain the large variance between the WinSMASH computed velocity change and the GMC's EDR summary*. The CDC assigned to this secondary impact to the GMC was 12-FYEW-5 with a principal direction of force of (-)10 degrees. The hood was deformed up and rearward from the impact force. Rearward displacement of the left fender restricted/deflated the left front wheel/tire and door opening. Moderate bed to cab contact was noted on each side. The windshield was fractured in multiple locations from exterior impact forces only. The left door, windshield, and roof were removed by fire department personnel during driver extrication activities post-crash. Reduction in the left side wheelbase measured 58.0 cm (22.8 in) as elongation in the right side wheelbase measured 5.0 cm (2.0 in).

Direct contact damage was also identified along the front right area and attributed to the initial impact with the 1995 Lincoln Mark VIII. The direct contact damage began at the front right bumper corner and extended 34.0 cm (13.4 in) inboard. Subsequent engagement along the right side surface measured approximately 51.0 cm (20.1 in) aft of the front left bumper corner. Although partially masked by damage from the Oldsmobile impact, a CDC of 12-FREE-3 (with a principal direction of force of 0 degrees) was accurately assigned for this impact to the GMC.

Figure 4. Impact #2 front left damage to the 2000 GMC Sonoma pickup truck (V2).

The 1989 Oldsmobile Delta 88 Royale (V1) sustained severe frontal damage **(Figure 5)** as a result of the impact with the 2000 GMC Sonoma pickup truck (V2). The direct contact damage began at the front left bumper corner and extended 108.0 cm (42.5 in) inboard. The impact deformed the entire front end width resulting in a combined direct and induced damage length (Field L) of 57.0 cm (22.4 in). Six crush measurements were documented at the level of the bumper: C1= 145.0 cm (57.1 in), C2= 68.0 cm (26.8 in), C3= 49.0 cm (19.3 in), C4= 30.0 cm (11.8 in), C5= 13.0 cm (5.1 in), C6= 0 cm. The CDC assigned to this impact to the Oldsmobile was 11-FYEW-5 with a principal direction of force of (-)20 degrees. The hood was deformed up and rearward from the impact force. The left fender was displaced rearward

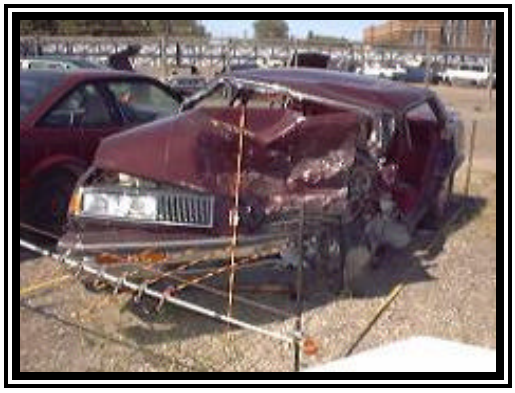

Figure 5. Impact #2 front left damage to the 1989 Oldsmobile Delta 88 Royale (V1).

which restricted/deflated the left front wheel/tire and door opening. Outward buckling of the left front door and window frame was noted which resulted in significant integrity loss, however, exact measurements were unknown due to removal of both left side doors by rescue personnel post-crash. Additional extrication damage was noted to the backlight (disintegrated) and roof support pillars (cut). Induced contact damage produced moderate roof buckling at the left A and B-pillars. Reduction in the left side wheelbase measured 71.0 cm (28.0 in) while elongation of the right side wheelbase measured 22.0 cm (8.7 in).

The 1995 Lincoln Mark VIII (V3) sustained minor rear left damage **(Figure 6)** as a result of the initial impact with the 2000 GMC Sonoma pickup truck (V2). The direct contact damage began at the rear left bumper corner and extended 36.0 cm (14.2 in) inboard. The impact deformed the entire rear end width resulting in a combined direct and induced damage length (Field L) of 150.0 cm (59.1 in). Six crush measurements were documented at the level of the bumper: C1= 2.0 cm (0.8 in), C2= 1.0 cm (0.4 in), C3= 2.0 cm (0.8 in), C4= 0 cm, C5= 0 cm, C6= 0 cm. The CDC assigned to this impact to the Lincoln was 06-BLEE-2 with a principal direction of force of (+)170 degrees. The rear left turn signal lens was fractured with induced contact damage extending forward to the left rear axle. No wheelbase reduction was identified.

Figure 6. Impact #1 rear left damage to the 1995 Lincoln Mark VIII (V3).

Interior

Interior damage to the GMC was severe and was attributed to occupant contact and component intrusions. Large indentations and scuff marks were documented on the left knee bolster. Deformation to the upper portion of the steering wheel rim measured 2.0 cm (0.8 in). Driver loading separated the steering mechanism and shifted the column upward approximately 5.0 cm (2.0 in). Column compression measured 4.0 cm (1.6 in) with complete displacement off the shear plate. Longitudinal intrusions into the driver space involved 27.0 cm (10.6 in) of instrument panel, 28.0 cm (11.0 in) of toepan, and 20.0 cm (7.9 in) of steering assembly intrusion. Lateral intrusions into the driver space involved 5.0 cm (2.0 in) of door panel intrusion.

MANUAL RESTRAINT SYSTEMS

The interior of the GMC Sonoma consisted of a three passenger seating configuration with a split bench seat (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 a dual mode retractor (inertial lock/belt

sensitive). Loading evidence consisted of fabric transfers to the shoulder belt webbing along with heavy abrading to the latchplate and D-ring. The driver restraint was cut by rescue personnel during driver extrication activities post-crash **(Figure 7)**. The front right 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 center seat was equipped with a 2-point manual lap belt and a locking latchplate. The GMC was not equipped with seat belt pretensioners.

Figure 7. GMC driver manual restraint cut during post-impact driver extrication activities.

SUPPLEMENTAL RESTRAINT SYSTEMS

The 2000 GMC Sonoma was equipped with redesigned frontal air bags for the driver and front right passenger positions. The driver frontal air bag failed to deploy as a result of the impact with the 1989 Oldsmobile Delta 88 Royale. The vehicle was equipped with a front right passenger air bag cutoff switch which was found in the "off" position **(Figure 8)**. 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 mid-instrument panel area with a single cover flap design hinged at the top aspect.

Figure 8. 2000 GMC Sonoma pickup truck non-deployed driver redesigned frontal air bag with the front right passenger air bag cutoff switch found in the "off" position.

Event Data Recorder (EDR)

The 2000 GMC Sonoma Sensing and Diagnostic Module (SDM) was located under the center seat as the event data was retrieved directly from the module due to extensive vehicle and wire damage which compromised 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 deployment event at ignition cycle number 3172. The system status at deployment reflected the driver's belt switch circuit status as "buckled" and the front right passenger air bag as "suppressed". As the vehicle and engine speed decreased from 86.9 km/h (54.0 mph) to 54.7 km/h (34.0 mph) during the five second pre-crash interval, the brake switch circuit status went from "off" to "on" three seconds prior to algorithm activation.

DRIVER DEMOGRAPHICS

Age/Sex:	41 year old male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Middle position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection, police report
Eyeware:	Unknown
Type of Medical Treatment:	Pronounced deceased at the scene

Driver Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
Unknown *(medical report revealed no injury specifics)*	N/A	N/A

Driver Kinematics

The 41 year old male driver of the 2000 GMC Sonoma was restrained by the available 3-point manual lap and shoulder belt system, and presumed to be seated in an upright posture with the seat track adjusted to the middle position. Belt usage was confirmed by the loading evidence documented on the D-ring, latchplate, and webbing of the front left restraint. In addition, belt usage was confirmed by the vehicle's EDR summary.

At initial impact with the 1995 Lincoln Mark VIII, the driver probably remained in his pre-impact posture as this minor event resulted in little damage nor produced any significant occupant kinematic response. At impact with the 1989 Oldsmobile Delta 88 Royale, the driver initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint, knee bolster, and steering wheel hub/rim. Loading of frontal components was evidenced by the extensive deformation documented to these components, resulting in unspecified fatal injuries. The GMC driver was pronounced deceased at the scene. Injury information is unknown as the emergency room record obtained by the NASS researcher revealed no injury specifics (no autopsy performed). Following the collision, the GMC driver remained in the vehicle (entrapped through lower extremity restriction by frontal intruding components) as police investigators completed their investigation. He was subsequently removed through the left door opening and transported to the local morgue. Deployment of the driver redesigned frontal air bag would have mitigated the severity of thoracic injury by preventing further contact to the steering wheel hub/rim.

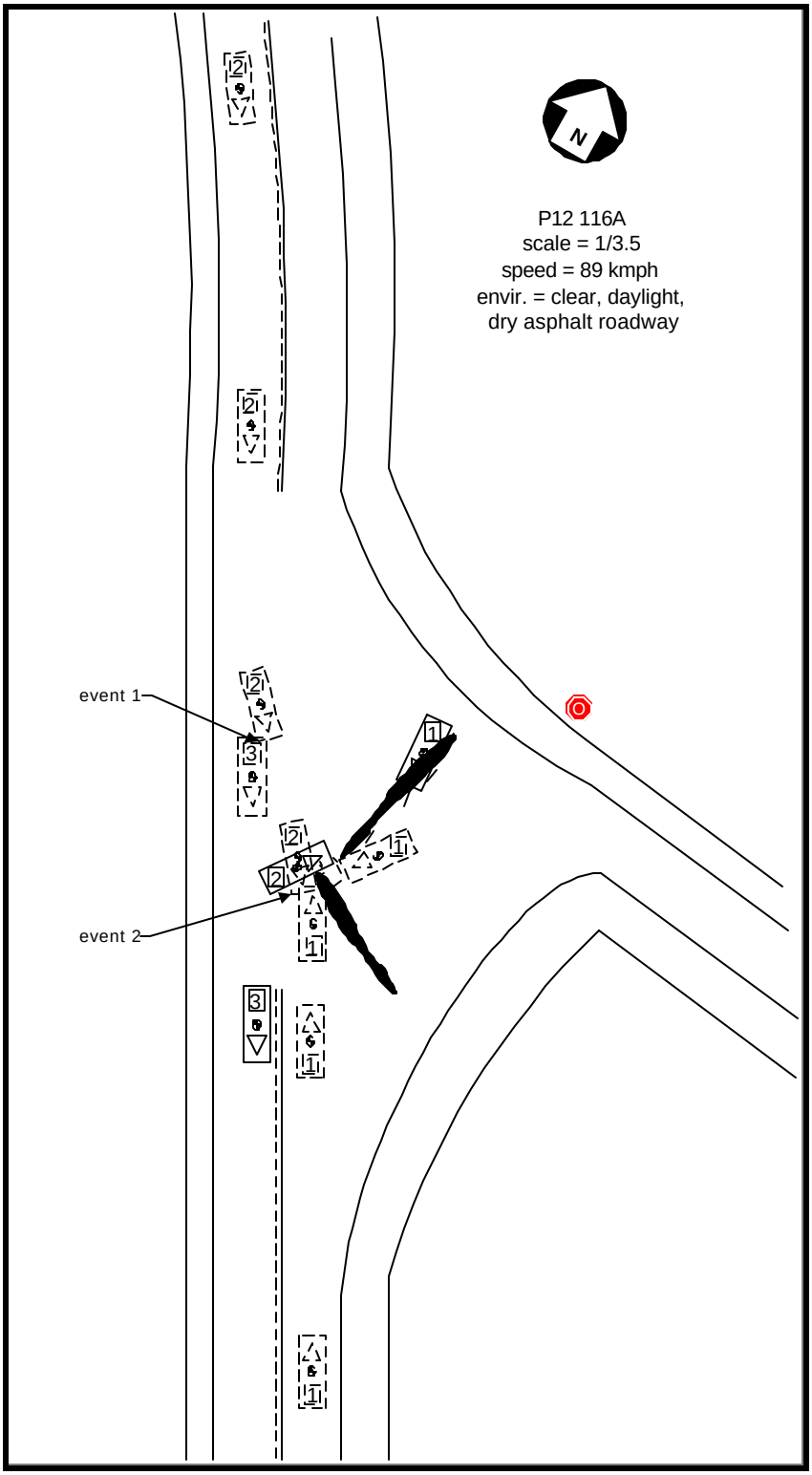

Figure 9. NASS Scene Diagram.

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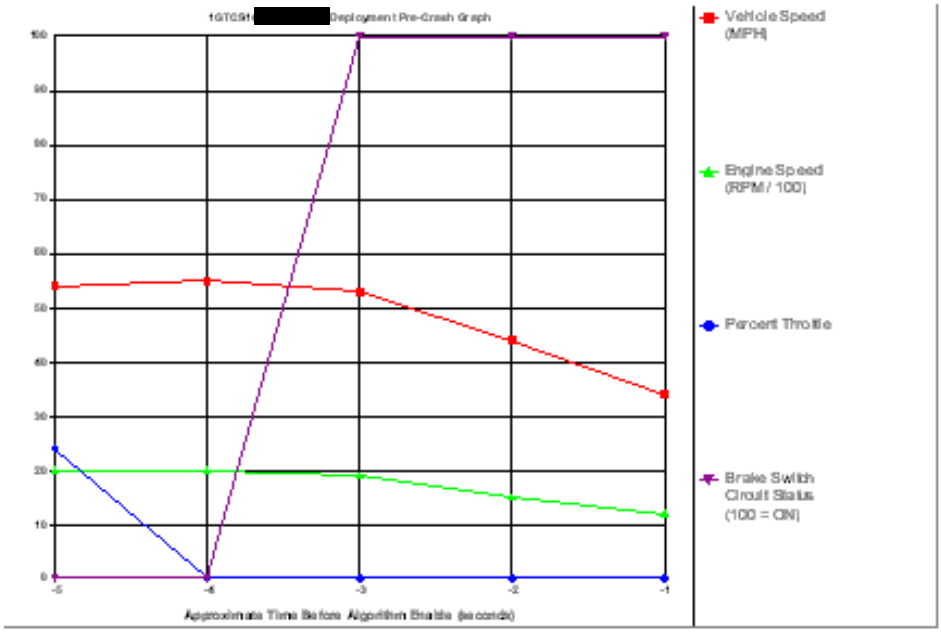
CDR CRASH DATA RETRIEVAL SYSTEM

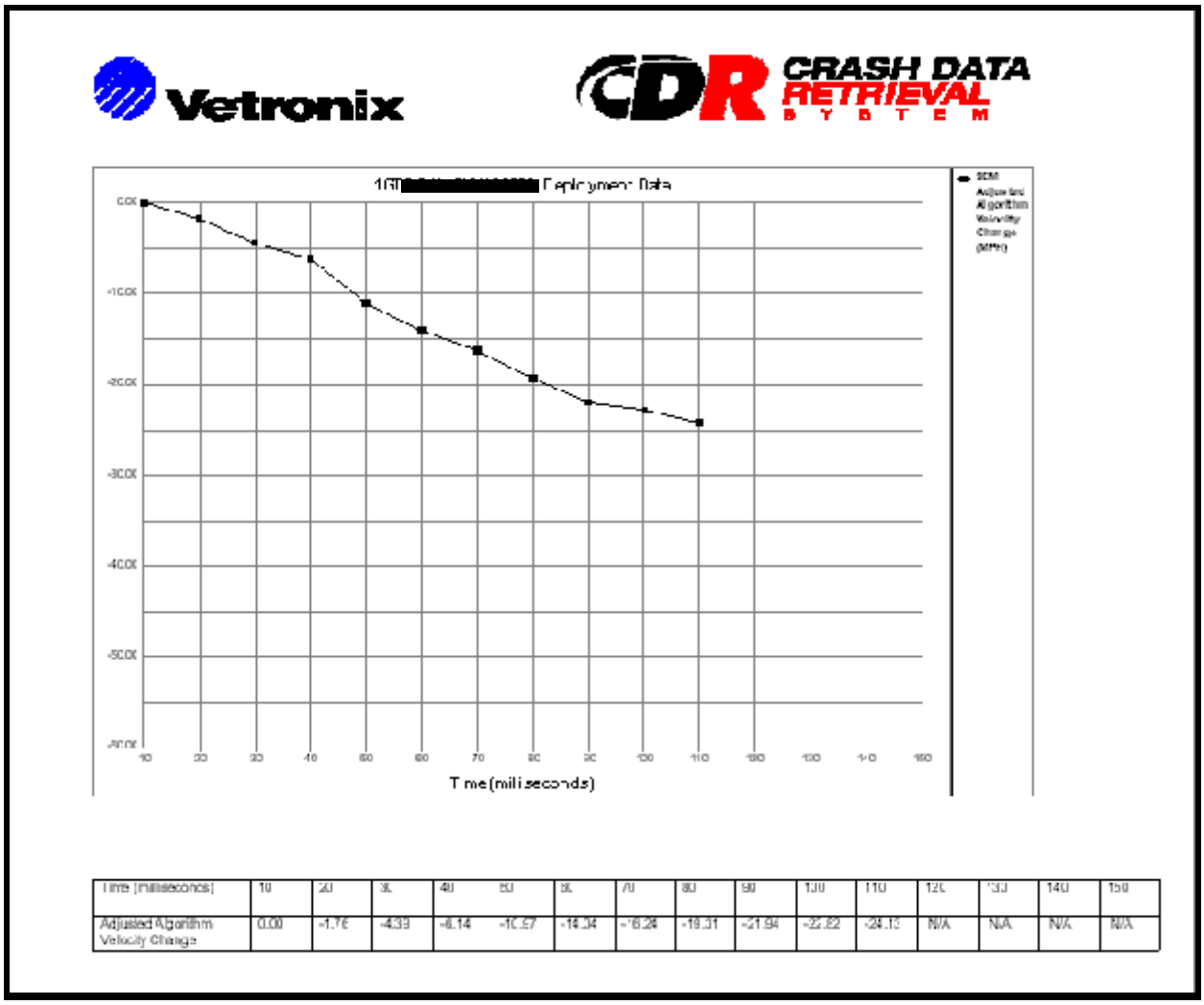
System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Suppressed
Ignition Cycles At Deployment	3172
Time Between Near Deployment And Deployment Events (sec)	.5



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	54	1984	24	OFF
-4	55	1984	0	OFF
-3	53	1856	0	ON
-2	44	1536	0	ON
-1	34	1152	0	ON

Figure 10. 2000 GMC Sonoma pickup truck EDR report (deployment event).



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Adjusted Algorithm Velocity Change	0.00	-1.76	-4.39	-8.14	-10.57	-14.34	-16.24	-19.31	-21.94	-22.82	-24.13	N/A	N/A	N/A	N/A

Figure 11. 2000 GMC Sonoma EDR report (deployment event).

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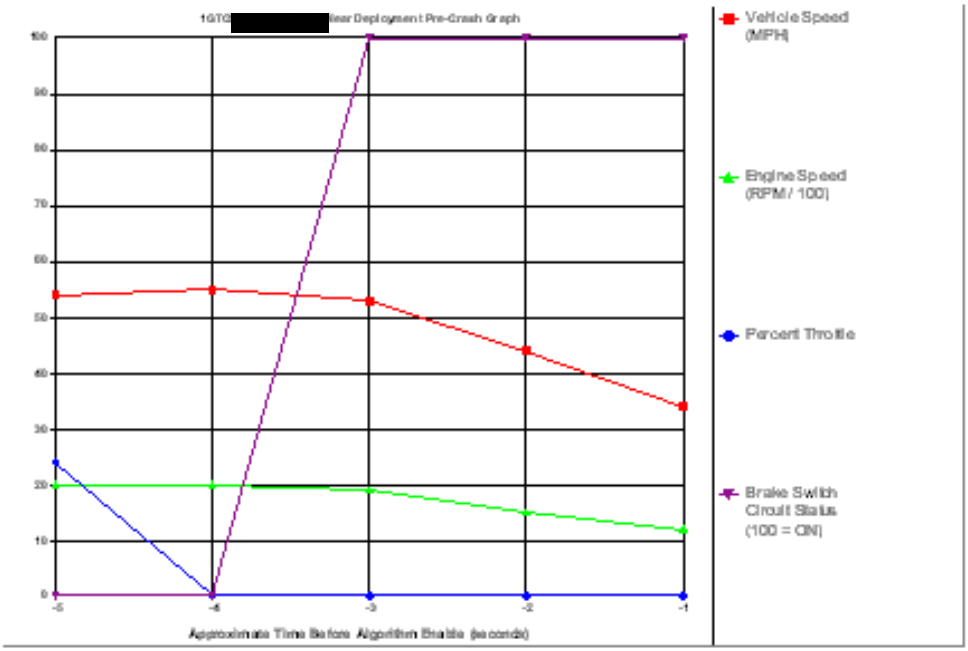
CDR CRASH DATA RETRIEVAL SYSTEM

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 Suppressed
Ignition Cycles At Near Deployment	2977



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	54	1984	24	OFF
-4	55	1984	0	OFF
-3	53	1856	0	ON
-2	44	1536	0	ON
-1	34	1152	0	ON

Figure 12. 2000 GMC Sonoma pickup truck EDR report (near deployment event).