

**TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER**

Advanced Information Engineering Services
A General Dynamics Company
Buffalo, NY 14225

**GENERAL DYNAMICS REMOTE CERTIFIED ADVANCED COMPLIANT
VEHICLE CRASH INVESTIGATION**

SCI TECHNICAL SUMMARY REPORT

NASS/SCI COMBO CASE NO. 03-08-109C

VEHICLE – 2003 GMC SIERRA

LOCATION - STATE OF PENNSYLVANIA

CRASH DATE – MAY 2003

Contract No. DTNH22-01-C-17002

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

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|---|---|--|------------------|
| <i>1. Report No.</i> 03-08-109C | <i>2. Government Accession No.</i> | <i>3. Recipient's Catalog No.</i> | |
| <i>4. Title and Subtitle</i> General Dynamics Remote Certified Advanced Compliant Vehicle Crash Investigation Vehicle: 2003 GMC Sierra Location: State of Pennsylvania | | <i>5. Report Date:</i> February 2004 | |
| | | <i>6. Performing Organization Code</i> | |
| <i>7. Author(s)</i> Crash Data Research Center | | <i>8. Performing Organization Report No.</i> | |
| <i>9. Performing Organization Name and Address</i> Transportation Sciences Advanced Information Engineering Services A General Dynamics Company P.O. Box 400 Buffalo, New York 14225 | | <i>10. Work Unit No.</i> C00410.0000.0144 | |
| | | <i>11. Contract or Grant No.</i> DTNH22-01-C-17002 | |
| <i>12. Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590 | | <i>13. Type of Report and Period Covered</i> Technical Report Crash Date: May 2003 | |
| | | <i>14. Sponsoring Agency Code</i> | |
| <i>15. Supplementary Note</i> This remote investigation focused on the performance of the Certified Advanced Compliant safety system in a 2003 GMC Sierra. | | | |
| <i>16. Abstract</i> This remote investigation focused on the performance of the Certified Advanced Compliant safety system in a 2003 GMC Sierra. The system included dual stage frontal air bags, seat track position sensors for the front left and front right seats, and an occupant presence sensor for the front right seat. The GMC was also equipped with an Event Data Recorder (EDR) that was downloaded (Deployment data) by the NASS researcher and is include as Attachment A of this report. The GMC was occupied by a restrained 34-year-old male driver. The GMC was involved in a multiple event crash that included a minor left side impact from an unknown hit and run vehicle and a run-off-road impact with a wooden utility pole that resulted in the deployment of the driver's frontal air bag. The driver sustained an AIS-2 level injury that consisted of a right fourth metatarsal fracture. The driver was transported to a hospital where he was admitted for two days. | | | |
| <i>17. Key Words</i> Certified Advanced Compliant Driver's Air Bag Stage 2 Deployment | | <i>18. Distribution Statement</i> General Public | |
| <i>19. Security Classif. (of this report)</i> Unclassified | <i>20. Security Classif. (of this page)</i> Unclassified | <i>21. No. of Pages</i> 13 | <i>22. Price</i> |

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**GENERAL DYNAMICS REMOTE CERTIFIED ADVANCED COMPLIANT
VEHICLE CRASH INVESTIGATION
SCI SUMMARY TECHNICAL REPORT
NASS/SCI COMBO CASE NO. 03-08-109C
SUBJECT VEHICLE – 2003 GMC SIERRA
LOCATION - STATE OF PENNSYLVANIA
CRASH DATE – MAY 2003**

BACKGROUND

This remote investigation focused on the performance of the Certified Advanced Compliant safety system in a 2003 GMC Sierra. The manufacturer of this vehicle has certified that this 2003 GMC Sierra meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The system included dual stage frontal air bags, seat track position sensors for the front left and front right seats, and an occupant presence sensor for the front right seat. The GMC was also equipped with an Event Data Recorder (EDR) that was



Figure 1. 2003 Chevrolet Silverado.

downloaded (Deployment data) by the NASS researcher and is include as **Attachment A** of this report. The GMC was occupied by a restrained 34-year-old male driver. The GMC (**Figure 1**) was involved in a multiple event crash that included a minor left side impact from an unknown hit and run vehicle and a run-off-road impact with a wooden utility pole that resulted in the deployment of the driver’s frontal air bag. The driver sustained an AIS-2 right fourth metatarsal fracture. The driver was transported to a trauma center where he was admitted for two days for observation and released.

This crash was identified by the National Automotive Sampling System (NASS) PSU 08 during the weekly sampling of Police Accident Reports (PARs). This crash was selected and researched as CDS Case No. 03-08-109C. The NASS PSU performed the vehicle and scene inspections and conducted the driver interview. Due to the presence of the Certified Advanced Compliant safety system in the GMC, NHTSA assigned the tasks of case review and report preparation to the General Dynamics SCI team.

SUMMARY

Crash Site

This multiple event crash occurred during the evening hours in May 2003. At the time of the crash, it was daylight and there were no adverse weather conditions and the road surface was dry. The crash occurred on a two-lane, two-way north/south roadway. The north/south roadway was straight and level and was delineated by a solid double yellow centerline. Concrete barrier curbs bordered the north/south roadway. The posted speed limit for the roadway was 56 km/h (35 mph).

Crash Sequence

Pre-Crash

The 2003 GMC Sierra was traveling southbound driven by a restrained 34-year-old male. An unknown type, hit and run vehicle was traveling northbound on the same roadway. The hit and run vehicle began to encroach into the southbound lane. Its unknown if the driver of the GMC attempted to avoid the oncoming vehicle. The driver stated to the NASS researcher that he did not recall the details of either impact. The EDR data indicated that the GMC was traveling at 61.2 km/h (38.0 mph) five seconds prior to crash and the vehicle speed increased to 62.8 km/h (39.0 mph) one second prior to the crash. The EDR also indicated that the brake switch circuit status was in the off-position from five seconds to one second prior to the crash. The recorded EDR data pertains to the pole impact, which resulted in the air bag deployment. The sideswipe impact was minor and not sufficient to wake-up the Sensing and Diagnostic control Module (SDM). The NASS scene schematic is included as **Figure 13** of this report.

Crash

The hit and run vehicle crossed the centerline and impacted the left side of the GMC in a sideswipe impact configuration (**Figure 2**). The resultant direction of force was within the 12 o'clock sector for the GMC. The impact resulted in minor damage to the left side of the GMC. The WINSMASH program was not used to calculate a delta-V due to the minor sideswipe damage.



Figure 2. Area of impact between hit and run vehicle and GMC.

The driver stated to the NASS researcher that he possibly swerved right subsequent to the impact with the hit and run vehicle. The combination of the impact with the hit and run vehicle and steering input by the driver, redirected the GMC in a southwesterly direction. The GMC traveled approximately 29.0 meters (95.0 feet) forward and departed the west road edge at a shallow angle. The GMC traveled approximately 3.0 meters (10.0 feet) off-road and impacted a wooden utility pole (**Figure 3**) with its front right corner. The EDR data indicated that the driver did not apply the brakes during the five-second pre-crash recording. The resultant direction of force was within the 12 o'clock sector for GMC. A WINSMASH barrier equivalent speed algorithm was used to determine an approximate delta-V. The WINSMASH computed delta-V was 20.3 km/h (12.6 mph), which appears low due to the corner engagement that involved the frontal and right side planes. The damage from the pole did not engage the frame rail and



Figure 3. GMC's impact with utility pole.

extended down the right side of the vehicle, which is beyond the scope of the WINSMASH program. The EDR recorded a maximum delta V of -43.1 km/h (-26.8 mph), which is more representative of the damage.

Post-Crash

Police and ambulance personnel responded to the scene. The 34-year-old driver of the GMC stated to the NASS researcher that he was removed from the vehicle while unconscious. The driver sustained a moderate AIS-2 level injury that consisted of a right fourth metatarsal fracture. The driver was transported to a trauma center where he was admitted for two days for observation and released.

VEHICLE DATA

2003 GMC Sierra

The 2003 GMC Sierra was identified by the Vehicle Identification Number (VIN): 2GTEK19T13 (production sequence omitted). The odometer reading could not be obtained from the vehicle due to lack of power, however, the driver stated to the NASS researcher that the vehicle had approximately 9,300 km (5,800 miles). The vehicle was a four-door pickup truck that was equipped with a 5.3-liter, eight-cylinder engine, four-wheel drive and a four-speed automatic transmission, and four-wheel disc brakes with ABS. The GMC was configured with Firestone Wilderness AT radial tires size P265/75R16. The maximum pressure for the tires was 303 kpa (44 psi). The manufacturer recommended front and rear tire pressure was 241 kpa (35 psi). The specific tire data is as follows:

| Tire | Measured Pressure | Tread Depth | Restricted | Damage |
|-------------|--------------------------|--------------------|---|-----------------|
| LF | 269 kpa (39 psi) | 10 mm (13/32) | No | None |
| LR | 276 kpa (40 psi) | 10 mm (13/32) | No | None |
| RF | 0 kpa (0 psi) | 10 mm (13/32) | No, tire and suspension components separated from vehicle | Punctured tread |
| RR | 269 kpa (39 psi) | 10 mm (13/32) | No | None |

The GMC was configured with a three-passenger front bench seat with a flip and fold center seat armrest and a three-passenger rear bench seat. The GMC was also equipped with height adjustable head restraints for the four outboard seating positions. The head restraints were adjusted to the full-down position at the time of the NASS inspection.

Unknown Hit and Run Vehicle

The hit and run vehicle was not identified on the Police Accident Report, therefore it could not be located for inspection by the NASS researcher.

VEHICLE DAMAGE

Exterior – 2003 GMC Sierra

The 2003 GMC Sierra sustained minor severity damage as a result of the impact with the hit and run vehicle. The direct damage consisted of minor lateral deformation and a longitudinal scrape mark (**Figures 4 and 5**) that began approximately 13.0 cm (5.0”) forward of the left front door edge below the trim, and terminated approximately 10.0 cm (4.0”) rear of the left rear axle. No crush measurements were documented for this impact. The Collision Deformation Classification (CDC) for this impact was 12-LZLS-1.



Figure 4. Sideswipe damage to front left half from hit and run vehicle. Note damage is under door panel trim.



Figure 5. Sideswipe damage to rear left half from hit and run vehicle. Note damage is under door panel trim.

The 2003 GMC Sierra sustained severe severity damage as a result of the impact with the wooden utility pole (**Figures 6 and 7**). The direct contact damage began on the front right bumper corner and extended to the left 17.0 cm (6.7”). The direct contact damage also extended rearward 124.0 cm (48.8”) on the right side of the vehicle. Maximum crush was located at the front right bumper corner and measured 44.0 cm (17.3”). The damage from the pole impact involved the following a fractured right front axle and longitudinal deformation of the hood, right side of the upper and lower radiator support, right front fender and bumper. The induced damage consisted of longitudinal deformation of the right front and right rear doors. Six crush measurements were documented along the front bumper and were as follows: C1 = 0.0 cm, C2 = 0.0 cm, C3 = 0.0 cm, C4 = 10.0 cm (3.9”), C5 = 27.0 cm (10.6”), C6 = 44.0 cm (17.3”). The CDC for this impact was 12-FREE-5.



Figure 6. Frontal view of damage from pole impact.



Figure 7. Damage to front right area from pole impact.

Interior – 2003 GMC Sierra

The 2003 GMC Sierra sustained moderate interior damage as a result of intrusion into the front right occupant (unoccupied) position. The NASS researcher noted no occupant contacts. **Figure 8** is lateral view of the first row. The interior intrusions are listed in the table below:



Figure 8. Lateral view of interior first row.

| Intruded Component | Magnitude | Direction |
|------------------------------------|-----------------------|------------------|
| Right instrument panel (estimated) | 3.0-8.0 cm (1.0-3.0") | Longitudinal |
| Right toe pan (estimated) | 3.0-8.0 cm (1.0-3.0") | Longitudinal |
| Right floor | 3.0-8.0 cm (1.0-3.0") | Longitudinal |

Certified Advanced Compliant Safety System – 2003 GMC Sierra

The 2003 GMC Sierra was equipped with a Certified Advanced Compliant safety system. The system included dual-stage frontal air bags, a passenger presence sensor for the front right seat and seat track position sensors for the front left and front right seats. The system was monitored and controlled by a Sensing and Diagnostic control Module (SDM) that was mounted under the driver's seat. The SDM deploys the appropriate safety component(s) dependant on: occupant presence, belt usage, seat track position and crash severity. In the subject crash, the SDM commanded a Stage one deployment at 17.5 milliseconds of Algorithm Enable (AE) and a Stage two deployment at 20.0 milliseconds of AE.

The front left air bag (**Figure 9**) was located in the center of the steering wheel hub. The air bag module consisted of two symmetrical I-configuration cover flaps that measured 12.0 cm (4.7") in height and 6.0 cm (2.4") in width. The air bag measured 55.0 cm (21.7") in diameter. The front left air bag contained two tethers and was vented by two vent ports on the rear aspect of the air bag at the 11 and 1 o'clock positions. There was no occupant contacts evidence or damage to the air bag membrane.



Figure 9. Deployed driver's frontal air bag.

The front right seat was not occupied during the crash; therefore the system did not deploy the front right air bag (**Figure 10**). The front right air bag was equipped with a

cut-off switch (**Figure 11**). At the time of the NASS inspection the switch was keyed to the “Auto On” position.



Figure 10. Non-deployed front right air bag.



Figure 11. Front right air bag cut-off switch. Note the switch was keyed to the "Auto-On" position at the time of the NASS inspection.

Event Data Recorder – 2003 GMC Sierra

The 2003 GMC Sierra was equipped with an Event Data Recorder (EDR). The NASS researcher successfully downloaded the EDR data and the output is included in this report as **Attachment A**. The EDR data indicated that driver’s safety belt was buckled at the time of the crash and the vehicle speed was 61.2 km/h (38.0 mph) five seconds prior to crash and the speed increased to 62.8 km/h (39.0 mph) one second prior to the crash. The EDR also indicated that the brake switch circuit status was in the off-position from five seconds to one second prior to the crash. The maximum recorded velocity change was -43.1 km/h (-26.8 mph) at 177.5 milliseconds following AE.

MANUAL RESTRAINT SYSTEMS – 2003 GMC Sierra

The 2003 GMC Sierra was equipped with integrated manual 3-point lap and shoulder belts for the front outboard positions (**Figure 12**) and a 2-point manual lap belt for the front center position. The rear seat was configured with manual 3-point lap and shoulder belts for the outboard positions and a manual 2-point lap belt for the center position. The driver’s safety belt was configured with a sliding latch plate and a belt-sensitive Emergency Locking Retractor (ELR). The driver utilized the integrated safety belt in this crash. No loading evidence was noted to the safety belt. According to the NASS researcher, evidence of historical use was present on the safety belt. The front center lap safety belt was configured with a locking latch plate and no retractor. The front right safety belt and the two rear outboard safety



Figure 12. Driver's integrated lap and shoulder belt.

belts were configured with sliding latch plates and switchable ELR/ Automatic Locking Retractor's (ALR). The rear center safety belt was configured with a locking latch plate and no retractor.

OCCUPANT DEMOGRAPHICS – 2003 GMC Sierra

Driver

Age/Sex: 34-year-old male
 Height: 165 cm (65")
 Weight: 91 kg (201 lbs)
 Seat Track Position: Mid-track
 Manual Restraint Use: 3-point manual lap and shoulder belt
 Usage Source: Vehicle inspection
 Eyewear: None
 Type of Medical Treatment: Hospitalized for two days

Driver Injuries

| Injury | Injury Severity (AIS 90/Update 98) | Injury Mechanism |
|---|---|-------------------------|
| Right fourth metatarsal distal end fracture | Moderate (852200.2,1) | Toe Pan |

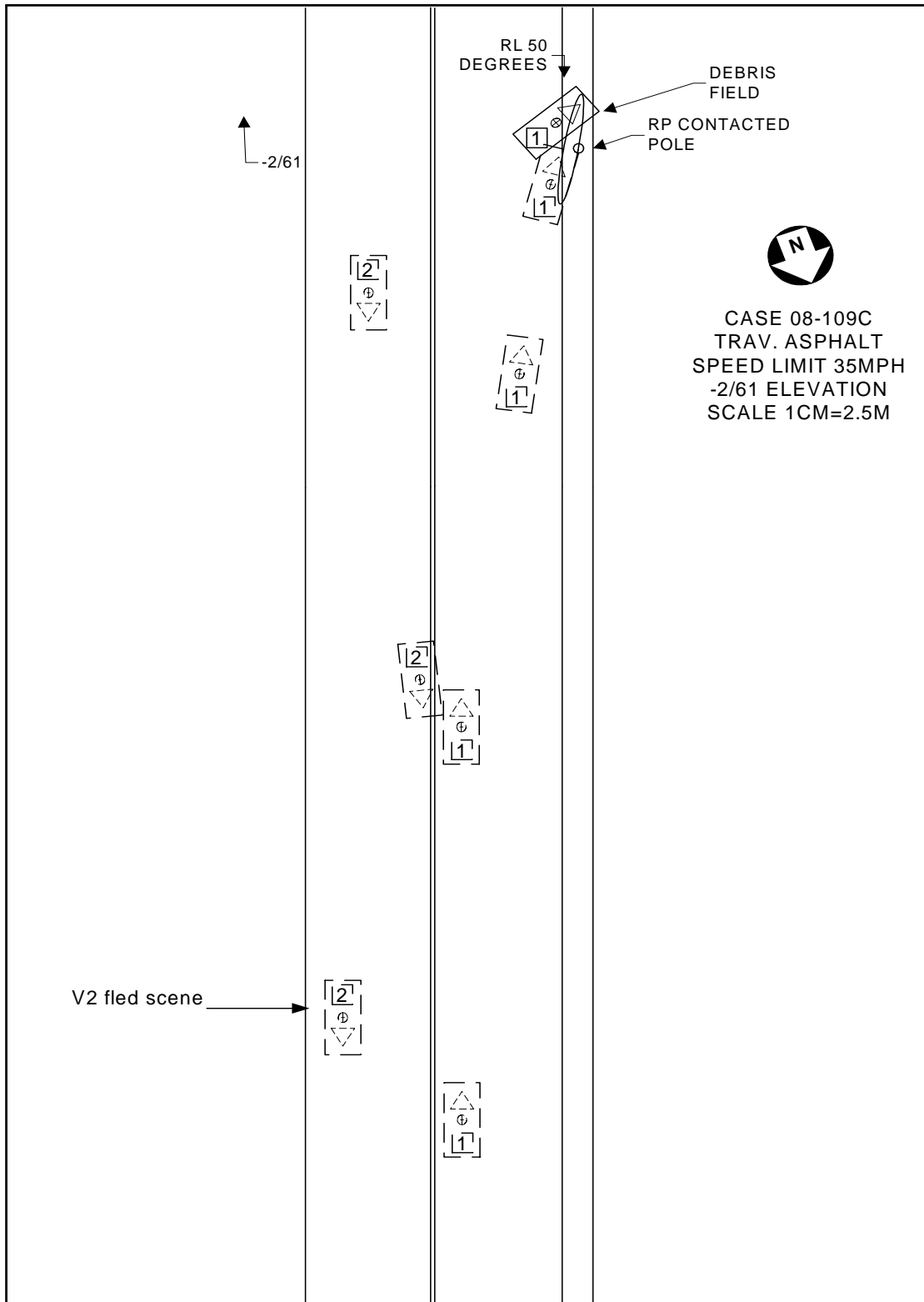
Source: Hospital medical records

Driver Kinematics

The 34-year-old male driver of the 2003 GMC Sierra was seated in an upright posture and was restrained by the vehicle's integrated manual 3-point lap and shoulder belt. Although, the seat track was in the full-rear track position at the time of the NASS inspection, the driver stated to the NASS researcher that the seat was adjusted to a mid-track position at the time of crash. At impact with the hit and run vehicle, the driver remained seated in the upright posture and was not displaced by this minor severity impact.

At impact with the utility pole, the front left air bag deployed. The restrained driver initiated a forward trajectory in response to the 12 o'clock direction of force. The driver's right foot loaded the toe pan, which resulted in the right fourth metatarsal fracture of the distal end. As result of being amnesic, the driver was transported to a trauma center. The driver was diagnosed with a right fourth metatarsal fracture of the distal end and was admitted for observation due to being amnesic of the crash events. In addition, the driver had complaints of pain to the neck, lower back, bilateral pelvis, and temporal and occipital regions. The combination of safety belt usage and air bag deployment helped prevent the driver from sustaining possible further injury.

Figure 13: NASS scene schematic



Attachment A: EDR Printout



CDR File Information

| | |
|--|--|
| Vehicle Identification Number | 2GTEK19T131 |
| Investigator | |
| Case Number | 109 |
| Investigation Date | |
| Crash Date | |
| Filename | 2GTEK19T131 .CDR |
| Saved on | |
| Data check information | |
| Collected with CDR version | Crash Data Retrieval Tool 2.00 |
| Collecting program verification number | |
| Reported with CDR version | Crash Data Retrieval Tool 2.00 |
| Reporting program verification number | |
| Interface information | Block number: 00 Interface version: 35 Date: Checksum: 6200 |
| Event(s) recovered | Deployment |

SDM Data Limitations

SDM Recorded Crash Events:

There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 250 times.

The second type of SDM recorded crash event is the Deployment Event. It also contains Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within five seconds of one another. Deployment events can not be overwritten or cleared from the SDM. Once the SDM has deployed the air bag, the SDM must be replaced.

The data in the non-deployment file will be locked after a deployment, if the non-deployment occurred within 5 seconds before the deployment or a deployment level event occurs within 5 seconds after the deployment.

SDM Data Limitations:

-SDM Recorded Vehicle Forward Velocity Change is one of the measures used to make air bag deployment decisions. SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. The SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. The SDM will also record 150 milliseconds of data after non-deployment criteria is met.

-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.

-SDM Recorded Vehicle Speed accuracy can be affected if the vehicle has had the tire size or the final drive axle ratio changed from the factory build specifications.

-Brake Switch Circuit Status indicates the status of the brake switch circuit.

-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if the SDM does not receive a valid message for any of the four Pre-Crash data parameters (Vehicle Speed, Engine Speed, Percent Throttle, and Brake Switch Circuit Status).

-Driver's Belt Switch Circuit Status indicates the status of the driver's seat belt switch circuit

-The Time Between Non-Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than 25.4 seconds, "N/A" is displayed in place of the time.

-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.

SDM Data Source:

All SDM recorded data is measured, calculated, and stored internally, except for the following:

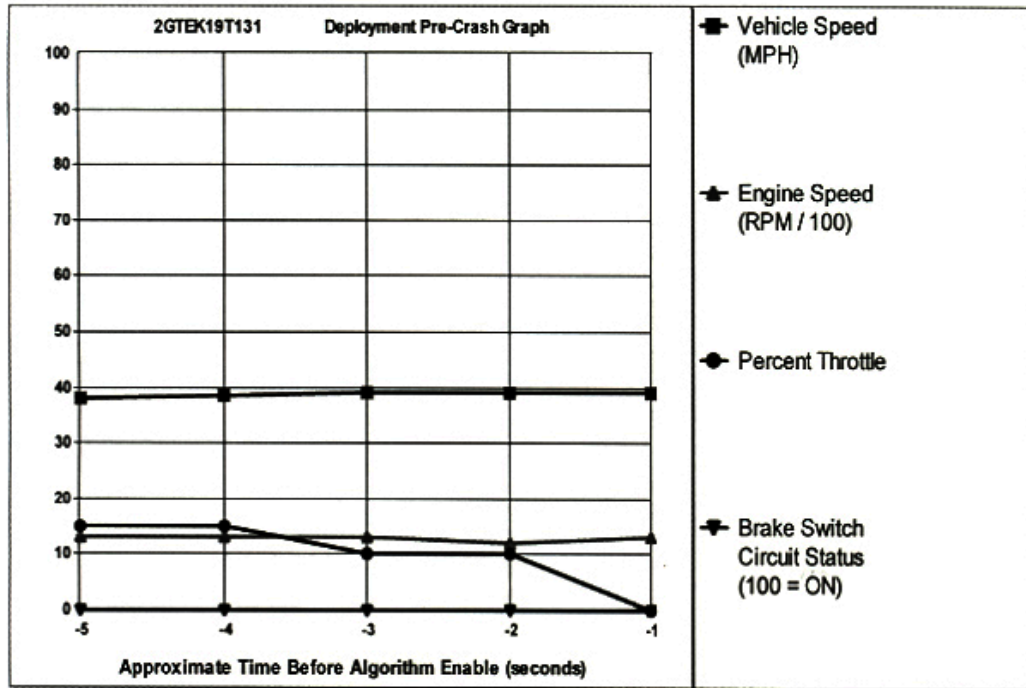
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the Class 2 data link, to the SDM.

-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the Class 2 data link, to the SDM.

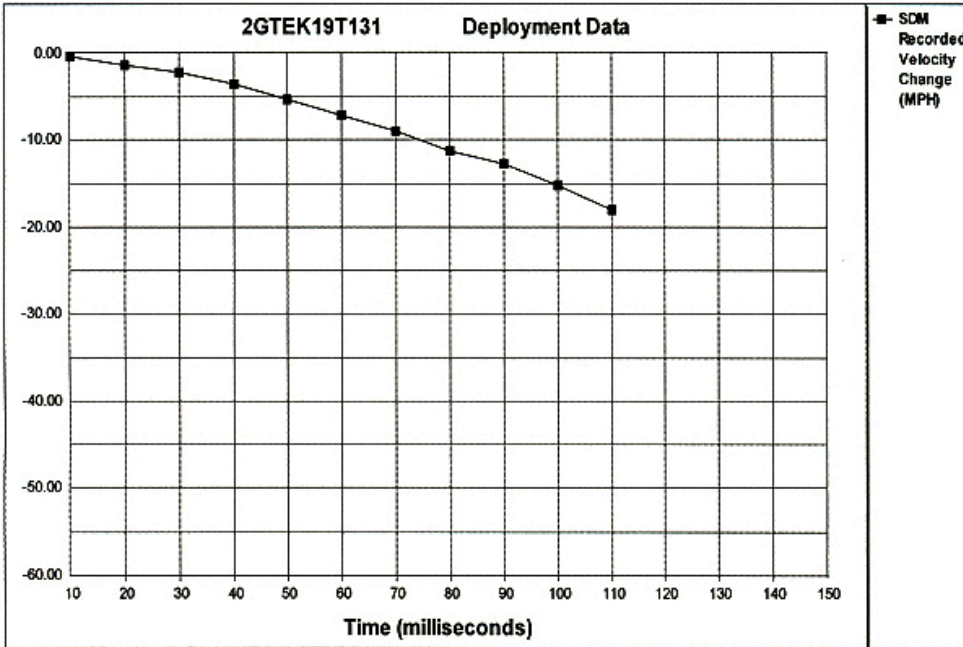
-In most vehicles, the Driver's Belt Switch Circuit is wired directly to the SDM. In some vehicles, the Driver's Belt Switch Circuit Status data is transmitted from the Body Control Module (BCM), via the Class 2 data link, to the SDM.

System Status At Deployment

| | |
|---|---------|
| SIR Warning Lamp Status | OFF |
| Driver's Belt Switch Circuit Status | BUCKLED |
| Ignition Cycles At Deployment | 532 |
| Ignition Cycles At Investigation | 538 |
| Maximum SDM Recorded Velocity Change (MPH) | -26.83 |
| Algorithm Enable to Maximum SDM Recorded Velocity Change (msec) | 177.5 |
| Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec) | 17.5 |
| Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec) | 20 |
| Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec) | N/A |
| Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec) | N/A |
| Time Between Non-Deployment And Deployment Events (sec) | N/A |
| Frontal Deployment Level Event Counter | 1 |
| Event Recording Complete | Yes |
| Multiple Events Associated With This Record | No |
| One Or More Associated Events Not Recorded | No |



| Seconds Before AE | Vehicle Speed (MPH) | Engine Speed (RPM) | Percent Throttle | Brake Switch Circuit Status |
|-------------------|---------------------|--------------------|------------------|-----------------------------|
| -5 | 38 | 1344 | 15 | OFF |
| -4 | 39 | 1344 | 15 | OFF |
| -3 | 39 | 1280 | 10 | OFF |
| -2 | 39 | 1216 | 10 | OFF |
| -1 | 39 | 1280 | 0 | OFF |



| Time (milliseconds) | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 |
|--------------------------------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|-----|-----|-----|-----|
| Recorded Velocity Change (MPH) | -0.31 | -1.24 | -2.17 | -3.41 | -5.27 | -7.13 | -8.99 | -11.16 | -12.71 | -15.19 | -17.98 | N/A | N/A | N/A | N/A |

Hexadecimal Data

This page displays all the data retrieved from the air bag module.
It contains data that is not converted by this program.

```
$01 F0 21 F7 3C AE 5A
$02 F1 F1 00 00 B8 00
$03 41 53 32 32 30 35
$04 4B 31 31 4E 35 31
$05 30 30 33 36 35 37
$06 15 05 78 16 00 00
$07 31 02 31 56 00 00
$08 41 44 75 06 56 21
$09 76 48 30 59 4A 4C
$0A 41 44 75 06 56 21
$0B 76 48 30 59 4A 51
$0C 00 00 00 00 00 00
$0D 00 00 00 00 00 00
$0E 00 00 00 00 00 00
$0F 00 00 00 00 00 00
$10 FF BC FC 00 00 00
$11 82 81 82 80 80 80
$12 8F 00 00 3C 3E 00
$13 FF 02 00 00 00 00
$14 1D 1D 00 00 64 40
$15 FA FA FA FA FA FA
$16 FA FA FA FA FA FA
$17 FA FA 00 00 00 00
$18 00 0F 05 AC F1 00
$19 09 00 0A 00 00 64
$1A 00 00 00 00 00 00
$1B 00 00 00 00 00 00
$1C 00 0C 00 00 00 00
$1D 00 00 00 00 00 00
$1F FE 00 00 00 00 00
$20 FF FF FF FF FF FF
$21 FF FF FF FF FF FF
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$3B 1D 24 29 31 3A 00
$3C 00 00 00 0B FF BD
$3D F0 A5 00 00 00 00
$40 3F 3F 3F 3E 3D 00
$41 00 00 00 1A 1A 27
$42 27 00 14 13 14 15
$43 15 00 42 FC 00 00
```



```
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$45 FF FF FF FF FF FF  
$46 FF FF FF FF FF FF  
$47 FF FF FF FF 00 00  
$48 FF FF FF FF FF FF  
$49 FF FF FF FF FF FF  
$4A FF FF FF FF FF FF  
$4B FF FF FF FF 00 00  
$4C FF FF FF FF FF FF  
$4D FF FF FF FF FF FF  
$4E FF FF FF FF FF FF  
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$50 FF FF FF FF FF FF  
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$54 FF FF FF FF FF FF
```