TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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GENERAL DYNAMICS ON-SITE CERTIFIED 208-ADVANCED COMPLIANT VEHICLE CRASH INVESTIGATION

GENERAL DYNAMICS CASE NO: CA03-065

VEHICLE: 2004 GMC YUKON

LOCATION: NEW JERSEY

CRASH DATE: OCTOBER 2003

Contract No. DTNH22-01-C-17002

Prepared for:

U.S. Department of Transportation
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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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16. Abstract This on-site investigation focused on the Certified Advanced 208-Compliant (CAC) safety system in a 2004 GMC Yukon. The manufacturer of this has certified that this 2004 GMC Yukon meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS 208) No. 208. The system included dual-stage frontal air bags, a passenger presence sensor for the front right seat and seat track positioning sensors for the front left and front right seats. In addition, the GMC was also equipped with seatback mounted side impact air bags for the front left and front right positions and an Event Data Recorder (EDR). The 51-year-old male driver of the GMC was traveling southbound on a three-lane roadway approaching a four-leg intersection. A 1989 Toyota Corolla occupied, by a 17-year-old female driver and a 17-year-old male front right occupant, was traveling northbound on the same roadway and was intending to turn left at the intersection. A 1997 Ford Taurus station wagon that was occupied by a 31-year-old female driver and three passengers was stopped on the westbound lane of the same intersection at a red light. As the driver of the Toyota initiated a left turn into the intersection, the front of the GMC impacted the right side of the Toyota. The impact redirected both vehicles as the frontal aspect of the Toyota swiped the left side of the GMC. The GMC began a southeast trajectory from the initial impact and the front of the GMC impacted the front of the stopped Ford. The initial impact with the Toyota resulted in the deployment of the driver's frontal air bag in the GMC. The driver of the GMC was police reported as not injured. However, the driver of the GMC stated to the SCI investigator that he sustained 25.4 cm (10.0") contusion to his left forearm and a contusion to the top of his left thumb. The driver and front right passenger of the Toyota sustained police reported complaints of pain and were transported to a local hospital. The driver and three passengers of the Ford were not injured. The EDR data (deployment) from the GMC was successfully downloaded from the vehicle during this on-site SCI investigation and is included in this report as **Attachment A**. The driver of the GMC was not the vehicle owner; the vehicle was on a GM 24-hour test drive.			
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GENERAL DYNAMICS ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION
GENERAL DYNAMCIS CASE NO. – CA03-065
SUBJECT VEHICLE – 2004 GMC YUKON
LOCATION - STATE OF NEW JERSEY
CRASH DATE – OCTOBER 2003

BACKGROUND

This on-site investigation focused on the Certified Advanced 208-Compliant (CAC) safety system in a 2004 GMC Yukon **(Figure 1)**. The manufacturer of this has certified that this 2004 GMC Yukon meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS 208) No. 208. The system included dual-stage frontal air bags, a passenger presence sensor for the front right seat and seat track positioning sensors for the front left and front right seats. In addition, the GMC was also equipped with seatback mounted side impact air bags for the front left and front right positions and an Event Data Recorder (EDR). The 51-year-old male driver of the GMC was traveling southbound on a three-lane roadway approaching a four-leg intersection. A 1989 Toyota Corolla occupied, by a 17-year-old female driver and a 17-year-old male front right occupant, was traveling northbound on the same roadway and was intending to turn left at the intersection. A 1997 Ford Taurus station wagon that was occupied by a 31-year-old female driver and three passengers was stopped on the westbound lane of the same intersection at a red light. As the driver of the Toyota initiated a left turn into the intersection, the front of the GMC impacted the right side of the Toyota. The impact redirected both vehicles as the frontal aspect of the Toyota swiped the left side of the GMC. The GMC began a southeast trajectory from the initial impact and the front of the GMC impacted the front of the stopped Ford. The initial impact with the Toyota resulted in the deployment of the driver's frontal air bag in the GMC. The driver of the GMC was police reported as not injured. However, the driver of the GMC stated to the SCI investigator that he sustained 25.4 cm (10.0") contusion to his left forearm and a contusion to the top of his left thumb. The driver and front right passenger of the Toyota sustained police reported complaints of pain and were transported to a local hospital. The driver and three passengers of the Ford were not injured. The EDR data (deployment) from the GMC was successfully downloaded from the vehicle during this on-site SCI investigation and is included in this report as **Attachment A**. The driver of the GMC was not the vehicle owner; the vehicle was on a GM 24-hour test drive.

Figure 1. 2004 GMC Yukon.

This crash was identified by the National Automotive Sampling System (NASS) through the weekly review of Police Accident Reports (PAR). The PAR was forwarded to the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA). Due to the Certified Advanced 208-Compliant safety system, the crash was assigned to the General Dynamics SCI team on November 5, 2003. An on-site investigation effort was initiated on November 6, 2003.

SUMMARY

Crash Site

This intersection crash occurred during the nighttime hours of October 2003. At the time of the crash, the weather was clear with no adverse conditions. The crash occurred at a four-leg intersection of two local roadways **(Figure 2)**. The north/southbound roadway was configured with one travel in each direction and a center left turn lane. The north leg was divided by a solid double yellow centerline. The south leg was divided by a raised concrete median. Concrete barrier curbs bordered the north/southbound roadway. The east/westbound roadway was configured with one travel lane in each direction with a center left turn lane. Both legs were divided by solid double yellow centerlines and were bordered by concrete barrier curbs.

Figure 2. Northwest view of crash site.

Traffic through the intersection was controlled by overhead three phase traffic lights. The posted speed limit for both roadways was 64 km/h (40 mph). The scene schematic is included as **Figure 11** of this report.

Vehicle Data – 2004 GMC Yukon

The 2004 GMC Yukon was identified by the Vehicle Identification Number (VIN): 1GKEK13T64 (production sequence omitted). The odometer reading at the time of the inspection was 756 km/h (470 miles). The vehicle was a full-size, four-door sport utility vehicle that was equipped with a 5.3-liter V8 engine, 4-speed automatic transmission with overdrive, 4-wheel drive, power-front and rear disc brakes with anti-lock, OEM alloy wheels, power-steering, and a tilt steering wheel. The GMC was also equipped with a direct tire pressure monitoring system, power adjustable pedals, daytime running lights, and electronic traction control. The GMC was configured with Bridgestone Dueler P265/70R17 tires. The manufacture recommended tire pressure was 220.6 kpa (32.0 psi); the maximum pressure for these tires was 303.4 kpa (44.0 psi). The specific tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	282.7 kpa (41.0 psi)	10 mm (12/32)	No	None
LR	282.7 kpa (41.0 psi)	10 mm (12/32)	No	None
RF	286.1 kpa (41.5 psi)	10 mm (12/32)	No	None
RR	286.1 kpa (41.5 psi)	10 mm (12/32)	No	None

The seating positions in the GMC were configured with front buckets seats with height adjustable head restraints. The front seat head restraints were both adjusted to the full-down positions at the time of the vehicle inspection. The second row seats were configured with two-bucket seats and height adjustable head restraints that were adjusted to the full-down positions.

The second row seat was equipped with LATCH (Lower Anchors and Tethers for Children). The third row seat was configured with a spilt bench seat with height adjustable head restraints that were adjusted to the full-down positions. The third row was not equipped with the LATCH system.

1989 Toyota Corolla

The 1989 Toyota Corolla was not inspected. The vehicle had been crushed prior to the initiation of this investigation.

1997 Ford Taurus

The 1997 Ford Taurus was not inspected. This vehicle could not be located, as the owner had not filed an insurance claim. The owner could not be located through various searches.

Crash Sequence

Pre-Crash

The 51-year-old male driver of the GMC was operating the vehicle on a GM 24-hour test drive and was traveling southbound on the three-lane roadway approaching an intersection **(Figure 3)**. The EDR indicated that the GMC was traveling at 64.3 km/h (40.0 mph) five seconds prior the crash. The EDR also indicated that the driver applied the brakes and slowed the vehicle to 45.1 km/h (28.0 mph) one-second prior to the crash. The 17-year-old female driver of the Toyota was operating the vehicle northbound approaching the same intersection where she was intending to turn left. The 31-year-old female driver of the Taurus was stopped on the westbound lane of the intersection at a red light. No pre-impact skid marks were present at the scene.

Figure 3. GMC's approach to intersection.

Crash

The driver of the Toyota initiated a left turn across the path of the oncoming GMC. The frontal aspect of the GMC impacted the right side of the Toyota in the intersection **(Figure 4)**. The resultant directions of force were with the 11 o'clock sector for the GMC and 2 o'clock sector for the Toyota. The GMC's EDR recorded a maximum delta V of -16.2 km/h (-10.1 mph). A WinSmash missing vehicle algorithm computed a total delta V for the GMC of 17.0 km/h (10.6 mph). The longitudinal and lateral components for the GMC were -16.0 km/h (-9.9 mph) and 5.8 km/h (3.6 mph) respectively. The total delta V calculated by the missing vehicle algorithm for the Toyota was 36.0 km/h (22.4 mph). The calculated longitudinal and lateral components for the Toyota were -23.1 km/h (-14.4 mph) and -27.6 km/h (-17.1 mph) respectively.

Figure 4. Area of impact from southbound approach.

The GMC was deflected laterally right as its center of gravity continued forward. The Toyota was rotated counterclockwise. The frontal aspect of the Toyota sideswiped the left side of the GMC. The resultant direction of force for the secondary impact was within the 12 o'clock sector for the GMC. The GMC continued its trajectory and entered the westbound lane. The front right corner area of the GMC impacted the frontal aspect of the stopped Ford Taurus **(Figure 5)**. All three vehicles came to rest in the southeast quadrant of the intersection.

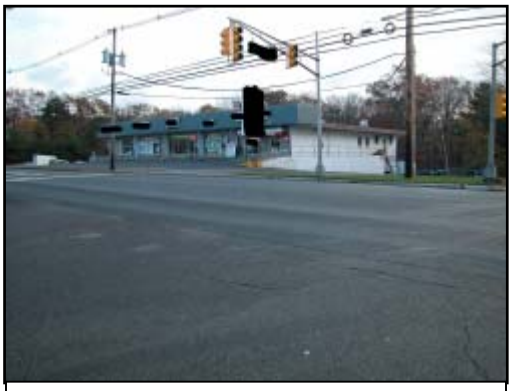


Figure 5. Area of impact between GMC and stopped Ford.

Post-Crash

The driver of the GMC reported no injuries as result of the crash and was not transported to a hospital. The driver and front right passenger of the Toyota sustained minor injuries and were transported to a local hospital. The driver and three passenger of the Ford were police reported as not injured. The GMC and Toyota were towed from the scene due to disabling damage. The Ford sustained minor damage was driven from the scene.

Vehicle Damage

Exterior Damage – 2004 GMC Yukon

The 2004 GMC Yukon sustained moderate damage as a result of the multiple impacts **(Figure 6)**. The damage for the impact with the Toyota consisted of a longitudinally displaced bumper, fractured grille, and displaced left and right turn signal lenses. The direct contact damage began on the front left bumper corner and extended 150.0 cm (59.4") to the right. Maximum crush was located 17.0cm (6.7") right of the vehicle's centerline and measured 6.0 cm (6.3"). Six crush measurements were documented at the bumper level using a combined direct and induced damage width of 173.0 cm (68.1") and were as follows: C1=10.0 cm (3.9"), C2=9.0 cm (3.5"), C3= 10.0 cm (3.9"), C4= 16.0 cm (6.3"), C5= 8.0 cm (3.1"), C6= 7.0 cm (2.8"). The Collision Deformation Classification (CDC) for this impact was 11-FDEW-1.

Figure 6. Frontal view of damaged 2004 GMC Yukon.

The damage from the second impact with the Toyota consisted of a large scuffmark and a minor dent from sideswipe-type damage on the front left side **(Figure 7)**. The direct damage width was 168.0 cm (66.1") and began 177.0 cm (69.7") forward of the left rear axle and extended forward. Maximum crush was located at the rear aspect of the front left fender and was approximately 2.5 cm (1.0"). No crush measurements were obtained for this impact. The CDC for this impact was 12-LYES-1

The damage from the impact with the Ford consisted of a 9.0 cm (3.5") scuffmark on the right front bumper corner **(Figure 8).** No residual crush was present from this impact. The CDC for this impact was 12-FRLS-1.

Figure 7. Sideswipe damage from second impact with the Toyota.

Figure 8. Damage from impact with Ford.

Interior Damage –2004 GMC Yukon

The 2004 GMC Yukon sustained no interior damage as result of the crash. No occupant contacts were identified in the vehicle.

Certified Advanced 208-Compliant Safety System – 2004 GMC Yukon

The 2004 GMC Yukon was equipped with a Certified Advanced 208-Compliant safety system. The system consisted of dual-stage frontal air bags, a passenger presence sensor for the front right seat and seat track positioning 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 located on the floor under the driver's seat. The SDM deployed the appropriate safety component(s) dependant on occupant presence, belt usage, seat track position and crash severity. In this crash, the SDM commanded a stage one deployment of the driver's air bag at 40 milliseconds. The driver's air bag module was located in the center of the steering wheel hub **(Figure 9)**. The air bag was 61.0 cm (24.0") in diameter and contained two tethers and was vented by two vent ports at the 11 and 1 o'clock positions on the rear aspect of the air bag. The front right seat was not occupied during the crash; therefore the system did not deploy the front right air bag. The GMC was also equipped seatback mounted side impact air bags for the front seating positions. The side impact air bags did not deploy in this crash.

Figure 9. Deployed driver's frontal air bag.

Event Data Recorder– 2004 GMC Yukon

The 2004 GMC Yukon was equipped with an EDR that was located under the driver's seat. The data indicated that the driver's safety belt was buckled and front right safety belt was unbuckled at the time of the crash and the vehicle speed was 64.3.0 km/h (40.0 mph) five seconds prior to

Algorithm Enable (AE). The EDR also indicates that the driver applied the brakes and slowed the vehicle to 45.1 km/h (28.0 mph) one-second prior to AE. The maximum delta V recorded by the EDR was of -16.2 km/h (-10.1 mph) at 180 milliseconds. The SDM commanded a stage one deployment of the driver's air bag at 40 milliseconds, in this crash. The EDR recorded one event for this crash, although two others occurred. The front right air bag did not deploy, as the front right seat was not occupied. The EDR data is included as **Attachment A** of this report.

Manual Restraint Systems – 2004 GMC Yukon

The 2004 GMC Yukon was equipped with integrated manual 3-point lap and shoulder safety belts for the front left **(Figure 10)** and front right seating positions. The front left safety belt was configured with a sliding latch plate and a belt sensitive emergency locking retractor (ELR). The driver utilized the safety belt during this crash. However, no loading evidence was present on the safety belt. The front right safety belt was configured with a sliding latch plate and switchable ELR/Automatic Locking Retractor (ALR). The second row was equipped with manual 3-point manual lap and shoulder belts that were configured with sliding latch plates and switchable ELR/ALR retractors. The third row was equipped with integrated manual 3-point lap and shoulder belts for the outboard seats and a manual 2-point lap belt for the center position. The outboard safety belts were configured with sliding latch plates and switchable ELR/ALR retractors and the center belt was configured with a locking latch plate and no retractor.

Figure 10. Driver's integrated safety belt.

Occupant Demographics – 2004 GMC Yukon

Driver

Age/Sex:	51-year-old male
Height:	180.0 cm (71.0”)
Weight:	95.0 kg (209.0 lbs)
Seat Track Position:	18.0 cm (7.1”) rear of full forward and 2.0 cm (0.8”) forward of full rear.
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	None
Type of Medical Treatment:	Minor injuries not transported to a hospital.

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
25.4 cm (10.0”) contusion on left forearm; contusion to top of left thumb	Minor (790402.1,2)	Deploying driver’s air bag

Injury source = Driver

Driver Kinematics

The 51-year-old male driver of the 2004 GMC Yukon was seated in an upright posture with the seat track adjusted to a rear track position. The seat back was located 70.0cm (27.5”) from the center of the steering wheel hub. He was restrained by the integrated manual 3-point lap and shoulder belt. At impact, the frontal air bag deployed as the driver initiated a forward and left trajectory. The driver’s left forearm and top of his left thumb were contacted by the deploying front left air bag which resulted in a 25.4 cm (10.0”) left forearm contusion and a contusion to the top of the left thumb. The driver loaded the manual belt system, which prevented him from contact with frontal components. The driver was not transported to a hospital and did not seek medical treatment post-crash. The safety belt usage protected the driver from contact with frontal components, thus preventing further possible injury. Additional crash protection was offered by the first stage deployment of the driver’s frontal air bag.

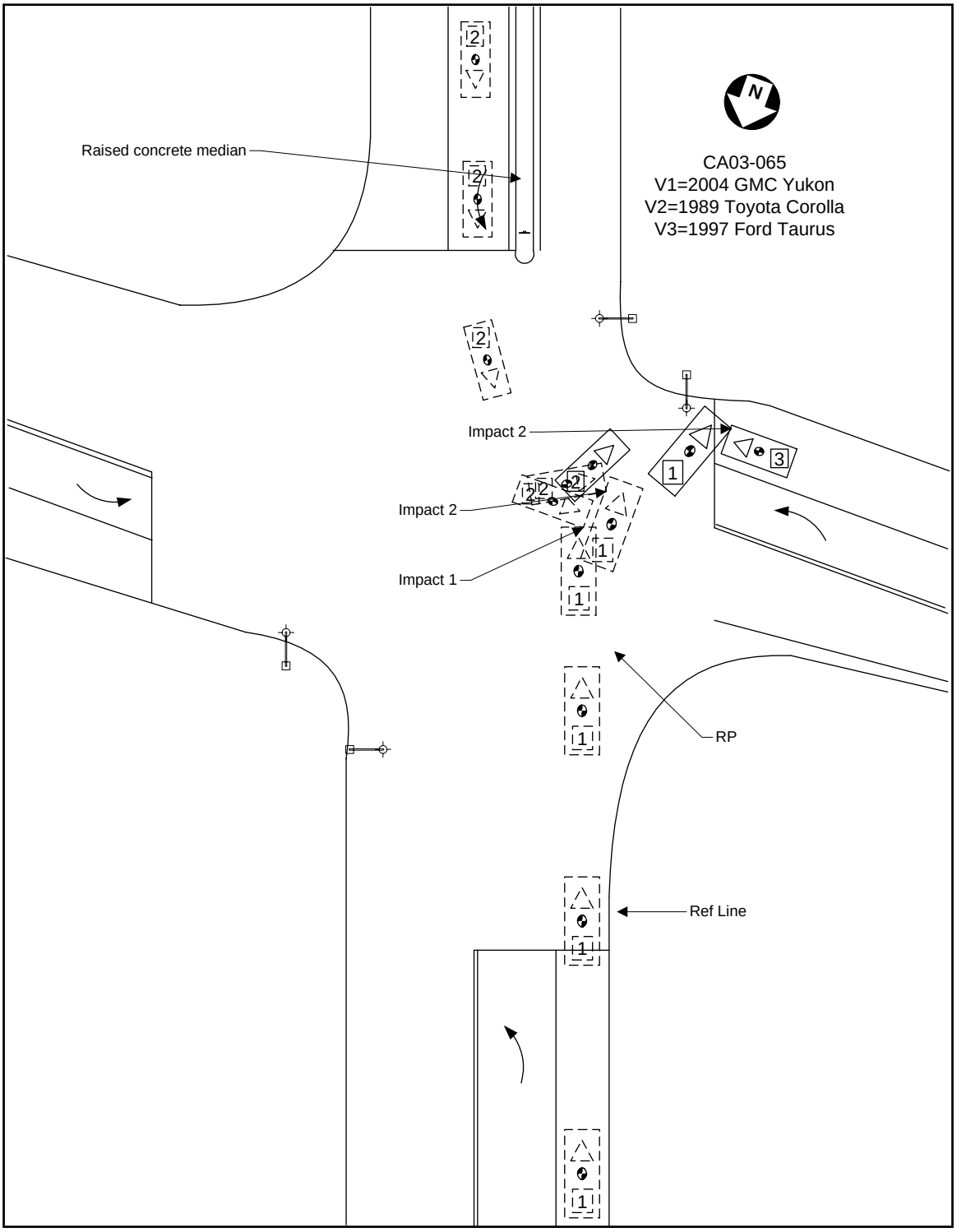


Figure 9. Scene schematic

Attachment A: EDR data

CDR File Information

Vehicle Identification Number	1GKEK13T64Rxxxxxx
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	
Saved on	
Data check information	
Collected with CDR version	
Collecting program verification number	6B1D6F0F
Reported with CDR version	Crash Data Retrieval Tool 2.21
Reporting program verification number	6B1D6F0F
Interface used to collected data	Block number: 00 Interface version: 39 Date: 10-09-03 Checksum: 0300
Event(s) recovered	Deployment

SDM Data Limitations

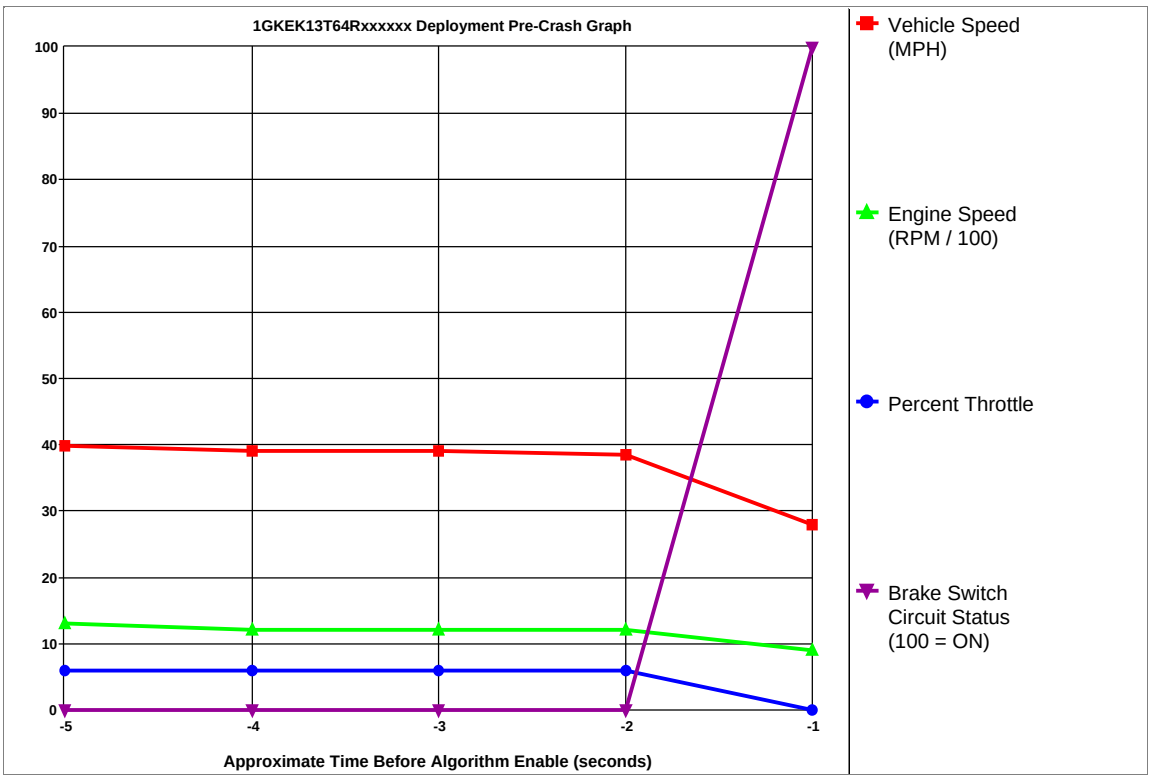
SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store 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. SDM Recorded Vehicle Forward Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. 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. For deployments and deployment level events, the SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. For non-deployments, the SDM will record the first 150 milliseconds of data after algorithm enable.
-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.
-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.

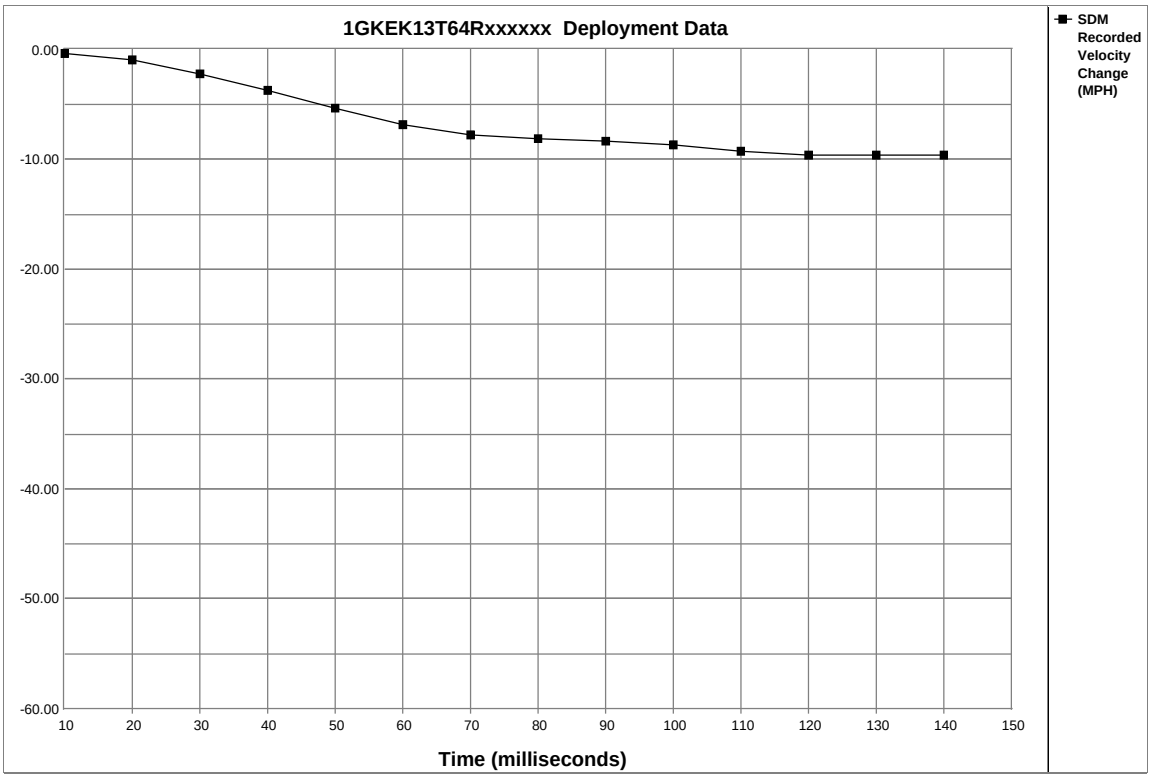
SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the Class 2 data link, to the SDM.
-Brake Switch Circuit Status 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
Passenger's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Deployment	121
Ignition Cycles At Investigation	138
Maximum SDM Recorded Velocity Change (MPH)	-10.07
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	180
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	40
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
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	40	1280	6	OFF
-4	39	1216	6	OFF
-3	39	1216	6	OFF
-2	39	1216	6	OFF
-1	28	896	0	ON



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.31	-0.93	-2.17	-3.72	-5.27	-6.82	-7.75	-8.06	-8.37	-8.68	-9.30	-9.61	-9.61	-9.61	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.

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$02  F1 F1 3C 3C A8 00
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$04  4B 39 42 37 37 31
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$12  8B 00 00 3D 3C 00
$13  FF 02 00 00 00 00
$14  1D 1D 05 05 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 3F 55 EC F5 00
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$1C  00 0C 00 00 00 00
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