TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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

SCI TECHNICAL SUMMARY REPORT

GENERAL DYNAMICS CASE NO. – CA03-055

SUBJECT VEHICLE – 2003 CHEVROLET SILVERADO

LOCATION - STATE OF MICHIGAN

CRASH DATE – SEPTEMBER 2003

Contract No. DTNH22-01-C-17002

Prepared for:

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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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16. Abstract This on-site Certified Advanced-208 Compliant vehicle crash investigation focused on the survivability of an Event Data Recorder (EDR) from a 2003 Chevrolet Silverado pickup truck. The vehicle was equipped with an EDR and a Certified Advanced-208 Compliant (CAC) frontal air bag system. The CAC system included dual stage frontal air bags, seat track position sensors for the front left and front right seats, an occupant-detection sensor for the front right seat, and safety belt buckle switch sensors. The driver of the vehicle was traveling northbound on a two-lane rural roadway approaching a "T" intersection. The driver fell asleep as he approached the "T" intersection and relinquished control of the vehicle and departed the northwest corner of the intersection. The vehicle drove over a mountable curb and impacted an advertisement sign with its front bumper. The Chevrolet continued off-road and entered a pond where it came to rest, fully submerged. The CAC system did not deploy as result of the crash. The vehicle was submerged for approximately 10-11 hours prior to its removal from the water. The tow yard personnel stated to the SCI investigator that the vehicle was completely under water with the top surface of the roof visible. The driver was not injured during the crash. The EDR data (non-deployment) was successfully downloaded from the vehicle during this on-site SCI investigation and is included in this report as Attachment A.			
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SUBJECT VEHICLE – 2003 CHEVROLET SILVERADO
LOCATION - STATE OF MICHIGAN
CRASH DATE – SEPTEMBER 2003

BACKGROUND

This on-site Certified Advanced-208 Compliant vehicle crash investigation focused on the survivability of an Event Data Recorder (EDR) from a 2003 Chevrolet Silverado **(Figure 1)** pickup truck. The CAC system included dual stage frontal air bags, seat track position sensors for the front left and front right seats, an occupant-detection sensor for the front right seat, and safety belt buckle switch sensors. The driver of the vehicle was traveling northbound on a two-lane, two-way rural roadway approaching a "T" intersection. The driver fell asleep as he approached the "T" intersection and relinquished control of the vehicle and departed the northwest corner of the intersection. The vehicle drove over a mountable curb and impacted an advertisement sign with its front right area. The Chevrolet continued off-road and entered a pond where it came to rest, fully submerged. The CAC system did not deploy as result of the crash. The vehicle was submerged for approximately 10-11 hours prior to its removal from the water. The tow yard personnel stated to the SCI investigator that the vehicle was completely underwater with the top surface of the roof visible. The driver was not injured during the crash. The EDR data (non-deployment) was successfully downloaded from the vehicle during this on-site SCI investigation and is included in this report as **Attachment A**.

Figure 1. 2003 Chevrolet Silverado.

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 crash circumstances, the crash was assigned to the General Dynamics SCI team on September 26, 2003. Cooperation was established with the insurance carrier and the on-site investigation effort was initiated on September 30, 2003.

SUMMARY

Crash Site

This single vehicle crash occurred during the nighttime hours of September 2003. At the time of the crash, the weather was clear with no adverse conditions. The crash occurred off-road on the northwest sector of a "T" intersection of two roadways. The off-road area consisted of two real estate signs, a large rock, a sewer grate, and a fresh water pond. The perimeter of the pond began 8.5 m (27.8') north of the curb edge and ended 47.6 m (156.1') north of the referenced point. The total length and width of the pond was 39.1 m (128.3') and 32.6 m (106.9')

respectively. The north/south roadway was configured with one travel lane in each direction and was separated by a double-yellow centerline and was bordered with gravel shoulders. The roadway was straight with a downhill grade for the northbound direction. The posted speed limit for northbound traffic was 89 km/h (55 mph). The scene schematic is included as **(Figure 9)** of this report.

Ve*hicle Data – 2003 Chevrolet Silverado*

The 2003 Chevrolet Silverado was identified by the Vehicle Identification Number (VIN): 1GCEK19T73 (production sequence omitted). The odometer reading could not be obtained due to water damage to the electrical system. The driver stated to the SCI investigator that he purchased the vehicle in August 2002. At the time of the purchase the vehicle had approximately 108 km (67 miles) on the odometer. The driver also stated to the SCI investigator that the vehicle had approximately 32-35,000 km (20-22,000 miles) on the odometer at the time of the crash. The vehicle was a four-door pick-up truck that was equipped with a 5.3-liter, V8 engine, 4-speed automatic transmission, 4-wheel drive, power-front and rear disc brakes with anti-lock, OEM alloy wheels, power-steering, and a tilt steering wheel. The Chevrolet was configured with Durango Radial AT LT285/75R16 tires. The maximum pressure for these tires was 448 kpa (65.0 psi). The vehicle manufacturer recommended tire pressure was 345 kpa (50 psi) for both front and rear tires. The specific tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	314 kpa (45.5 psi)	4.0 mm (5/32) middle of tread, 6.0 mm (7/32) outer tread)	No	None
LR	314 kpa (45.5 psi)	0.0 mm (0/32) middle of tread, 4.0 (5/32) outer tread	No	None
RF	307 kpa (44.5 psi)	4.0 mm (5/32) middle of tread, 6.0 mm (7/32) outer tread)	No	None
RR	303 kpa (44 psi)	0.0 mm (0/32) middle of tread, 4.0 (5/32) outer tread	No	None

The seating positions in the Chevrolet were configured with a front split bench seat with height adjustable head restraints and a flip and fold front center seat/armrest. The front seat head restraints were both adjusted to 3.0 cm (1.2”) above the full-down positions at the time of the vehicle inspection. The rear seat was configured with a bench seat with a folding rear seat back and height adjustable head restraints for the outboard positions. The rear seat was equipped with LATCH (Lower Anchors and Tethers for Children) in the center and right positions for use with child safety seats.

Crash Sequence

Pre-Crash

The 45-year-old male driver of the Chevrolet was operating the vehicle northbound on the two-lane, two-way roadway approaching the "T" intersection. The driver stated to the SCI investigator that he fell asleep as he was driving. The Chevrolet drifted into the southbound lane as it approached the intersection **(Figure 2)**. The lack of pre-impact evidence indicated that no avoidance maneuvers were attempted by the driver. It should be noted that, the EDR recorded an "On" status for the vehicle's brake switch for a four-second period prior to the Non-Deployment event. It was assumed that the driver's foot was resting on the brake pedal as he fell asleep; therefore he was not intending an avoidance maneuver.

Figure 2. Northwest view of crash site.

Crash

The Chevrolet overrode the northwest mountable curb and impacted a real estate sign with the right aspect of the front plane. The sign was located 4.9 meters (16.1') north of the curb **(Figure 3)**. The Chevrolet continued in a northwest direction an additional 3.6 meters (11.8') off-road and impacted a fresh water pond with its frontal undercarriage. The driver stated to the SCI investigator that vehicle traveled approximately 6-15 meters (20-50') into the pond before the vehicle stopped and began to sink. At rest, the vehicle was totally submerged in the pond. The frontal CAC system did not deploy in this crash. The impact with the pond produced a Non-Deployment event that was recorded by the EDR. The maximum-recorded delta-V was -9.0 km/h (-5.6 mph) at 227.5 milliseconds after algorithm wake-up.

Figure 3. Impact to small sign and pond.

Post-Crash

The driver exited the vehicle through the left front door window and climbed onto the hood of the Chevrolet. The driver then jumped off the vehicle and swam to the shore. The driver reported no injuries as result of the crash and was not medically treated. The vehicle was towed from the pond approximately 10-11 hours post-crash, during daylight hours.

Vehicle Damage

Exterior Damage – 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado sustained minor cosmetic damage as a result of the impact with the real estate sign. The direct contact damage from the impact with the sign consisted of a fractured trim panel at the front right headlight assembly **(Figure 4)**. No residual crush was

present to the bumper of the Chevrolet; therefore a crush profile was documented. The Collision Deformation Classification (CDC) for this impact was 12-FREE-1.
The second event consisted of the undercarriage plastic stone guard impacting the water as the Chevrolet entered the pond. The damage consisted of a dent to the undercarriage plastic stone guard that shielded the front of the engine. The dent was 22.0 cm (8.7") in width and 20.0 cm (7.9") in height and approximately 2.5 cm (1.0") in depth **(Figure 5)**. The location of the damage was above the level of the curb; therefore it was presumed to be associated with the vehicle striking the water as it entered the pond. This impact was also consistent with the recorded Non-Deployment event for both the magnitude and the duration of the impact. The CDC for this event was 12-UFCN-1.

The Chevrolet sustained severe electrical damage (corrosion) and water contamination to the engine, transmission, and brake system from the submersion in the pond.

Figure 4. Fractured trim panel near front right headlight assembly.

Figure 5. Damage to stone guard from pond.

Interior Damage –2003 Chevrolet Silverado

The 2003 Chevrolet Silverado sustained moderate interior damage that was attributed to the passenger compartment being submerged underwater **(Figure 6)**. The water shorted the electronic components in the instrument cluster and corroded the vehicle's fuse panels **(Figure 7)**. No intrusions or occupant contact points were noted to the interior of the vehicle.

Figure 6. Interior from right to left.

Figure 7. Right side fuse panel. Note oxidation from water damage.

Certified Advanced-208 Compliant Safety System – 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado was equipped with a Certified Advanced-208 Complaint (CAC) safety system. The CAC system consisted of dual stage frontal air bags, seat track position sensors for the front left and front right seats, an occupant-detection sensor for the front right seat, and safety belt buckle switch sensors. The CAC system was monitored and controlled by a Sensing and Diagnostic control Module (SDM). The SDM identifies the crash severity, occupant presence, and seat track positions and deploys the appropriate safety system. Due to the minor severity of the subject crash, no safety systems were deployed.

Electronic Data Recorder- 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado was equipped with an EDR that was located under the driver's seat. The vehicle was submerged in a fresh water pond for approximately 10-11 hours. The submersion did not damage the EDR and a Non-Deployment Event was recorded and stored in the unit. The SCI investigator attempted to restore power to the vehicle through the battery using jumper cables in order to facilitate a download from the Diagnostic Link Connector (DLC). However, power to the vehicle's interior electrical components could not be restored due to the oxidized fuse panels. The SCI investigator proceeded to the EDR module to recover the data. The appropriate Vetronix CDR cable was plugged into the EDR module. External power was supplied to the interface box and a Non-Deployment event was successfully downloaded. The data indicated that the driver safety belt was buckled at the time of the crash and the vehicle speed was 58.0 kmh (36.0 mph) one second prior to Algorithm Enable (AE). The EDR recoded a maximum delta-V of -9.0 km/h (-5.6mph) at 227.5 milliseconds following AE. The EDR data is included as **Attachment A** of this report.

Manual Restraints System – 2003 Chevrolet Silverado

The 2003 Chevrolet Silverado was equipped with 3-point manual lap and shoulder safety belts for the four outboard seating positions and a lap belt for the front and rear center positions. The front safety belts were integrated into the seat backs **(Figure 8)** and were configured with sliding latch plates and Emergency Locking Retractors (ELR). The driver utilized the safety belt in the crash; however, no crash related evidence such as stretching was present on the safety belt. The front right safety belt was equipped with a switchable ELR/Automatic Locking Retractor (ALR). The rear outboard safety belts were configured with sliding latch plates and switchable ELR/ALR. The front and rear center safety belts were configured with locking latch plates and no retractors.

Figure 8. Integrated driver's 3-point lap and shoulder belt.

Occupant Demographics - 2003 Chevrolet Silverado

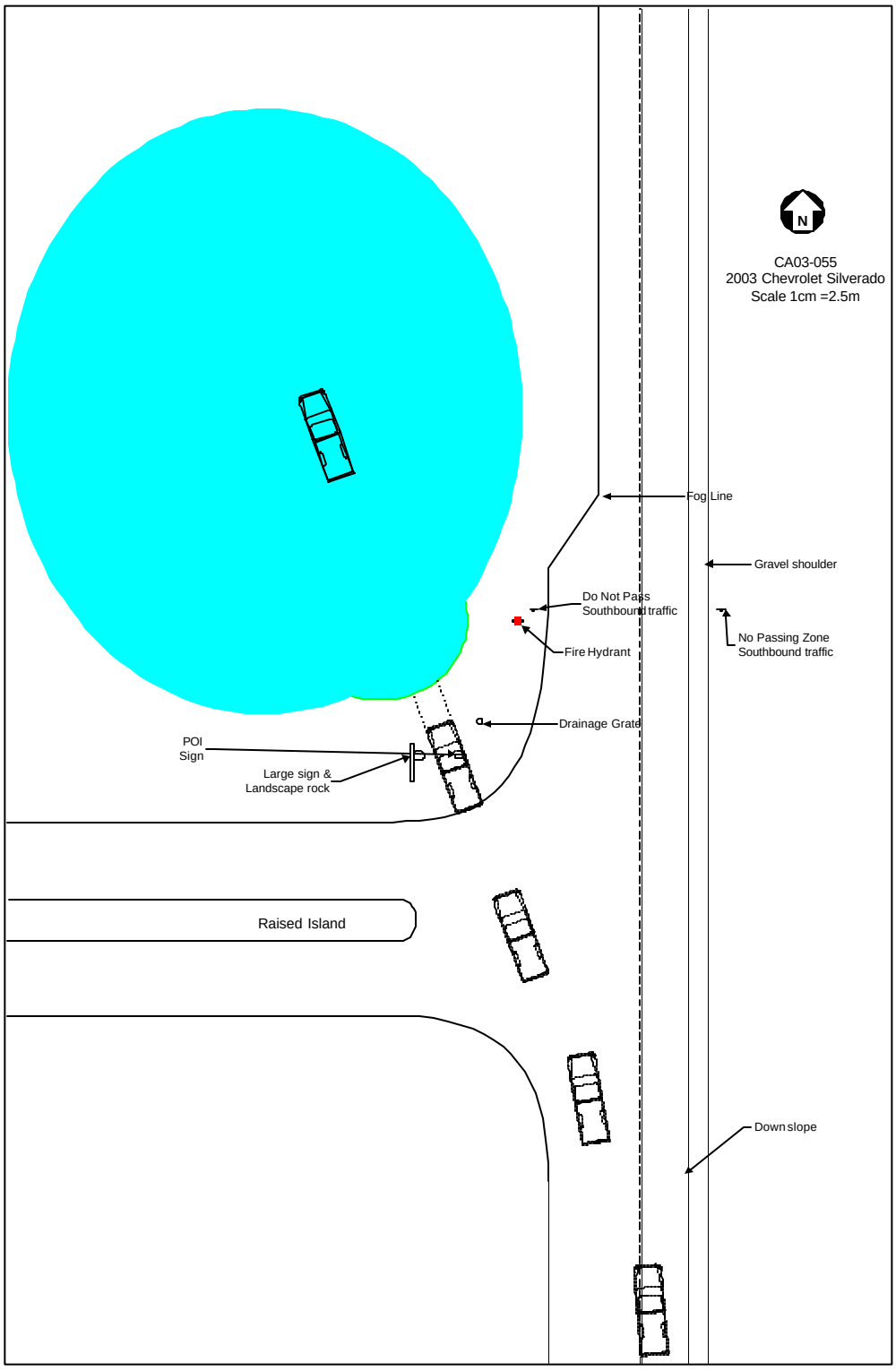
Driver

Age/Sex:	45-year-old male
Height:	188.0 cm (74.0”)
Weight:	106.5 kg (235.0 lbs)
Seat Track Position:	Seat track was adjusted to full rear [track travel = 23.0 cm (9.1”)]
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Not injured or transported to a hospital.

Driver Kinematics

The 45-year-old male driver of the 2003 Chevrolet Silverado was seated in a presumed upright posture. He was restrained by the integrated manual 3-point lap and shoulder belt. At impact, he initiated a forward trajectory and loaded the manual belt system. However, no loading evidence such as stretching, transfers etc. was present on the safety belt. The driver was not injured in the crash. The safety belt protected the driver from contact with frontal components, thus preventing possible injury.

Figure 9. Scene schematic



Attachment A: EDR data

CDR File Information

Vehicle Identification Number	1GCEK19T73Exxxxxx
Investigator	[redacted]
Case Number	[redacted]
Investigation Date	[redacted]
Crash Date	[redacted]
Filename	[redacted]
Saved on	[redacted]
Data check information	[redacted]
Collected with CDR version	Crash Data Retrieval Tool 2.10
Collecting program verification number	[redacted]
Reported with CDR version	Crash Data Retrieval Tool 2.21
Reporting program verification number	[redacted]
Interface used to collected data	Block number: 00 Interface version: 35 Date: 01-02-03 Checksum: 6200
Event(s) recovered	Non-Deployment

SDM Data Limitations

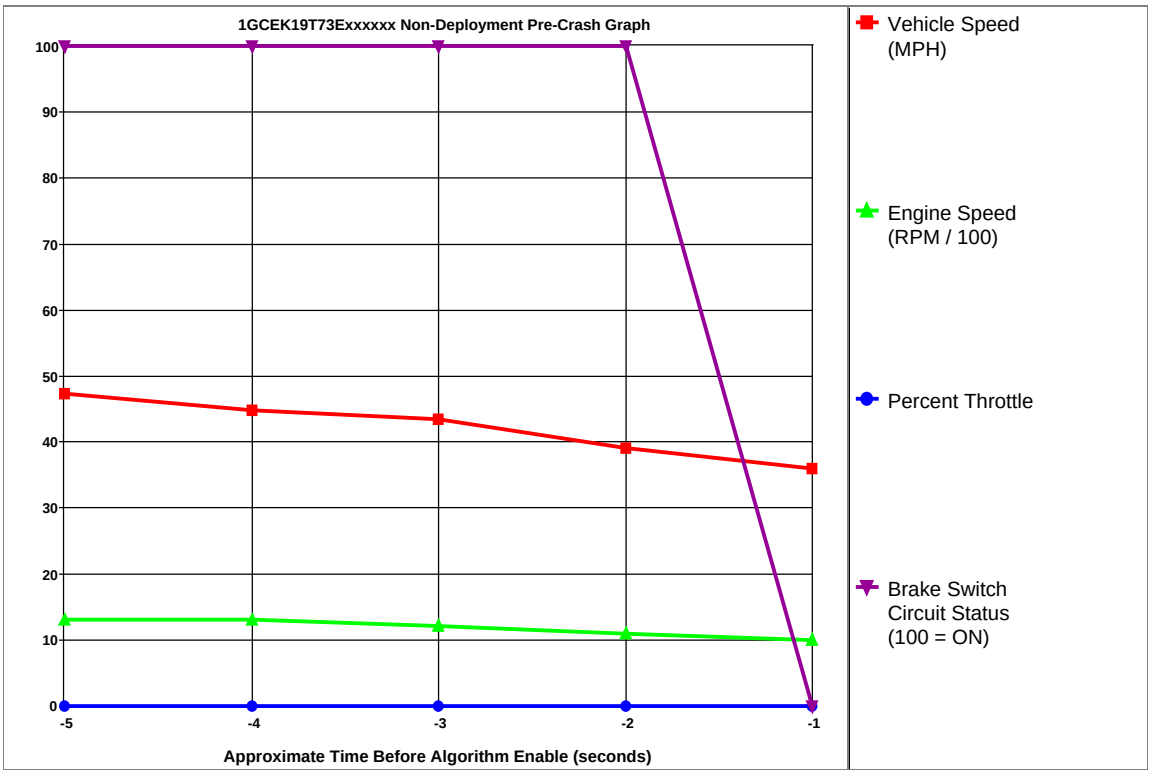
SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store 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.

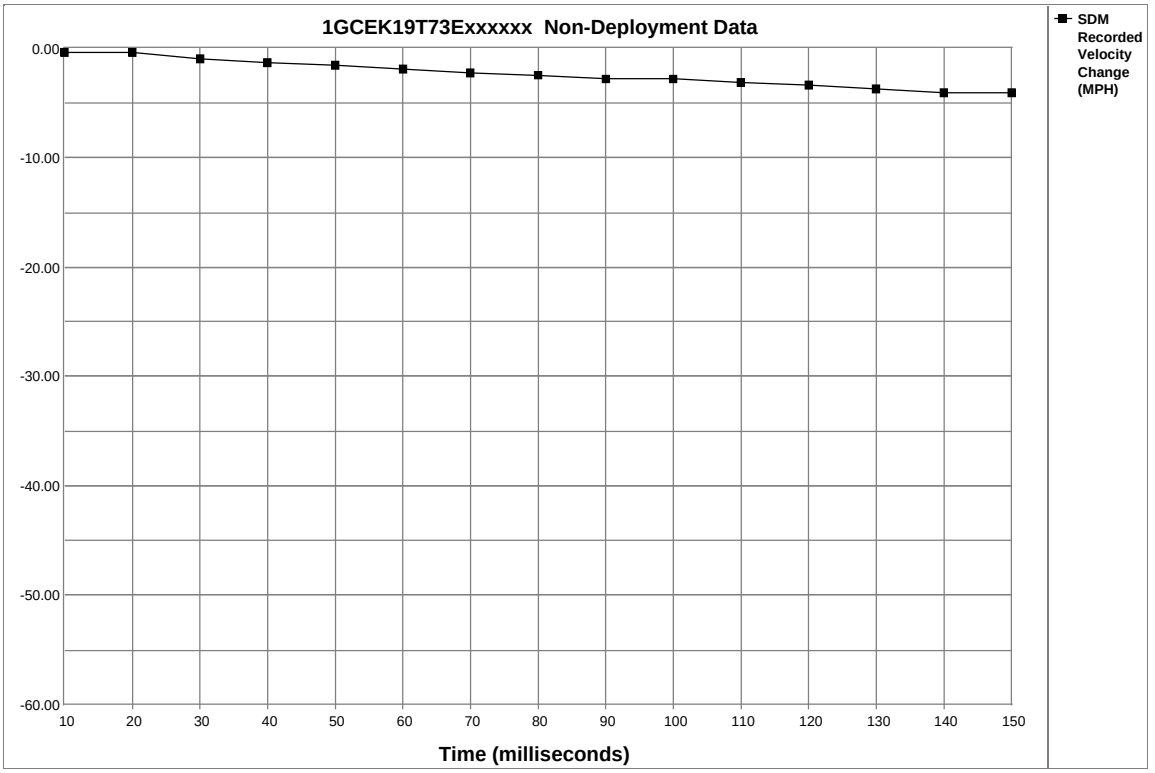
SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the Class 2 data link, to the SDM.
-Brake Switch Circuit Status 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 Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Non-Deployment	4064
Ignition Cycles At Investigation	4065
Maximum SDM Recorded Velocity Change (MPH)	-5.55
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	227.5
Event Recording Complete	Yes
Multiple Events Associated With This Record	Yes
One Or More Associated Events Not Recorded	Yes



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	47	1280	0	ON
-4	45	1280	0	ON
-3	44	1152	0	ON
-2	39	1088	0	ON
-1	36	960	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	-0.31	-0.93	-1.24	-1.55	-1.86	-2.17	-2.48	-2.79	-2.79	-3.10	-3.41	-3.72	-4.03	-4.03

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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$01  F0 21 F7 3C AE 5A
$02  F1 F1 00 00 B8 00
$03  41 53 32 32 32 38
$04  4B 31 41 34 53 31
$05  00 00 00 00 00 00
$06  15 05 78 16 00 00
$07  00 00 00 00 00 00
$08  00 00 00 00 00 00
$09  00 00 00 00 00 00
$0A  00 00 00 00 00 00
$0B  00 00 00 00 00 00
$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  FE 03 FE 00 00 00
$11  7E 7C 80 82 81 83
$12  A0 8D 89 23 23 01
$13  FF 02 00 00 00 00
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$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  FF 00 00 00 00 00
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$21  FF FF FF FF FF FF
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$27  07 08 09 09 0A 0B
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