Advanced Occupant Protection System Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS02029
2003 GMC Safari van
Washington
October, 2002

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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 be 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 was a single vehicle collision versus a fixed object (concrete wall). The collision occurred in October, 2002 at 0910 hours in the state of Washington. The roadway is bordered on both sides by concrete walls and the north edge is bordered by a raised concrete curb. There are no traffic controls and the speed limit is 97 km/h (60 mph). It was raining at the time of the collision and the roadway surface was wet which may have been a contributing factor in the crash. The case vehicle is fleet rental vehicle, a 2003 GMC Safari van that was driven by an unrestrained 27-year-old male. The case vehicle had entered the freeway on-ramp and was initially traveling eastbound in the far left lane. As the roadway curved sharply to the right and the on-ramp became three lanes, the case vehicle was traveling northbound and in the second lane from the left. The police report indicates that the case vehicle was traveling too fast for the weather conditions. As the roadway curved sharply to the right the driver lost control of the vehicle. The vehicle veered to the left and the left front tire struck the raised concrete curb (impact 1), continued and the front bumper of the vehicle then struck the concrete wall (impact 2). At impact with the concrete wall, the driver's and front right passenger's air bags deployed. After impact with the concrete wall, the case vehicle rotated counterclockwise about the concrete wall, deflected off the wall, continued rotating counterclockwise, crossed all eastbound travel lanes and came to final rest in the far right lane heading east. The driver of the case vehicle did not report any injuries to the police or the insurance adjuster.

17. Key Words	18. Distribution Statement
Air bag, deployment, AOPS, unrestrained driver	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No of pages	22. Price

Dynamic Science, Inc.
Crash Investigation
Case Number: DS02029

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BACKGROUND:

Description:	This Advanced Occupant Protection Systems (AOPS) case was identified by the local National Automobile Sampling System Primary Sampling Unit. The case was reported to DSI by the National Highway Traffic Safety Administration with instructions to locate the case vehicle for an on-scene investigation. DSI was able to locate the vehicle and obtained permission to conduct the investigation. DSI was assigned the case on November 22, 2002. All field work was completed on February 1, 2003.
Investigation Type:	Advanced Occupant Protection System
Crash Location:	Washington
Crash Date:	October, 2002
Notification Date:	November 22, 2002
Field Work Completed:	February 1, 2003

SUMMARY

Crash Site

Figure 1. Direction of travel towards POI (east)

This was a single vehicle collision versus a fixed object (concrete wall). The collision occurred in October, 2002 at 0910 hours in the state of Washington. At the area of impact, the roadway is a freeway on-ramp in a commercial area. Initially the on-ramp is two lane, straight and level concrete roadway. The on-ramp then curves sharply to the right and becomes a three lane roadway, with the far left lane as a car pool lane, and two through lanes. The roadway is bordered on both sides by concrete walls. There are no traffic controls and the speed limit is 97 km/h (60 mph). It was raining at the time of the collision and the roadway surface was wet which may have been a contributing factor in the crash.

Pre-Crash

Figure 2. Area of impact

The case vehicle is fleet rental vehicle, a 2003 GMC Safari van that was driven by an unrestrained[1] 27-year-old male. Inspection of the driver's lap and shoulder belt did not reveal any evidence of loading and damage to the instrument panel also indicated that the driver was not restrained at the time of the crash. The case vehicle had entered the freeway on-ramp and was initially traveling eastbound in the far left lane. As the roadway curved sharply to the right and the on-ramp became three lanes, the case vehicle was traveling northbound and in the second lane from the left. The police report indicates that the case vehicle was traveling too fast for the weather conditions. As the roadway curved sharply to the right the driver lost control of the vehicle.

Crash

The vehicle veered to the left and the left front tire struck the raised concrete curb (impact 1), continued and the front bumper of the vehicle then struck the concrete wall (impact 2). The total velocity change for the case vehicle as calculated by the Barrier algorithm of the WinSmash collision model was 20.0 km/h (12.4 mph)[2]. The longitudinal and lateral delta V components were -19.7 km/h (-12.2 mph) and -3.5 km/h (-2.2 mph), respectively. The results fit the collision model but appear low. The impact was sufficient to generate a Deployment Event. The Sensing Diagnostic Module (SDM) recorded a maximum velocity change of -30.07 km/h (-18.69 mph) at the 115 ms mark. At impact with the concrete wall, the driver's and front right passenger's air bags deployed.

Figure 3. Exterior frontal damage to case vehicle

[1] Data was downloaded from the Sensing and Diagnostic Module (SDM) indicates the driver's safety seat belt circuit was unbuckled for the deployment event.

[2]Calculated using stiffness values derived from NCAP test number 3352

After impact, the case vehicle rotated counterclockwise about the concrete wall, deflected off the wall, continued rotating counterclockwise (to almost 360 degrees), crossed all eastbound travel lanes and came to final rest in the far right lane facing east.

Post-Crash

The driver of the case vehicle did not report any injuries to the police or the insurance adjuster. The driver's door remained closed and operational and presumably the driver was able to exit the vehicle under his own power.

VEHICLE DATA - 2003 GMC Safari

The 2003 GMC Safari SXT 8-passenger minivan was equipped with a 4-speed automatic transmission, anti-lock brakes, power steering, and a tilt steering column.

VIN:	1GKDM19X63B5XXXXXX
Odometer:	6,376 km (3,962 miles)
Engine:	4.3 L / 6 cylinder
Reported Defects:	None
Cargo:	None

The 2003 GMC Safari was equipped with Bridgestone Dueler H/T 684II P215/70R16 tires. The specific tire data is as follows:

Tire	Tread	Pressure	Manufacturer Maximum Recommended Pressure
LF	9 mm (11/32 in)	Tire flat	276 kPa (40 psi)
LR	8 mm (10/32 in)	207 kPa (30 psi)	276 kPa (40 psi)
RF	9 mm (11/32 in)	241 kPa (35 psi)	276 kPa (40 psi)
RR	8 mm (10/32 in)	241 kPa (35 psi)	276 kPa (40 psi)

The front seating positions in the 2003 GMC Safari were equipped with fabric covered bucket seats with integral head rests. The second and third rows were equipped with fabric covered removable bench seats.

VEHICLE DAMAGE

Exterior Damage - 2003 GMC Safari

Damage Description:	Moderate front end damage to bumper, grille, radiator and hood. Bumper slightly shifted to left. Towed from the scene due to damage.	
CDC:	12FLWN3 (Event 1) 12FDEW2 (Event 2)	
Delta V:	Total	20.0 km/h (12.4 mph)
	Longitudinal	-19.7 km/h (-12.2 mph)
	Latitudinal	-3.5 km/h (-2.2 mph)
	Energy	32,376 joules (23,879 ft-lbs)

During impact 1 with the concrete wall, the case vehicle sustained 170 cm (67 in) of direct and induced contact damage that extended across the entire frontal end width of the vehicle. The impact energy was managed by the forward structures of the vehicle. The damaged components included the bumper fascia and reinforcement bar, upper and lower radiator supports, the grille area, and the hood. Six crush measurements were documented at the bumper level: Cl= 19 cm (8 in), C2= 18 cm (7 in), C3= 16 cm (6 in), C4= 12 cm (5 in), C5= 2 cm (1 in), C6= 0 cm (0 in). A Collision Deformation Classification of 12FDEW2 was assigned to the damage. The principal direction of force was within the 12 o'clock sector and was an estimated 10 degrees. There was no reduction of the right side wheelbase, but there was a reduction of the left side wheelbase which measured 9 cm (4 in). All doors remained closed and operational, and there was no glazing damage.

Figure 4. Frontal damage to case vehicle

Figure 5. Damage to front left tire

Interior Damage - 2003 GMC Safari

Interior damage to the 2003 GMC Safari was minimal and was attributed to occupant contacts and the air bag deployments. The plastic cover beneath the left instrument panel was dislodged by the driver's knees. The left lower air vent was pushed into the instrument panel by the driver's knee. Both front air bags deployed.

Figure 6. Driver's seat area

MANUAL RESTRAINT SYSTEMS - 2003 GMC Safari

The driver's manual restraint system consisted of a continuous loop 3-point lap and shoulder safety belt with the sliding latch plate and an adjustable shoulder belt upper anchorage (full up position). The emergency locking retractor was located in the B-pillar. The front right seat was equipped with 3-point manual lap and shoulder safety belt which consisted of continuous loop belt webbing with a sliding latch plate and switchable automatic/emergency locking retractor. The two rear bench seat outboard positions were equipped with 3-point lap and shoulder safety belts which consisted of continuous loop belt webbing with a locking latch plate and emergency locking retractors. The two rear bench middle positions were equipped with manual 2-point lap safety belt which consisted of continuous loop belt webbing with a locking latch plate. Only the driver's restraint exhibited evidence of historical use in the form of minor scratching to the latch plate. Faint frictional abrasions were identified on the latch plate's plastic surface, but are not associated to with this deployment event. As indicated earlier, the Deployment Event recorded by SDM reports that the driver's belt switch circuit status was "UNBUCKLED". The instrument panel (knee bolster covering) was uniformly deformed by contact with both of the driver's knees, a good indication that the driver was not wearing the lap and shoulder safety belt.

Figure 7. Knee bolster contacts

FRONTAL AIR BAG SYSTEM - 2003 GMC Safari

The case vehicle was equipped with redesigned (reduced force) driver and front right passenger air bags. The driver air bag module was located in the center hub of the steering wheel rim with a vertically oriented flap tear seam (I-configuration). The diameter of the deflated circular air bag was 62 cm (24 in). It was equipped with two internal tether straps and had two vent ports (11 and 01 o'clock positions). The maximum deflated air bag excursion measured approximately 20 cm (8 in). There were no indications of any damage to driver's air bag or the module cover flaps. On the face of the lower right quadrant of the air bag, there were vinyl transfers to the membrane from expansion within the module. There were nine horizontal folds and seven vertical folds. There was no occupant contact evidence on the air bag.

Figure 8. Driver's air bag

Figure 9. Front right passenger's air bag

The front right passenger air bag was a mid instrument panel mount with dual symmetrical module cover flaps. The deflated air bag was rectangular in shape with a height of approximately 53 cm (21 in) and a width of approximately 56 cm (22 in). The maximum deflated air bag excursion measured approximately 53 cm (21 in). The air bag was untethered and had two vent ports (02 and 10 o'clock positions). There were no indications of any damage to front right passenger air bag or the dual module cover flaps. There was faint evidence of vinyl transfer to the membrane from expansion within the module to the middle face of the air bag. There were six vertical folds on the air bag face.

The air bag system is controlled by the SDM. The system records the vehicle's forward velocity change. The SDM will record 100 milliseconds of data after the deployment criteria is met and up to 50 milliseconds of data before deployment criteria is met. The SDM will also record 150 milliseconds of data after non-deployment criteria is met.

The SDM data was downloaded using the Vetronix Crash Data Retrieval System. Two events were recorded by the SDM; a deployment and non-deployment event.

System Status at <u>deployment</u> indicates that:

1. The SIR warning lamp status was OFF.
2. The driver's belt switch circuit status was UNBUCKLED.
3. Passenger front air bag suppression switch circuit status: air bag was not suppressed.
4. Ignition cycles at deployment were 385.
5. Ignition cycles at investigation were 390.
6. Maximum SDM recorded velocity change was -30.07 km/h (-18.69 mph).
7. Algorithm enable (AE) to maximum SDM recorded velocity change was 115 milliseconds.
8. Time between non-deployment and deployment events (sec): N/A
9. Time from AE to deployment command criteria met 22.5 milliseconds.
10. The brake switch circuit status was OFF five and four seconds before AE. At three through one second before AE the brake switch circuit status was ON.
11. The pre-crash data indicated that at a point five seconds before AE the case vehicle was traveling at 58 km/h (36 mph) and at four seconds prior to AE had accelerated to 77 km/h (48 mph). This would indicate an unrealistic acceleration rate of 17.38 f/s/s for the vehicle[3]. One possible explanation for the discrepancy might be wheel slippage as the vehicle entered the wet curve.
12. The pre-crash data also indicated that the vehicle decelerated to 61 km/h (38 mph) three seconds before AE, to 53 km/h (33 mph) two seconds before AE, and 35 km/h (22 km/h) one second before AE. These numbers appear realistic and conform with the crash events.

System Status at <u>non-deployment</u>[4] indicates that:

1. The SIR warning lamp status was OFF.
2. The driver's belt switch circuit status was BUCKLED.
3. Passenger front air bag suppression switch circuit status: air bag was not suppressed.
4. Ignition cycles at non-deployment were 141.
5. Ignition cycles at investigation were 390 (249 ignition cycles from non-deployment ignition cycles) .
6. Maximum SDM recorded velocity change was -1.07 km/h (-0.67 mph).
7. Algorithm enable (AE) to maximum SDM recorded velocity change was 55 milliseconds.

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[3]See Attachment 3. Calculations

[4] The recorded non-deployment event is not associated with the recorded deployment event. There is a difference of 244 between ignition cycles at deployment and non-deployment events.

OCCUPANT DEMOGRAPHICS - 2003 GMC Safari

	Driver
Age/Sex:	27/Male
Seated Position:	Front left
Seat Type:	Fabric covered bucket seat. Seat adjusted to between middle and rear most track position. Seat back slightly reclined.
Height:	Unknown
Weight:	Unknown
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Presumed to be normal, upright
Hand Position:	Unknown
Foot Position:	Right foot on brake, left on floor
Restraint Usage:	Lap and shoulder belt available, not used
Air bag:	Steering wheel mounted air bag, deployed

OCCUPANT INJURIES - 2003 GMC Safari

	Injury	OIC Code	Injury Mechanism	Confidence Level
Driver:	Not injured			

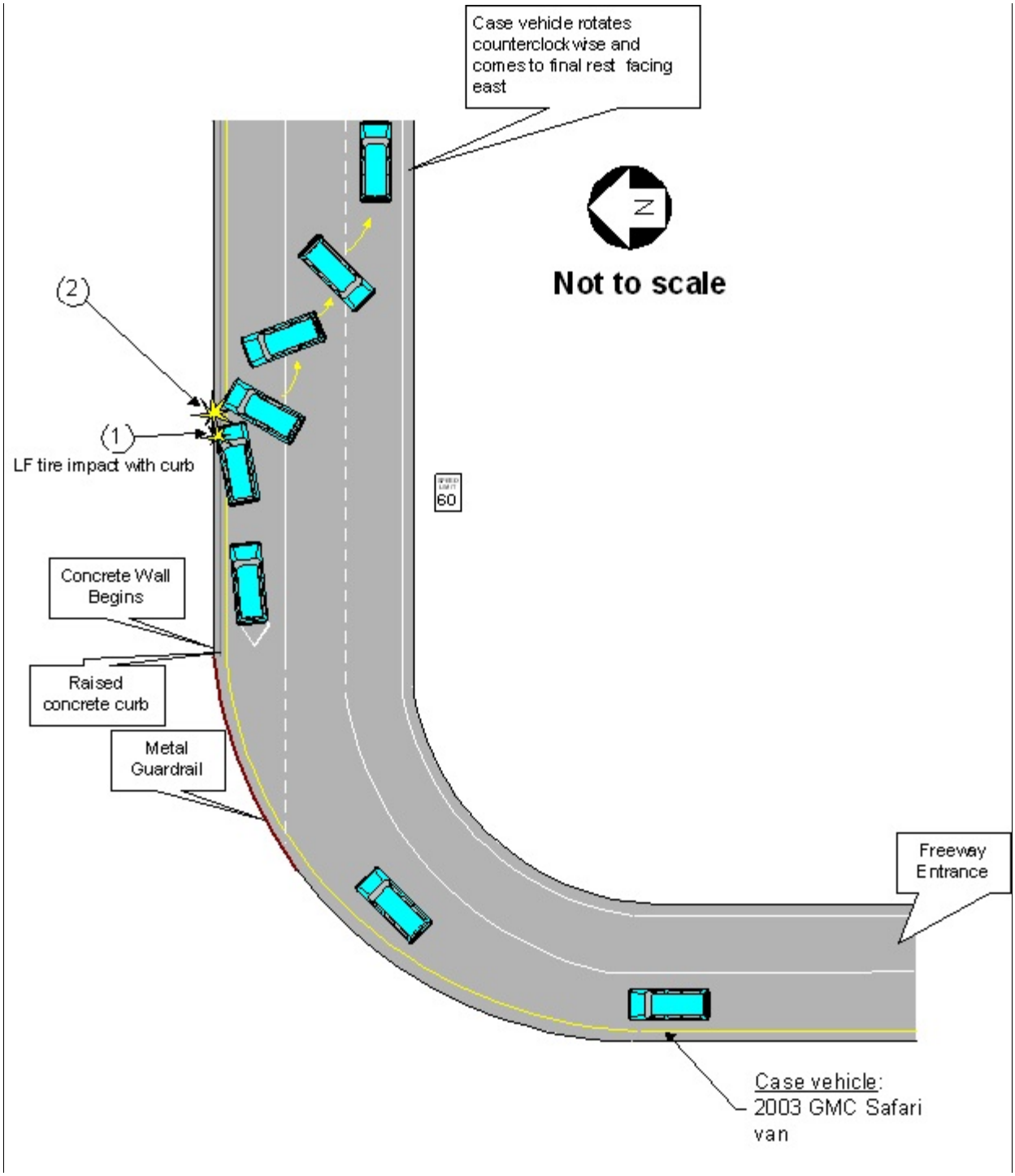
OCCUPANT KINEMATICS - 2003 GMC Safari

The driver was seated in a fabric covered bucket seat that was adjusted to between the middle and rear most track position (26 cm/10.2 in forward of A pillar) with a seat back slightly reclined aft of vertical. The driver's manual restraint system consisted of a continuous loop 3-point lap and shoulder safety belt with the sliding latch plate and an adjustable shoulder belt upper anchorage (full up position). The seat belt was not being used at the time of the crash. The driver was actively steering the vehicle and his right foot was likely on the brake. The vehicle was being steered to the right and the driver would have likely shifted somewhat to the left. At impact with the concrete wall, the driver pitched forward and to the right in response to the 12 o'clock direction of force. The driver's torso and head likely engaged the deployed air bag. There were no indications of contact to the air bag. The driver slid forward and both knees engaged the lower instrument panel. The instrument panel was displaced. The driver did not report any injuries. The police report indicated that the driver was not injured.

Figure 10. Close up of left knee contact

Figure 11. Driver's air bag and right knee contact

Attachment 1 - Scene Diagram



Attachment 2 - Vetronix Report

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM

Vehicle Identification Number	1GKDM19X63Bxxxxx
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	DS02-029.CDR
Saved on	11/25/02 10:49:36 AM
Data check information	447B39EE
Collected with CDR version	Crash Data Retrieval Tool 1.670
Collecting program verification number	4209D064
Reported with CDR version	Crash Data Retrieval Tool 1.680
Reporting program verification number	337F4D2C
Event(s) recovered	Deployment 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. 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.
-Some of the Pre-Crash data, from the Deployment file, may be recorded after algorithm enable, if the Deployment event has a long crash pulse.
-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.
-Passenger Front Air Bag Suppression Switch Circuit Status indicates the status of the suppression switch circuit.
-The Time Between Non-Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than five 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.

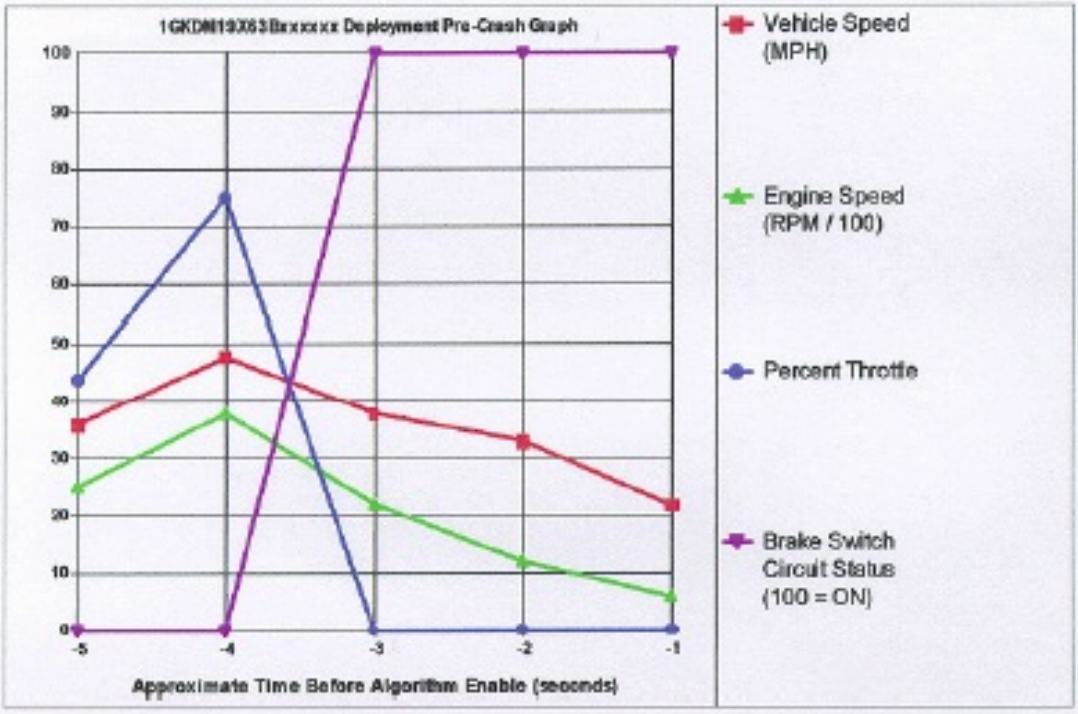
SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the Class 2 data link, to the SDM.
-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the Class 2 data link, to the SDM. Depending on vehicle option content, the Brake Switch Circuit Status data may not be available.
-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.
-The Passenger Front Air Bag Suppression Switch Circuit is wired directly to the SDM.

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Deployment	385
Ignition Cycles At Investigation	390
Maximum SDM Recorded Velocity Change (MPH)	-18.69
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	115
Time Between Non-Deployment And Deployment Events (sec)	N/A
Time From Algorithm Enable to Deployment Command Criteria Met (msec)	22.5



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	36	2496	44	OFF
-4	48	3776	75	OFF
-3	38	2240	0	ON
-2	33	1152	0	ON
-1	22	640	0	ON

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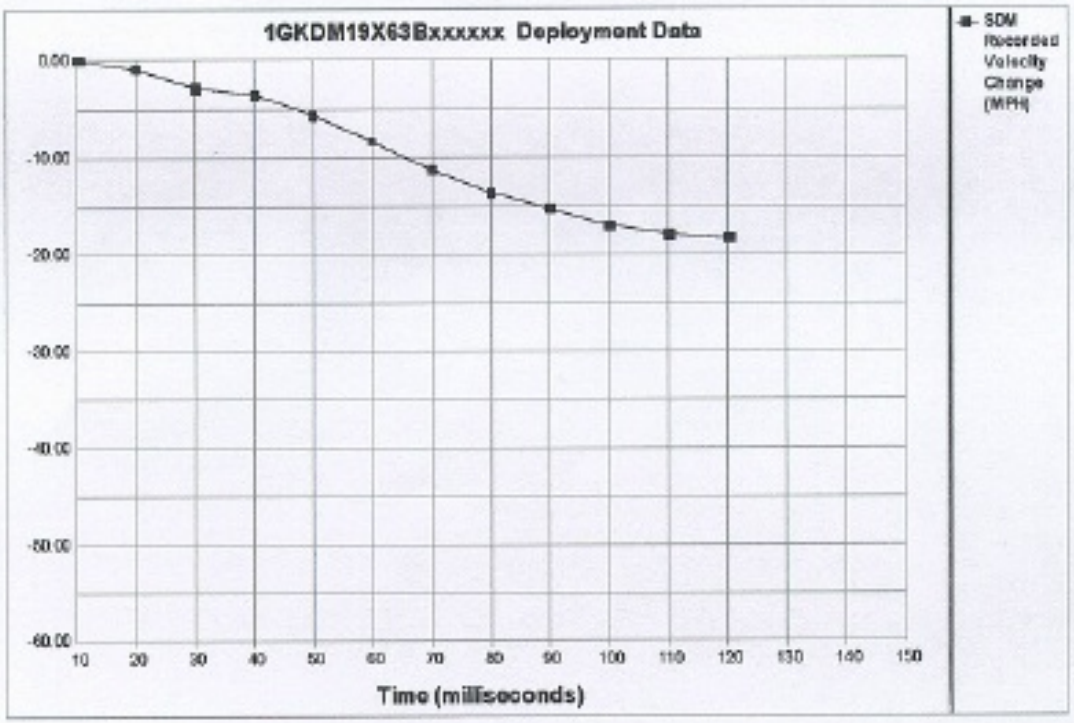
CDR CRASH DATA RETRIEVAL SYSTEM

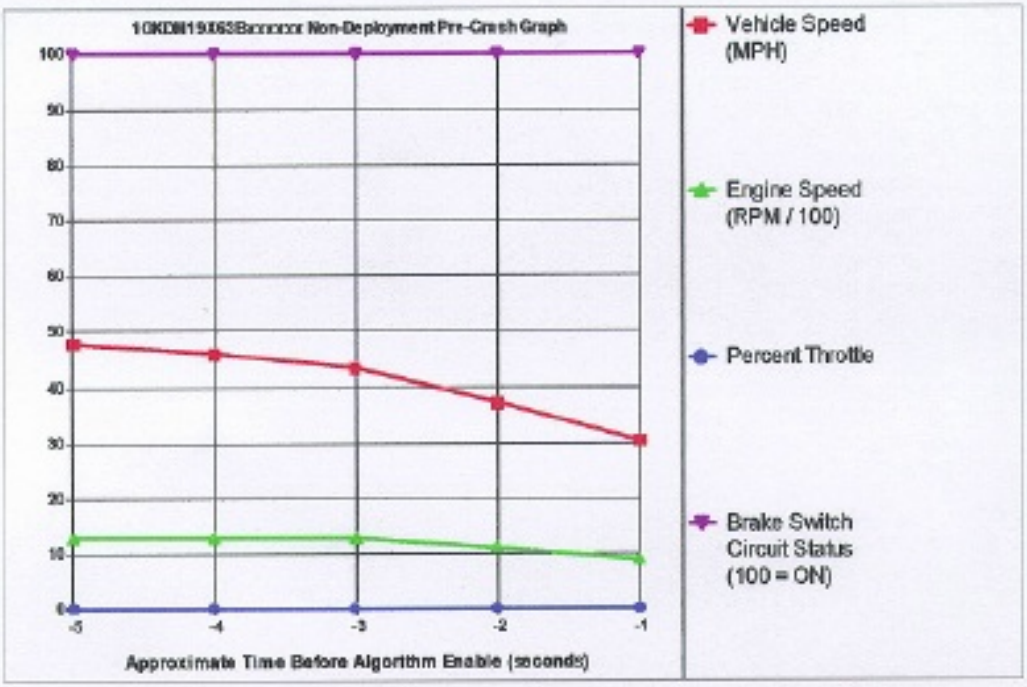


Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Recorded Velocity Change	0.00	-0.88	-2.65	-5.51	-8.75	-8.54	-11.41	-13.60	-15.38	-17.11	-17.89	-18.43	N/A	N/A	N/A

Vetronix CDR CRASH DATA RETRIEVAL SYSTEM

System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Non-Deployment	141
Ignition Cycles At Investigation	390
Maximum SDM Recorded Velocity Change (MPH)	-0.67
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	55



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	48	1344	0	ON
-4	46	1344	0	ON
-3	44	1280	0	ON
-2	37	1088	0	ON
-1	30	896	0	ON

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Recorded Velocity Change	0.00	0.00	0.00	0.00	-0.44	-0.44	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM

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  08 23 00 00
$02  94 CA
$03  41 53 32 31 39 32
$04  4B 33 34 46 41 31
$05  00
$06  15 07 12 42
$10  FF CF C0
$11  86 89 89 7B 8F 00
$14  03 84 34 80
$18  81 80 81 B5 FF 00
$1C  FA FA FA FA FA FA
$1D  FA FA FA FA FA FA
$1E  FA FA
$1F  FF 02 00 00 00
$20  A0 00 00 FF 11 F8
$21  FF FF FF FF FF FF
$22  FF FF FF FF FF FF
$23  FF 00 00 31 01 00
$24  00 00 00 01 01 FF
$25  FF FF FF FF FF FF
$26  FF FF 06 31 3C 46
$27  4A 4D 00 FE 00 00
$28  00 00 00 00 00 0E
$29  11 14 15 15 00 FF
$2A  EB E0 FC 00 01 00
$2B  02 FF FF 74 00 00
$2C  00 00 00 00
$2D  16 03 01 00
$30  A0 00 00 FF 2F 80
$31  FF BF FF FF FF FF
$32  FF FF FF FF FF FF
$33  7C 0E 03 00 00 02
$34  06 08 0D 13 1A 1F
$35  23 27 29 2A FF FF
$36  FF 0C 58 05 54 23
$37  35 3D 4D 3A 00 E0
$38  00 00 00 00 C0 70
$39  00 0A 12 23 3B 27
$3A  00 FF CF FE 00 00
$3B  00 40 00
$3C  09 2E 58 2E
$40  FF FF FF FF FF FF
$41  FF FF FF FF FF FF
$42  FF FF FF FF FF FF
$43  FF
```

Attachment 3. Calculations

CASE NUMBER: DS02029

Comments: 5 sec before AE to 4 sec before AE

**** ACCEL/DRAG FACTOR W/ LOWER TO HIGHER SPEED, KNOWN TIME ****

$$f = \frac{0.0455 \times (Sf - So)}{t}$$

$$f = \frac{0.0455 \times (48.00 - 36.00)}{1.00}$$

$$f = \frac{0.0455 \times 12.00}{1.00}$$

$$f = \frac{0.54}{1.00}$$

$$f = 0.54$$

f = The Acceleration/Drag Factor.
0.0455 = A Constant.
So = The Original Speed in MPH.
Sf = The Final Speed in MPH.
t = The Time in Seconds.

INPUTS:	
The Original Speed in MPH is:	36.00
The Final Speed in MPH is:	48.00
The Time in Seconds is:	1.00

RESULTS:	
The Acceleration/Drag Factor is:	0.54

CASE NUMBER: DS02029

Comments: acceleration rate

**** ACCELERATION RATE ****

$a = 32.2 \times f$
$a = 32.2 \times 0.54$
$a = 17.38$

a = The Acceleration Rate.
32.2 = A Constant.
f = The Acceleration/Drag Factor.

INPUTS:	
The Acceleration/Drag Factor is:	0.54

RESULTS:	
The Acceleration Rate is:	17.38