

Rollover Investigation / Vehicle rollover
Dynamic Science, Inc. / Case Number: 2006-78-069A
2005 Cadillac SRX
Arizona
July 2006

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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 combination on-site/off-site investigation focused on the performance of a 2005 Cadillac SRX involved in a rollover crash. This single vehicle crash occurred in June 2006 at 0755 hours. The Cadillac was occupied by a 78-year-old male driver. The driver was wearing the manual 3-point lap and shoulder belt. The Cadillac was traveling westbound at an EDR reported speed of 137 km/h (85 mph). For unknown reasons, the case vehicle drifted off the left side of the roadway onto the dirt shoulder. The driver then began braking and steering right back onto the roadway. The vehicle began a clockwise yaw. The vehicle re-entered the roadway while continuing the clockwise yaw. The vehicle crossed both westbound travel lanes and then the northern shoulder. It appears that the driver over-corrected by steering back to the left. The vehicle went into a counterclockwise yaw while on the roadside. The right side tires dug into the soil and the vehicle tripped and began a right side leading rollover. It appears that the vehicle completed at least eight quarter turns before coming to rest on its wheels facing south. The first responder, a law enforcement officer, found the driver sitting upright in the driver's seat still wearing the manual lap and shoulder belt. The driver was non responsive. Efforts to locate a pulse were not successful. Medical staff removed the driver from the vehicle and attempted to revive him. At approximately 0823 hours a paramedic pronounced the driver dead.				
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Dynamic Science, Inc.
Crash Investigation
Case Number: 2006-78-069A

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BACKGROUND

This combination on-site/off-site investigation focused on the performance of a 2005 Cadillac SRX involved in a rollover crash. This single vehicle crash occurred in June 2006 at 0755 hours. The Cadillac was occupied by a 78-year-old male driver. The driver was wearing the manual 3-point lap and shoulder belt. The Cadillac was traveling westbound at an EDR reported speed of 137 km/h (85 mph). For unknown reasons, the case vehicle drifted off the left side of the roadway onto the dirt shoulder. The driver then began braking and steering right back onto the roadway. The vehicle began a clockwise yaw. The vehicle re-entered the roadway while continuing the clockwise yaw. The vehicle crossed both westbound travel lanes and then the northern shoulder. It appears that the driver over-corrected by steering back to the left. The vehicle went into a counterclockwise yaw while on the roadside. The right side tires dug into the soil and the vehicle tripped and began a right side leading rollover. It appears that the vehicle completed at least eight quarter turns before coming to rest on its wheels facing south. The first responder, a law enforcement officer, found the driver sitting upright in the driver's seat still wearing the manual lap and shoulder belt. The driver was non responsive. Efforts to locate a pulse were not successful. Medical staff removed the driver from the vehicle and attempted to revive him. At approximately 0823 hours a paramedic pronounced the driver dead.



Figure 1. 2005 Cadillac SRX



Figure 2. 2005 Cadillac SRX, exemplar view

This case was identified by the local National Automotive Sampling System (NASS) team. This is a selected National Motor Vehicle Crash Causation Survey (NMVCCS) case. DSI was assigned the case on July 27, 2006 via an email message. The scene work was completed by the NASS team. The case vehicle was moved from Arizona to California. DSI inspected the case vehicle and downloaded data from the electronic data recorder on August 4, 2006. Information from the inspection and download were forwarded to the NASS Zone Center.

SUMMARY

Crash Site

This single vehicle crash occurred in June 2006 at 0755 hours in the state of Arizona. The crash occurred on an interstate highway. The east/west highway was configured with two lanes in each direction. The lanes were separated by a depressed median that was landscaped with

natural desert terrain. The westbound travel lanes were separated by broken painted white lines. The westbound lanes were of asphalt construction and were bordered to the north by a paved shoulder followed by natural desert terrain. There is a slight left hand curve and a 2.4% down grade. There were no reported defects or debris in the roadway at the time of the crash. The crash occurred during daylight hours and the weather was clear. The posted speed limit is 121 km/h (75 mph).

Pre-Crash

The Cadillac was traveling westbound at an EDR reported speed of 137 km/h (85 mph). The driver was likely using the cruise control¹. The driver was suffering from depression. He was taking Zoloft² for the depression. Apparently his wife and brother had recently died. According to the police supplemental report, his wife's remains were in a green bag in the vehicle. For unknown reasons, the case vehicle drifted off the left side of the roadway onto the dirt shoulder. The Cadillac continued traveling westbound on the dirt shoulder for approximately 61 m (199 ft). The driver then began braking and steering right back onto the roadway. The DSI calculated speed at the beginning of braking was 132 km/h (82.0 mph)—see Attachment 3. The EDR report indicated that the driver began braking four seconds before algorithm enable. The vehicle began a clockwise yaw. The vehicle re-entered the roadway while continuing the clockwise yaw. The vehicle crossed both westbound travel lanes and then the northern shoulder. According to the police, the driver had applied the brakes, activating the ABS system (indicated by ghost³ skid marks crossing the white fog line). It appears that the driver over-corrected by steering sharply back to the left. It appears that the front end of the Cadillac struck a reflective delineator with its front end. The vehicle went into a counterclockwise yaw while on the roadside.



Figure 3. Path of vehicle as it crosses roadway



Figure 4. Vehicle path as it departs roadway toward trip point

¹EDR reported 0 percent throttle

²Zoloft® (sertraline HCl) is a type of antidepressant known as a selective serotonin reuptake inhibitor (SSRI). It's approved to treat depression, social anxiety disorder, posttraumatic stress disorder (PTSD), panic disorder, obsessive-compulsive disorder (OCD), and premenstrual dysphoric disorder (PMDD) in adults over age 18. Per www.zoloft.com web site.

³Light skid marks that are barely discernible due to ABS operation

According to the EDR, the vehicle had decelerated to 43 km/h (27 mph) 1 second before algorithm enable.

Crash

The right side tires dug into the soil and the vehicle tripped and began a right side leading rollover. It appears that the vehicle completed at least eight quarter turns⁴ before coming to rest on its wheels facing south.

Post-Crash

The Cadillac came to rest off road on the north side of the roadway on its wheel facing south. The driver's door had come open during the rollover. The first responder, a law enforcement officer, found the driver sitting upright in the driver's seat still wearing the manual lap and shoulder belt. The driver was non responsive. Efforts to locate a pulse were not successful. An ambulance was dispatched at 0756 hours and arrived on scene at 0810 hours. The first responder entered the right door and noted that the driver had a 12.7 cm (5.0 in) long by 7.6 cm (3.0 in) gash across the top right of the driver's head, exposing the skull. Medical staff removed the driver from the vehicle and attempted to revive him. At approximately 0823 hours a paramedic pronounced the driver dead. No autopsy was conducted, only a death certificate. The ambulance was cleared from the scene at 0851 hours.

The Cadillac was towed from the scene due to damage. It was originally located near the border between Arizona and California. Eventually, it was moved a second location in California where it was declared a total loss by the insurance company.



Figure 5. Vehicle final rest



Figure 6. Vehicle final rest

⁴Based on the distance traveled and scratches in two directions to the vehicle exterior

VEHICLE DATA - 2005 Cadillac SRX

The 2005 Cadillac SRX five door sport utility vehicle was identified by the Vehicle Identification Number (VIN): 1GYEE637050xxxxxx. The vehicle mileage at the time of inspection was 31,220 km (19,399 miles). The Cadillac was equipped a 3.6 liter six cylinder engine, a five speed automatic transmission, rear wheel drive, power/speed sensitive steering, four wheel disc brakes, and a tilt steering column. SRX comes standard with anti-lock brakes, traction control, Panic Brake Assist to help during emergency braking and Dynamic Rear Brake Proportioning to regulate brake pressure for improved stopping. It was also equipped with StabiliTrak, an active handling system designed to keep the SRX under the driver's control on wet, snowy and icy surfaces, in tight turns, and in evasive maneuvers. The static stability factor for this vehicle is not known (not tested).

The 2005 Cadillac SRX was equipped with Goodyear Eagle RS-A P255/60R17 tires. The vehicle manufacturer's recommended tire pressure was 303 kPa (44 psi). The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	179 kPa (26 psi)	5.5 mm (7/32 in)	Yes	None
LR	186 k Pa (27 psi)	4.8 mm (6/32 in)	No	Grass between rim and tire
RR	Flat	3.9 mm (5/32 in)	No	Flat
RF	Flat	6.4 mm (8/32 i)	No	Flat

The front seating positions in the 2005 Cadillac SRX were configured with leather covered front bucket seats with adjustable head rests and a rear 60/40 split bench seat. The driver's seat bottom face was located 53.0 cm (20.9 in) rear of the A pillar. The seat back angle was 20 degrees from the vertical, the seat bottom angle was 21 degrees from the horizontal. The front right passenger seat bottom face was located 53.0 cm (20.9 in) rear of the A pillar. The seat back angle was 25 degrees from the vertical and the bottom angle was 10 degrees from the horizontal. The rear seat back angle was 71 degrees from the vertical and the seat bottom angle was 12.5 degrees from the horizontal.



Figure 7. Front, 2005 Cadillac SRX

VEHICLE DAMAGE

Exterior Damage - 2005 Cadillac SRX

The 2005 Cadillac SRX sustained moderate rollover damage to the top, right and left side planes. Measurements were taken at each pillar location and referenced to a ground measurement. The following table lists the crush at each pillar location:

	Left	Right
A	16.0 cm (6.3 in)	17.0 cm (6.7 in)
B	14.0 cm (5.5 in)	7.0 cm (2.8 in)
C	17.0 cm (6.7 in)	11.0 cm (4.3 in)
D	20.0 cm (7.9 in)	35.0 cm (13.8 in)

The maximum crush (forward of the C pillar) was located at the left B pillar and measured 17.0 cm (6.7 in) vertically and 7.0 cm (2.8 in).

There was 98.0 cm (38.6 in) of lateral direct damage to the hood. The direct damage extended 123.0 cm (48.4 in) longitudinally along the hood, then into the windshield, and then extended rearward 230.0 cm (90.5 in) to the rear of the vehicle. The Collision Deformation Classification (CDC) for the rollover event was 00-TDDO-3.

There was also minor contact damage to the left front bumper area from the impact with the delineator.

The driver's door came open during the crash sequence. It was further damaged as the open door came into contact with the ground during the rollover. According to on-scene investigators, the front right door also came open during the crash sequence. Both rear doors were jammed shut. The tail gate was also jammed shut. All the tempered glazing at all locations disintegrated during the rollover. The windshield was cracked and holed. Both right side tires were deboned and flat.



Figure 8. Crush at left B pillar



Figure 9. Overview of roof damage

There was blood found along the left side B pillar; blood and hair were found along the interior portion of the driver's side roof rail. The left front door latch striker plate sustained minor loading damage to the inner side of the post.

Interior Damage - 2005 Cadillac SRX

The 2005 Cadillac sustained moderate interior damage as a result of passenger compartment intrusion and occupant contacts. The right and left pillars and roof rails sustained vertical intrusion. The driver's seat headrest was deformed from contact with the left roof rail. There was blood on the headrest, on the left seat back and on the right seat back. Both sides of the driver's seat belt were blood covered.



Figure 10. Door latch striker plate



Figure 11. Door latch



Figure 12. Driver's seat back/head restraint

The specific passenger compartment intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
LF	A pillar	4.0 cm (1.6 in)	Vertical
LF	Roof rail	1.0 cm (0.4 in)	Vertical
LF	B pillar	33.0 cm (13.0 in)	Lateral
LF	Roof	7.0 cm (2.8 in)	Vertical
LR	Roof	7.0 cm (2.8 in)	Vertical
LR	C pillar	18.0 cm (7.1 in)	Vertical
RF	A pillar	9.0 cm (3.5 in)	Vertical
RR	Roof rail	12.0 cm (4.7 in)	Vertical
RR	C pillar	6.0 cm (2.4 in)	Vertical
LF	Side curtain cladding	3.0 cm (1.2 in)	Vertical
RF	Side curtain cladding	4.0 cm (1.6 in)	Vertical
LR	Side curtain cladding	6.0 cm (2.4 in)	Vertical
RR	Side curtain cladding	10.0 cm (3.9 in)	Vertical

MANUAL RESTRAINT SYSTEMS - 2005 Cadillac SRX

The 2005 Cadillac SRX was equipped with integral manual 3-point lap and shoulder belts for both front seat positions and all three second row seat positions. The front seat belts were equipped with buckle pretensioners that did not actuate.

The driver's safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). The driver's belt showed evidence of historical usage and loading. There was blood found on both sides of the belt indicating that the belt was in use at the time of crash. The blood was located 37.0 cm (14.6 in) from the stop button and measured 53.0 cm (20.9 in) in length.



Figure 13. Driver's seat belt

The remaining safety belts were configured with sliding latch plates and switchable ELR/Automatic Locking Retractors (ALR). The second row outboard seating positions were equipped with the lower anchor and tether points that are part of this vehicle's Lower Anchors and Tethers for Children (LATCH) system.

Supplemental Restraint System - 2005 Cadillac SRX

The 2005 Cadillac SRX was configured with dual stage frontal air bags and buckle pretensioners for the driver and front right passenger positions. The Cadillac was also equipped with seat back mounted side air bags for the front seat passengers and roof-mounted side curtain air bags that cover the first and second rows of seats. There were no air bag deployments and no pretensioner actuations.

The advanced occupant protection system consists of the SDM, dual-level (dual stage) driver and front right passenger air bags, and a driver's seat belt latch usage detector. The system is controlled by the Sensing and Diagnostic Module (SDM). The primary function of the SDM is to control the deployment of the occupant protection systems. The system records the vehicle's forward velocity change. For Deployment Events 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-Deployment Events, the SDM will record the first 150 milliseconds of data after algorithm enable.

A single Non-Deployment Event was recorded by the SDM. The Non-Deployment Event occurred during the rollover sequence. The Vetronix system status at non-deployment report indicates that:

1. SIR warning lamp status was OFF.
2. The driver's belt switch status was BUCKLED.
3. Ignition cycles at deployment 2215.
4. Ignition cycles at investigation 2217.
5. Maximum SDM recorded velocity change was -11.5 km/h (-7.18 mph) at 150 milliseconds.
6. Algorithm enable to maximum SDM record velocity change was 107.5 milliseconds.
7. The crash record was not locked, there were multiple events associated with this record and there were one or more associated events not recorded.
8. Event recording complete YES.
9. The vehicle speed was 137 km/h (85 mph) 5 seconds before Algorithm Enable (AE) and decelerated to 43.4 km/h (27 mph) at 1 second before AE.
10. The brake switch status was ON from 4 through 1 second before AE.

OCCUPANT DEMOGRAPHICS - 2005 Cadillac SRX

	Occupant 1
Age/Sex:	78/Male
Seated Position:	Front left
Seat Type:	Leather covered bucket seat. Seat at rear most track position.
Height:	188 cm (74 in)
Weight:	100 kg (220 lbs)
Occupation:	Retired
Pre-existing Medical Condition:	Taking Zoloft (sertraline hydrochloride) for depression and Lipitor (atorvastatin calcium) for high cholesterol.
Alcohol/Drug Involvement:	None noted
Driving Experience:	Unknown
Body Posture:	Upright
Hand Position:	Unknown, actively steering
Foot Position:	Right foot presumed to be on brake based on scene evidence and EDR readout
Restraint Usage:	Lap and shoulder belt available, used
Air bag:	Driver's steering wheel mounted air bag available, did not deploy. Side curtain available, did not deploy. Seat back mounted side air bag, did not deploy.

OCCUPANT INJURIES -2005 Cadillac SRX

Driver: Injuries obtained from death certificate and observation of EMS personnel.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Closed head injury (died without further evaluation; no autopsy)	115099.7,0	Left side rail	Possible
The first responder noted that the driver had a 12.7 cm (5.0 in) long by 7.6 cm (3.0 in) gash across the top right of the driver's head, exposing the skull.	Not codeable		

OCCUPANT KINEMATICS - 2005 Cadillac SRX

Driver Kinematics

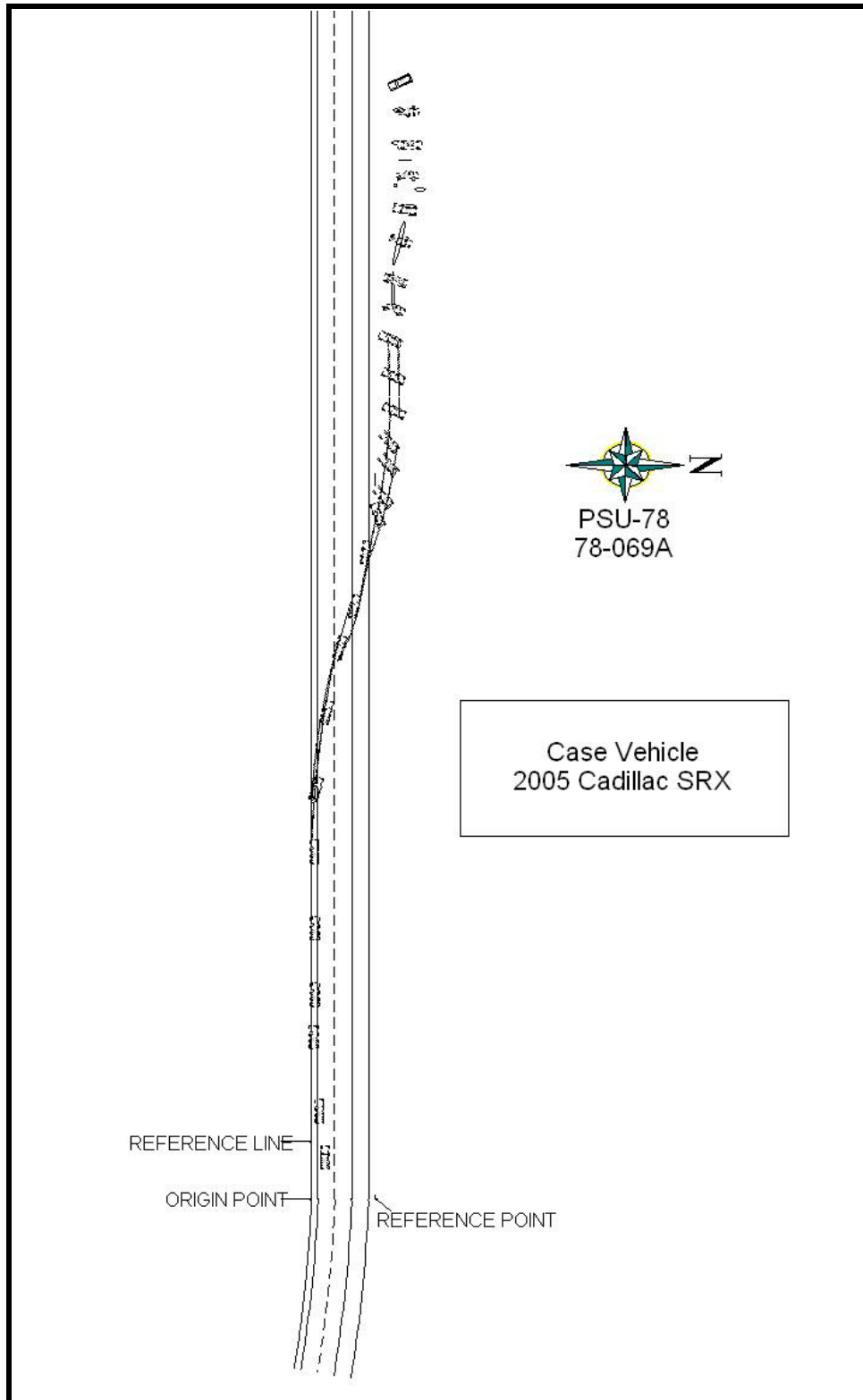
The 78-year-old driver was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt. The leather covered bucket seat was adjusted to the rear most track position. The driver's seat bottom face was located 53.0 cm (20.9 in) rear of the A pillar. The seat back angle was 20 degrees from vertical, the seat bottom angle was 21 degrees. The cruise control was likely on. The case vehicle had drifted off the left side of the roadway. The EDR report indicated that the driver began braking four seconds before algorithm enable. The driver began actively steering to the right. The vehicle began a clockwise yaw. The vehicle re-entered the roadway while continuing the clockwise yaw. The vehicle crossed both westbound travel lanes and then the northern shoulder.



Figure 14. Left front roof rail contact

As the vehicle traveled off the roadway, the driver over-corrected by steering sharply back to the left. The vehicle went into a counterclockwise yaw while on the roadside. The driver likely pitched laterally to the right at this point. The right side tires dug into the soil and the vehicle tripped and began a right side leading rollover. At some point during the rollover, the driver's door came open and the driver was partially ejected. The driver's head came into contact with the left side roof rail and probably the ground. The first responder, a law enforcement officer, found the driver sitting upright in the driver's seat still wearing the manual lap and shoulder belt. The driver was non responsive. Efforts to locate a pulse were not successful. The first responder entered the right door and noted that the driver had a 12.7 cm (5.0 in) long by 7.6 cm (3.0 in) gash across the top right of the driver's head, exposing the skull. An ambulance arrived shortly after the crash. Medical staff removed the driver from the vehicle and attempted to revive him. At approximately 0823 hours a paramedic pronounced the driver dead.

Attachment 1. Scene Diagram



Attachment 2. Vetronix Readout



CDR File Information

Vehicle Identification Number	1GYEE637050*****
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	069A W O VIN.CDR
Saved on	Monday, July 31 2006 at 09:16:18 AM
Collected with CDR version	Crash Data Retrieval Tool 2.800
Collecting program verification number	9238B95E
Reported with CDR version	Crash Data Retrieval Tool 2.800
Reporting program verification number	9238B95E
Interface used to collected data	Block number: 00 Interface version: 4A Date: 11-08-05 Checksum: 7500
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 25.4 seconds of one another. Deployment Events cannot 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 Event file will be locked after a Deployment Event, if the Non-Deployment Event occurred within 5 seconds before the Deployment Event. If multiple Non-Deployment Events occur within 5 seconds prior to a Deployment Event, then the most severe Non-Deployment Event will be recorded and locked. If multiple Non-Deployment Events precede a Deployment Event, and multiple Non-Deployment Events occur within 5 seconds of each other (but not necessarily all within 5 seconds of the Deployment Event), and subsequent Non-Deployment Events are less severe than prior Non-Deployment Events, and the last of the multiple Non-Deployment Events occurs within 5 seconds of a Deployment Event, then the most severe of the Non-Deployment Events (which may have occurred more than 5 seconds prior to the Deployment Event) will be recorded and locked.

SDM Data Limitations:

-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 Deployment Events 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-Deployment Events, 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 receive an invalid message from the module sending the pre-crash data.

-Driver's and Passenger's Belt Switch Circuit Status indicates the status of the seat belt switch circuit. If the vehicle's electrical system is compromised during a crash, the state of the Belt Switch Circuit may be reported other than the actual state.

-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.

-Multiple Events Associated with this Record: This parameter will indicate whether one or more associated events preceded the recorded event.

-One or More Associated Events Not Recorded: If a single event is recorded, this parameter will indicate whether one or more associated events, prior to the recorded event, was not recorded.

If two associated events are recorded, this parameter for the first event will indicate whether one or more associated events, prior to the first event, was not recorded.

If two associated events are recorded, this parameter, for the second event, will indicate whether one or more associated



events, between the first and second events, was not 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 vehicle's communication network, to the SDM.

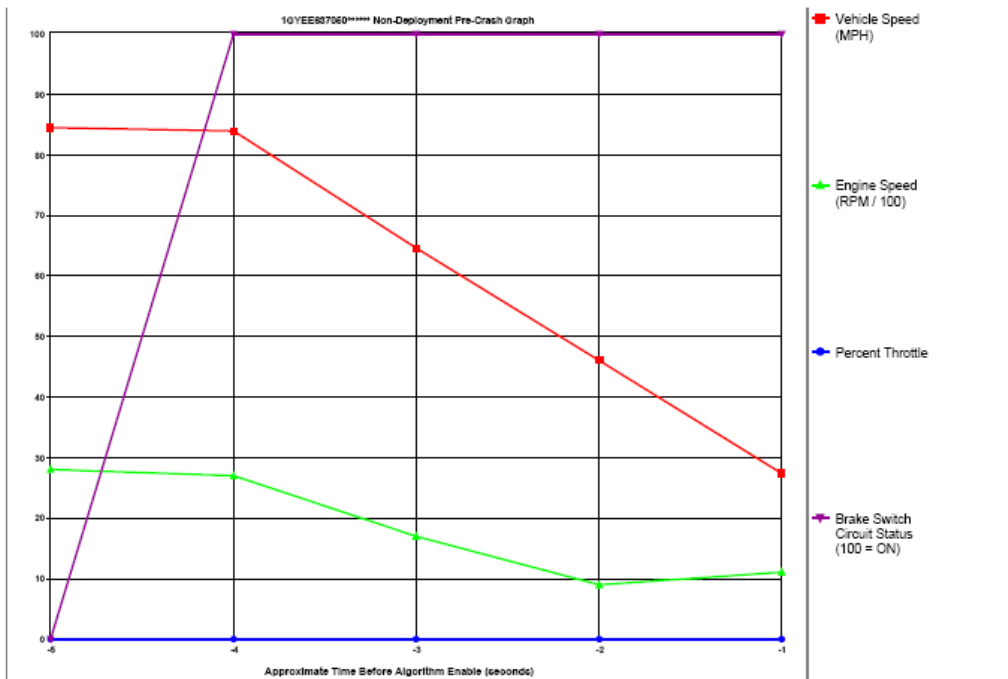
-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the vehicle's communication network, to the SDM.

-The SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture. Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle's communication network.

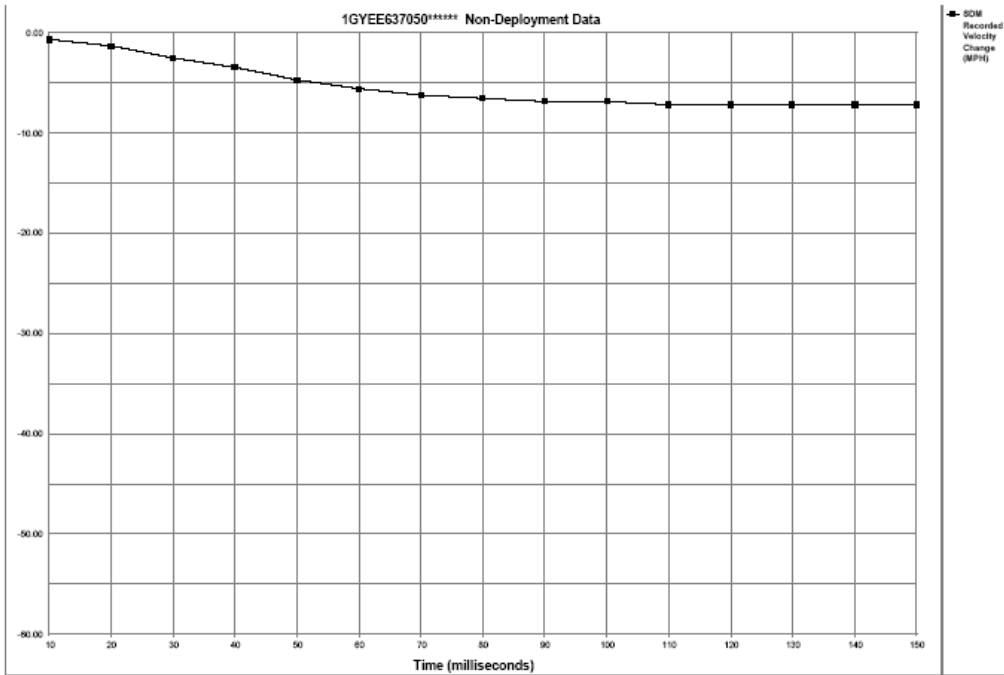


System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Non-Deployment	2215
Ignition Cycles At Investigation	2217
Maximum SDM Recorded Velocity Change (MPH)	-7.18
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	107.5
Crash Record Locked	No
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	85	2752	0	OFF
-4	84	2688	0	ON
-3	65	1664	0	ON
-2	46	896	0	ON
-1	27	1088	0	ON



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.62	-1.24	-2.48	-3.41	-4.65	-5.58	-6.20	-6.51	-6.82	-6.82	-7.13	-7.13	-7.13	-7.13	-7.13



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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$0A 41 44 34 51 58 42
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$0D 50 41 30 50 32 59
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$44 0B 12 18 2C 4A 00
$45 5E 00 00 00 00 00
$46 00 00 0B 0B 0E 11
$47 0E 00 7D 80 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
$4F FF FF FF FF 00 00
$50 FF FF FF FF FF FF
$51 FF FF FF FF FF FF
$52 FF FF FF FF FF FF
$53 FF FF FF FF FF FF
$54 FF FF FF FF FF FF
```

Attachment 3. Speed Calculations

CASE NUMBER: 2005-78-069A			
Comments: Begin braking in median			
** MINIMUM SPEED W/ KNOWN DRAG FACTOR **			
$S = \sqrt{30 \times D \times f}$		S = The Speed in MPH 30 = A Constant. D = The Distance in Feet. f = The Adjusted Accel/ Drag Factor.	
$S = \sqrt{30 \times 75.00 \times 0.50}$			
$S = \sqrt{1125.00}$			
S = 33.54			
INPUTS:		RESULTS:	
The Acceleration/ Drag Factor is:	0.50	The Speed in MPH is:	33.54
The Distance in Feet is:	75.00	The Velocity in FPS is:	49.19
75031			

CASE NUMBER: 2005-78-069A

Comments: Braking across roadway

**** MINIMUM SPEED W/ KNOWN DRAG FACTOR ****

$$S = \sqrt{30 \times D \times f}$$

$$S = \sqrt{30 \times 104.00 \times 0.70}$$

$$S = \sqrt{2184.00}$$

$$S = 46.73$$

S = The Speed in MPH.
 30 = A Constant.
 D = The Distance in Feet.
 f = The Adjusted Accel/Drag Factor.

INPUTS:	
The Acceleration/Drag Factor is:	0.70
The Distance in Feet is:	104.00

RESULTS:	
The Speed in MPH is:	46.73
The Velocity in FPS is:	68.53

CASE NUMBER: 2005-78-069A			
Comments: Travel across north roadside			
** MINIMUM SPEED W/ KNOWN DRAG FACTOR **			
$S = \sqrt{30 \times D \times f}$		S = The Speed in MPH. 30 = A Constant. D = The Distance in Feet. f = The Adjusted Accel/ Drag Factor.	
$S = \sqrt{30 \times 197.00 \times 0.50}$			
$S = \sqrt{2955.00}$			
$S = 54.35$			
INPUTS:		RESULTS:	
The Acceleration/ Drag Factor is:	0.50	The Speed in MPH is:	54.35
The Distance in Feet is:	197.00	The Velocity in FPS is:	79.71
7.50.31			

CASE NUMBER: 2005-78-069A

Comments: Combined speeds

**** COMBINED MINIMUM SPEEDS W/ KNOWN SPEEDS ****

$$S = \sqrt{S^2(1) + S^2(2) + \dots S^2(n)}$$

$$S = \sqrt{(33.54)^2 + (46.73)^2 + (39.49)^2 + (43.10)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2}$$

$$S = \sqrt{1124.93 + 2183.69 + 1559.46 + 1857.61 + 0.00 + 0.00 + 0.00 + 0.00}$$

$$S = \sqrt{6725.69}$$

$$S = 82.01$$

S = The Speed in MPH.
 S² = The Individual Min. Speed.
 (1), (2), (n) = The # of the individual speed.

INPUTS:	
Speed # 1 in MPH is:	33.54
Speed # 2 in MPH is:	46.73
Speed # 3 in MPH is:	39.49
Speed # 4 in MPH is:	43.10

RESULTS:	
The Speed in MPH is:	82.01
The Velocity in FPS is:	120.28