



# INDIANA UNIVERSITY

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### **ON-SITE CERTIFIED ADVANCED 208- COMPLIANT VEHICLE INVESTIGATION**

CASE NUMBER - IN-05-018  
LOCATION - TEXAS  
VEHICLE - 2003 CADILLAC C1500 ESCALADE  
CRASH DATE - March 2005

Submitted:

April 26, 2006  
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Contract Number: DTNH22-01-C-07002

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U.S. Department of Transportation  
National Highway Traffic Safety Administration  
National Center for Statistics and Analysis  
Washington, D.C. 20590-0003

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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.

**Technical Report Documentation Page**

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15. <i>Supplementary Notes</i> On-site air bag investigation involving a 2003 Cadillac C1500 Escalade with manual safety belts and dual front certified advanced 208-compliant air bag system.					
16. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash that involved a 2003 Cadillac C1500 Escalade (case vehicle), which ran-off-road and impacted a street sign and tree. This crash is of special interest because the case vehicle is certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The case vehicle was also equipped with an Event Data Recorder (EDR) and the driver [58-year-old, White (unknown if Hispanic) female] sustained a police reported "C" (possible) injury as a result of the crash. The case vehicle was traveling north in the right lane of a two-lane, one-way, undivided city street. The driver was under the influence of alcohol and/or drugs and was distracted by a dog in the vehicle. The case vehicle departed the east side of the roadway and impacted a metal street sign pole. The front right corner of the case vehicle then impacted a tree resulting in a stage one deployment of the case vehicle driver's air bag. The case vehicle deflected off the tree to the northwest and came to final rest on the roadway facing north, parallel to the east curb and north of the impacted tree. The driver attempted to avoid the crash by steering left and applying the brakes. The driver was not restrained. Her seat was adjusted to between the middle and rear most track position, the seat back was slightly reclined, and the tilt steering column was adjusted to between its middle and full up position. As a result of the tree impact the driver moved forward and her face and chest impacted her deployed air bag. She complained of back pain but refused to be transported to a medical facility.					
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This investigation was brought to NHTSA's attention on or before April 19, 2005 by NASS CDS sampling activities. This crash involved a 2003 Cadillac C1500 Escalade (case vehicle), which ran-off-road and impacted a street sign and tree. The crash occurred in March, 2005 at 12:48 a.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle is certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The case vehicle was also equipped with an Event Data Recorder (EDR) and the driver [58-year-old, White (unknown if Hispanic) female] sustained a police reported "C" (possible) injury as a result of the crash. This contractor inspected the case vehicle and downloaded the EDR on May 11, 2005, and inspected the scene on May 12, 2005. No interview was conducted with the case vehicle's driver because this contractor was unable to contact her. This report is based on the police crash report, scene and vehicle inspections, occupant kinematic principles, and this contractor's evaluation of the evidence.

## SUMMARY

The case vehicle was traveling north in the right lane of a two-lane, one-way, undivided city street. The driver was under the influence of alcohol and/or drugs and had a dog in the vehicle, which jumped into her lap. As she was trying to push the dog off her lap, she drove over the east curb. The center portion of the case vehicle's front bumper impacted a metal street sign pole. The front right corner of the case vehicle then impacted a 34 centimeter (13.4 inch) diameter tree resulting in a stage one deployment of the case vehicle driver's air bag. The case vehicle deflected off the tree to the northwest and came to final rest on the roadway facing north, parallel to the east curb and north of the impacted tree. The driver attempted to avoid the crash by steering left and applying the brakes.

The CDCs for the case vehicle were determined to be: **12-FCLN-1 (0 degrees)** for the impact with the metal street sign pole and **12-FREW-2 (0 degrees)** for the tree impact. The WinSMASH reconstruction program, barrier algorithm, calculated the case vehicle's Total, Longitudinal, and Lateral Delta Vs for the tree impact respectively as: 21.0 km.p.h. (13.0 m.p.h.), -21.0 km.p.h. (-13.0 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). Based on the damage to the case vehicle, specifically the rearward displacement of the right front wheel and deformation of the right frame member, the WinSMASH results appear low. The case vehicle's Delta V was recorded by the EDR. The EDR data indicated that the maximum recorded longitudinal Delta V was -31.94 km.p.h. (-19.85 m.p.h.). The case vehicle was towed due to damage.

Immediately prior to the crash, the case vehicle's driver (58-year-old, female) was seated in an unknown position. The driver most likely had one hand on the steering wheel and was using the other hand to push the dog off her lap. In addition, she had one of her feet on the brake pedal. The driver's seat track was located between its middle and forward most position, the seat back was slightly reclined and the tilt steering column was adjusted to between its center and full up position. The driver was not restrained by her integral, three-point, lap-and-shoulder safety belt.

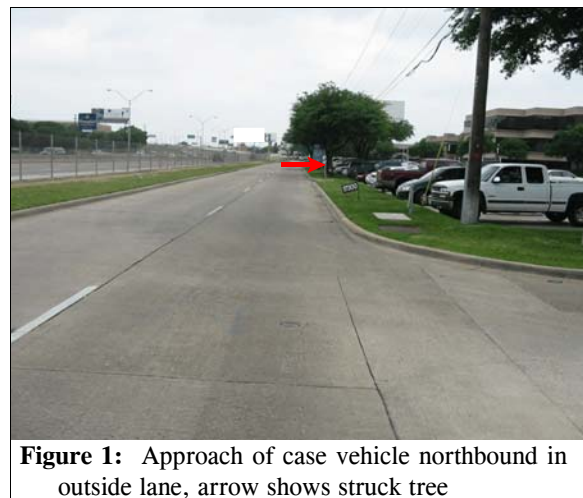
The case vehicle's impact with the curb most likely caused the driver to move down in her seat as well as slightly forward. The impact with the metal street sign post most likely caused the driver to move slightly forward in response to the case vehicle's 0 degree direction of principal force. The case vehicle's impact with the tree then caused the driver's air bag to deploy and she continued forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated, and her face and chest contacted her deployed air bag. The driver then most likely rebounded back into her seat. She most likely remained in her seat as the case vehicle came to final rest. The driver was most likely able to exit the case vehicle without assistance. The stage one deployment of the driver's air bag mitigated her interaction with the case vehicle's frontal interior components and reduced her potential for injury.

An ambulance was called to the scene; however, the driver refused to be transported to a medical facility. The police crash report narrative stated that the driver complained of back pain.

### CRASH CIRCUMSTANCES

**Crash Environment:** The trafficway on which the case vehicle was traveling was a two-lane, undivided, one-way city service road to a city tollway, traversing in a north-south direction. Each travel lane was approximately 3.6 meters in width (11.8 feet). Each side of the roadway was bordered by barrier curbs. On the east side of the roadway, an approximate 3.4 meters (11.2 feet) wide strip of land separated the roadway from adjacent parking lots. There was a line of utility poles, trees and a few signs within this strip of land. At the time of the crash, the light condition was dark, but lighted, the weather was clear and the roadway pavement was dry, level concrete with an estimated coefficient of friction of 0.72. Traffic density was light, and the site of the crash was urban commercial. See the Crash Diagram at the end of this report.

**Pre-Crash:** The case vehicle was traveling north in the right lane (**Figure 1**). The driver was intending to proceed straight ahead. The case vehicle driver reported to police that her dog jumped into her lap. As she tried to push the dog off her lap, she drove over the east curb. The police crash report also indicated the driver was under the influence of alcohol and/or drugs and refused to submit to an alcohol/drug test. Evidence in the case vehicle indicated there was in fact a dog in her vehicle. The EDR data supports driver brake application just prior to the crash. In addition, it appears the driver steered left in an attempt to avoid the cash. The crash occurred on the east side of the roadway.



**Figure 1:** Approach of case vehicle northbound in outside lane, arrow shows struck tree

**Crash:** The case vehicle drove over the east curb of the roadway (**Figure 2** below) and the center portion of the case vehicle's front bumper (**Figure 3** below) impacted a metal street sign pole and bent it over. The front right corner of the case vehicle then immediately impacted a 34 centimeter

(13.4 inch) diameter tree (**Figure 4**), which caused the case vehicle driver’s air bag to deploy. The downloaded EDR data indicated only the first stage of the dual stage air bag activated. The case vehicle’s front right air bag did not deploy because there was no front right passenger seated in the case vehicle.



**Figure 2:** Approach of case vehicle to impact with curb (arrow), sign post and tree



**Figure 3:** Damage to front of case vehicle from tree impact and street sign pole impact (arrow)



**Figure 4:** Impacted sign post and tree, arrow shows fluid spill stain on roadway at case vehicle’s final rest location, each increment on rod is 5 cm (2 in)



**Figure 5:** View to south opposite case vehicle’s approach showing fluid stain (arrow) at case vehicle’s final rest location

**Post-Crash:** The case vehicle deflected northwest off the tree and reentered the roadway. The police scene schematic showed the case vehicle on the roadway facing north, adjacent and parallel to the east curb, and north of the impacted tree at final rest. In addition, there was a fluid spill stain on the pavement in this area supporting the police reported final rest position (**Figure 5**).

**CASE VEHICLE**

The 2003 Cadillac Escalade 1500 was a rear wheel drive, four-door sport utility vehicle (VIN: 1GYEC63T43R-----) equipped with 5.3L, V8 engine; four speed automatic transmission with overdrive; four wheel, anti-lock brakes; traction control, stability control and power adjustable pedals (**Figure 6** below). The front seating row was equipped with bucket seats with



adjustable head restraints; integral, three-point, lap and shoulder safety belt systems with safety belt buckle switch sensors; dual stage driver and front right passenger air bags; driver and front right passenger seat back-mounted, side-impact air bags and a front right passenger detection and automatic air bag suppression system. The back seating row was equipped with a split bench seat with adjustable head restraints in the outboard seat positions and three-point, lap and shoulder safety belt systems in all three seat positions. In addition, the case vehicle was equipped with a LATCH system for securing child safety seats and an EDR housed within the air bag system's Sensing and Diagnostic Module (SDM). The case vehicle's wheelbase was 295 centimeters (116.1 inches). The odometer reading at the time of the vehicle inspection could not be determined because the case vehicle was equipped with an electronic odometer.



Figure 6: Case vehicle's adjustable pedals

The various sensors in the case vehicle's advanced occupant restraint system analyze a combination of factors including the predicted crash severity and driver and front right passenger safety belt usage to determine the front air bag inflation level appropriate for the severity of the crash. For the front right seat, an occupant pressure sensor and a seat belt tension sensor provide data to the electronic control module. The electronic control module (a) compares the seat pressure and seat belt tension data to threshold values, (b) determines if the front right air bag should be suppressed or enabled, and (c) communicates the decision to the air bag control module. The air bag will be suppressed when the seat pressure is at or below the established threshold or there is above normal tension on the safety belt (e.g., a secured child seat). The air bag will be enabled if the pressure is above the threshold and the seat belt tension is normal (e.g., a restrained adult occupant) or below (e.g., unrestrained occupant).

## CASE VEHICLE DAMAGE

**Exterior Damage:** The case vehicle's impact with the metal street sign pole involved the center portion of the front bumper, just to the right of the case vehicle's centerline (**Figure 7**). The direct damage began 91 centimeters (35.8 inches) left of the bumper corner and extended 8 centimeters (3.1 inches) along the bumper. Residual crush could not be determined due the subsequent impact with the tree. The case vehicle's impact with the tree involved the right portion of the front bumper, as well as the right headlamp/turn signal assembly, grille, hood and right fender (**Figure 7** and **Figure 8** below). The direct damage began at

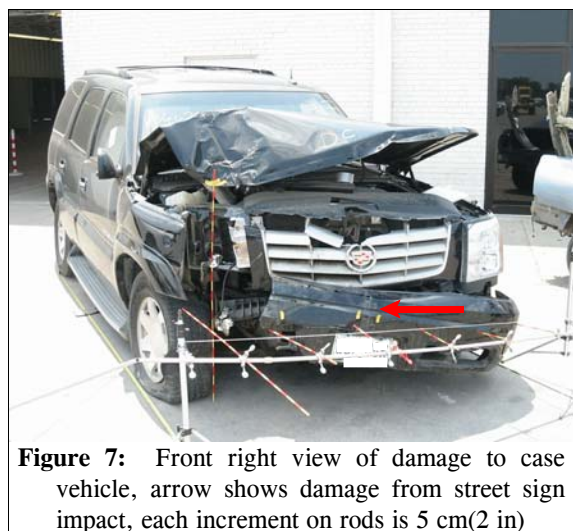


Figure 7: Front right view of damage to case vehicle, arrow shows damage from street sign impact, each increment on rods is 5 cm(2 in)



the right bumper corner and extended 47 centimeters (18.5 inches) along the bumper. The right portion of the front bumper, right fender and hood were crushed rearward. In addition, the right front wheel was crushed rearward to the back of the right front wheelhouse (Figure 9), and the end of the right frame member was engaged and bent upward. Crush measurements were taken to the front bumper bar behind the bumper fascia, due to rebound of the bumper fascia and loss of the right corner portion of the bumper fascia. The residual maximum crush was determined to be 42 centimeters (16.5 inches) occurring at C<sub>6</sub> (Figure 10). The table below shows the case vehicle's front crush profile for the tree impact.



Figure 8: Front left view of damage to case vehicle

Units	Event	Direct Damage		Field L	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	47	42	172	0	0	10	23	39	42	70	0
in		18.5	16.5	67.7	0.0	0.0	3.9	9.1	15.4	16.5	27.6	0.0



Figure 9: Displacement of case vehicle's right front wheel

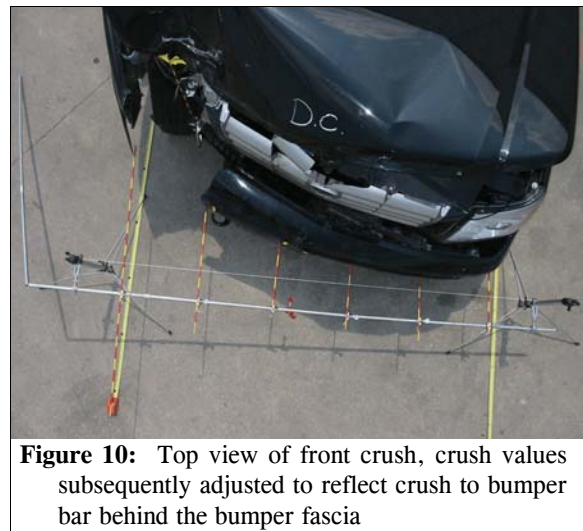


Figure 10: Top view of front crush, crush values subsequently adjusted to reflect crush to bumper bar behind the bumper fascia

The case vehicle's right side wheelbase was reduced 10 centimeters (4 inches), while the left side wheelbase was extended 1 centimeter (0.4 inch). In addition to the direct damage, the induced damaged also involved the front bumper, grille, hood, and right fender. The right A-pillar, windshield, right roof side rail and adjacent roof structure above the front right seat also sustained induced damage.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 <sup>nd</sup> of an inch			
LF	Flat	Flat	207	30	6	8	None	No	Yes
RF	Flat	Flat	207	30	7	9	Sheet metal against tire but not punctured	Yes	Yes
LR	Flat	Flat	207	30	7	9	None	No	Yes
RR	228	33	207	30	6	8	None	No	No

**Vehicle Interior:** Inspection of the case vehicle’s interior (**Figure 11**) revealed a possible scuff below the air vent, left of the steering wheel. There was also blood and white hair on the gear shift level (**Figure 12**), as well as blood splatter on the steering wheel, windshield, center instrument panel, console, front right seat, right front door, back of the front right seat and on the back seat cushion. This was most likely related to an injury sustained by the dog that the driver reported was in the vehicle. This was not related to a driver injury because the police crash report stated the driver only complained of back pain and refused transport to a treatment facility. Lastly, there was no intrusion of the passenger compartment, and no deformation of the steering wheel rim (**Figure 13** below). Some minor compression of the energy absorbing steering column may have occurred, but this could not be confirmed.



**Figure 11:** Overview of case vehicle’s steering wheel, instrument panel and windshield



**Figure 12:** White dog hair on gear shift lever

**Damage Classification:** Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **12-FCLN-1 (0 degrees)** for the impact with the metal street sign pole and **12-FREW-2 (0 degrees)** for the tree impact. The WinSMASH reconstruction program, barrier algorithm, was used to reconstruct the case vehicle’s Delta V for the tree impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 21.0 km.p.h. (13.0 m.p.h.), -21.0 km.p.h. (-13.0 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). Based on the damage to the case vehicle, specifically the rearward displacement of the right front wheel and deformation of the right frame member, the WinSMASH results appear low. Delta V data was recorded by the case vehicle’s EDR. The EDR data indicated that the maximum

recorded longitudinal Delta V was -31.94 km.p.h. (-19.85 m.p.h.). The case vehicle was towed due to damage.

### AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with certified advanced 208-compliant front air bags at the driver and front right passenger positions, as well as seat back-mounted side impact air bags. The case vehicle's SDM commanded a first stage deployment of the driver's air bag due to the tree impact. The front right passenger air bag did not deploy because there was no passenger seated in the front right passenger seat. The seat back-mounted side impact air bags did not deploy because the case vehicle sustained no side impact.

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag could not be completed because it had been cut out of the air bag module (**Figure 14**). Inspection of the module cover flaps revealed that they opened at the designated tear points. There was no damage due to deployment to the module cover flaps. The air bag module cover consisted of symmetrical "I" configuration cover flaps made of pliable vinyl approximately 2 millimeters (0.08 inch) thick. Each module cover flap was approximately 7.3 centimeters in width at the top, 4.1 centimeters (1.6 inches) in width at the bottom and 11 centimeters (4.3 inches) in height along the center tear seam. Inspection of the remaining air bag material indicated that the driver's air bag was designed with two tethers, each approximately 10 centimeters (3.9 inches) in width.

The front right passenger's air bag was located in the middle of the instrument panel (**Figure 15**). The seat back-mounted, side impact air bags were located in the outside of the driver and front right passenger's seat backs.



**Figure 13:** Left side view of case vehicle's steering column and steering wheel showing lack of deformation, steering column moved to full up position



**Figure 14:** Driver's air bag was cut out of case vehicle, steering wheel upside down, measurement rod shows height of cover flaps, each increment on rod is 5 cm (2 in)



**Figure 15:** Front right air bag located in middle of right instrument panel above glove box door



The download of the case vehicle's EDR was done during the vehicle inspection via connection to the case vehicle's data link connector. The EDR reports are presented in **Figures 16 - 21** at the end of this report. The downloaded data indicated that a non-deployment event and deployment event were recorded. The non-deployment event occurred during this crash because it was recorded on the same ignition cycle as the deployment event. The non-deployment event is most likely related to the case vehicle's right front wheel impact with the curb. The system status reports show that the SIR warning lamp was recorded as off, and the driver's seat belt switch circuit was recorded as unbuckled. In addition, the maximum SDM recorded velocity change was recorded as -31.94 km.p.h. (-19.85 m.p.h.) for the deployment event occurring 167.5 milliseconds after algorithm enable (AE), and -1.29 km.p.h. (-0.80 m.p.h.) for the non-deployment event occurring 82.5 milliseconds after AE. The system status report for the deployment event shows that the first stage deployment criteria for the driver's air bag was met 17.5 milliseconds after AE. The driver's air bag second stage deployment criteria was not met. In addition, the report indicates the time between the non-deployment event and the deployment event was 0.6 seconds, which is consistent with the non-deployment event occurring when the case vehicle impacted the curb.

The non-deployment and deployment event pre-crash data indicate that the case vehicle had accelerated from 9.7 km.p.h. (6 mph) to 35.4 km.p.h. (22 m.p.h) just prior to the crash. The deployment event pre-crash data also shows that the brake switch circuit was recorded on one second prior to the tree impact. This indication supports driver brake application just prior to the curb impact. In addition, the EDR reported pre-crash speed and acceleration data support the likelihood that the driver had just turned onto the roadway from the side street just south of the crash site. The driver's residence was within one-half mile of the crash site.

#### **CASE VEHICLE DRIVER KINEMATICS**

Immediately prior to the crash, the case vehicle's driver [58-year-old, White (unknown if Hispanic) female, unknown height and weight] was seated in an unknown position. Based on the driver's statement to police and the evidence indicating there was a dog in her vehicle, the driver most likely had one hand on the steering wheel and was using the other hand to push the dog off her lap. In addition, the EDR data supports the brakes being applied just prior to the crash, indicating the driver had one of her feet on the brake pedal. The driver's seat track was located between its middle and forward most position, the seat back was slightly reclined and the tilt steering column was adjusted to between its center and full up position.

Based on this contractor's vehicle inspection and supported by the EDR data, the case vehicle's driver was not restrained by her integral, three-point, lap-and-shoulder safety belt system. Inspection of the driver's safety belt assembly revealed no evidence of loading.

The case vehicle's impact with the curb most likely caused the driver to move down in her seat as well as slightly forward. The impact with the metal street sign post most likely caused the driver to move slightly forward in response to the case vehicle's 0 degree direction of principal force. The case vehicle's impact with the tree then caused the driver's air bag to deploy and she

continued forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated, and her face and chest contacted the deployed driver's air bag. The driver then most likely rebounded back into her seat. She most likely remained in her seat as the case vehicle came to final rest. The driver was most likely able to exit the case vehicle without assistance. The stage one deployment of the driver's air bag mitigated her interaction with the case vehicle's frontal interior components and reduced her potential for injury.

#### **CASE VEHICLE DRIVER INJURIES**

The driver sustained a police reported "C" (possible) injury. An ambulance was called to the scene; however, the driver refused to be transported to a medical facility. The police crash report narrative stated that the driver complained of back pain.

1GYEC63T43Rxxxxxx System Status At Non-Deployment															
SIR Warning Lamp Status	OFF														
Driver's Belt Switch Circuit Status	UNBUCKLED														
Ignition Cycles At Non-Deployment	2663														
Ignition Cycles At Investigation	2668														
Maximum SDM Recorded Velocity Change (MPH)	-0.80														
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	82.5														
Event Recording Complete	Yes														
Multiple Events Associated With This Record	No														
One Or More Associated Events Not Recorded	No														
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	-0.31	-0.31	-0.31	-0.31	-0.62	-0.62	-0.62	-0.62	-0.62	N/A	N/A	N/A	N/A
PRE-CRASH DATA															
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status											
-5	6	1088	19	OFF											
-4	9	1408	29	OFF											
-3	13	1664	34	OFF											
-2	19	1792	34	OFF											
-1	22	1920	40	OFF											

Figure 16: Case vehicle's System Status at Non-Deployment report



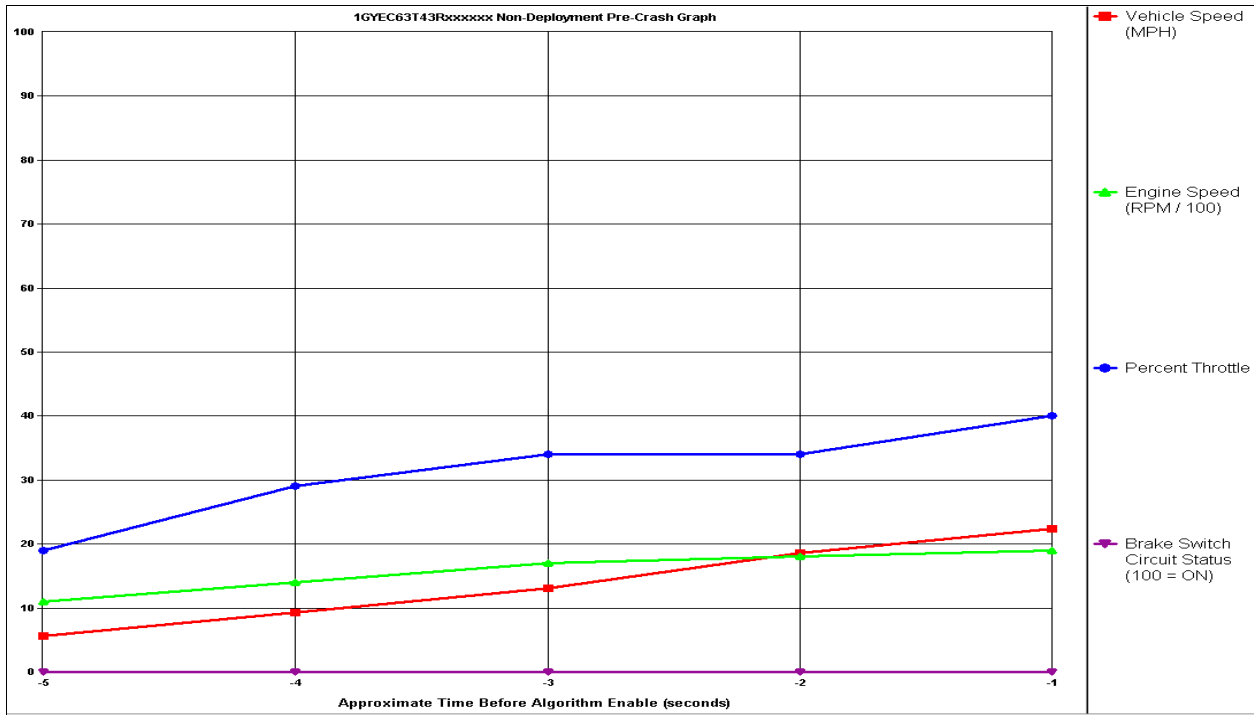


Figure 17: Case vehicle's Non-Deployment Pre-Crash Graph

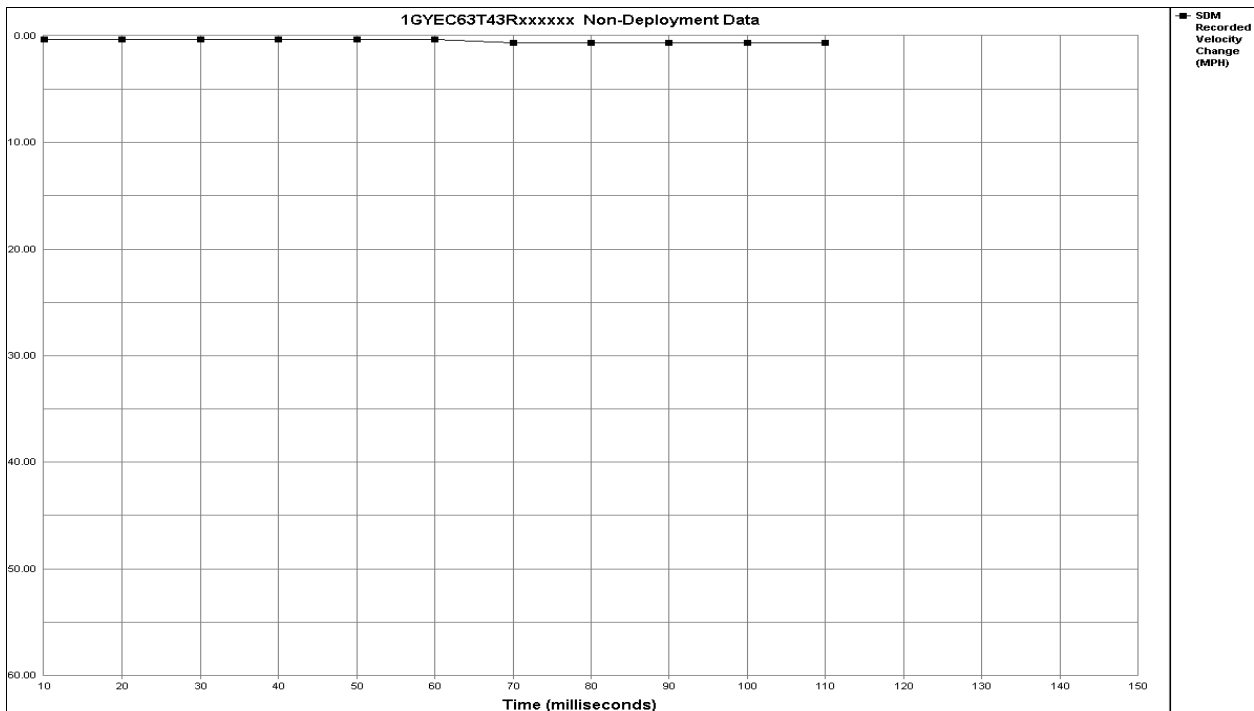


Figure 18: Case vehicle's non-deployment SDM Recorded Velocity Change graph

**EVENT DATA RECORDER DATA (CONTINUED)**

IN-05-018

1GYEC63T43Rxxxxxx System Status At Deployment															
SIR Warning Lamp Status	OFF														
Driver's Belt Switch Circuit Status	UNBUCKLED														
Ignition Cycles At Deployment	2663														
Ignition Cycles At Investigation	2668														
Maximum SDM Recorded Velocity Change (MPH)	-19.85														
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	167.5														
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	17.5														
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A														
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	Suppressed														
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A														
Time Between Non-Deployment And Deployment Events (sec)	.6														
Frontal Deployment Level Event Counter	1														
Event Recording Complete	Yes														
Multiple Events Associated With This Record	Yes														
One Or More Associated Events Not Recorded	No														
Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.31	-1.24	-1.86	-2.79	-3.72	-4.96	-6.20	-7.44	-8.68	-10.23	-12.09	N/A	N/A	N/A	N/A
PRE-CRASH DATA															
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status											
-5	9	1408	29	OFF											
-4	13	1664	34	OFF											
-3	19	1792	34	OFF											
-2	22	1920	40	OFF											
-1	22	1472	5	ON											

**Figure 19:** Case vehicle's System Status at Deployment report

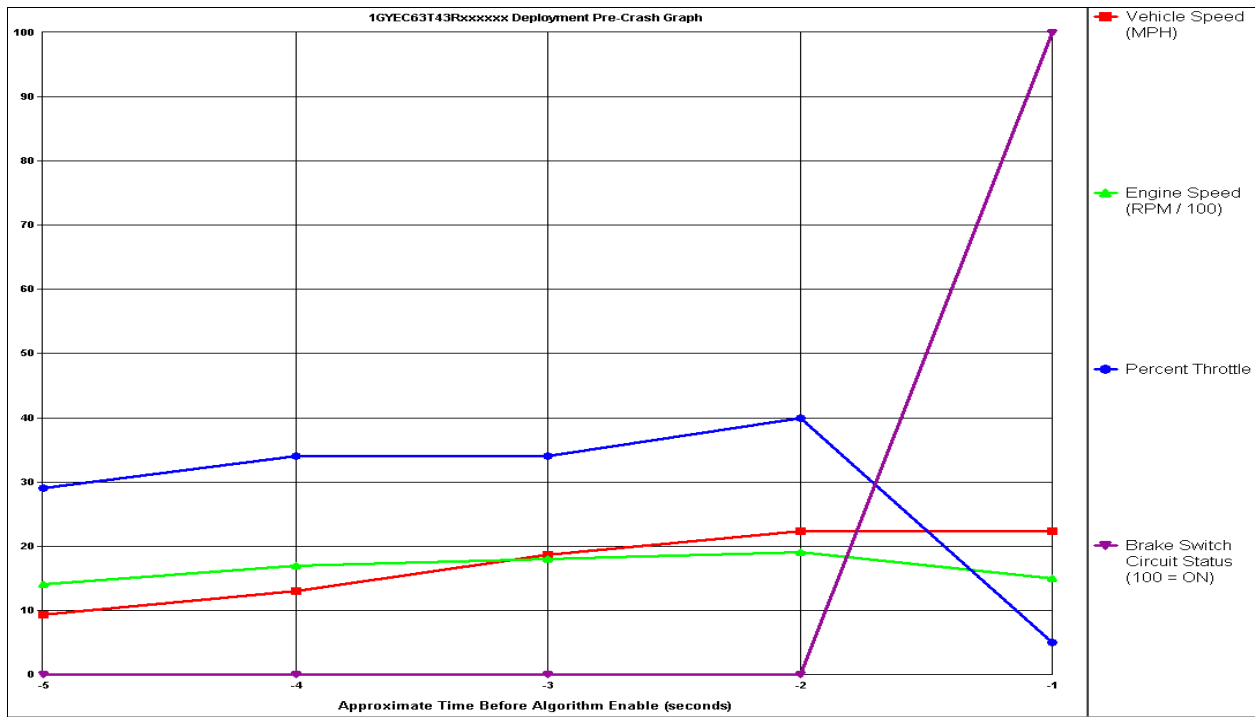


Figure 20: Case vehicle's Deployment Pre-Crash Graph

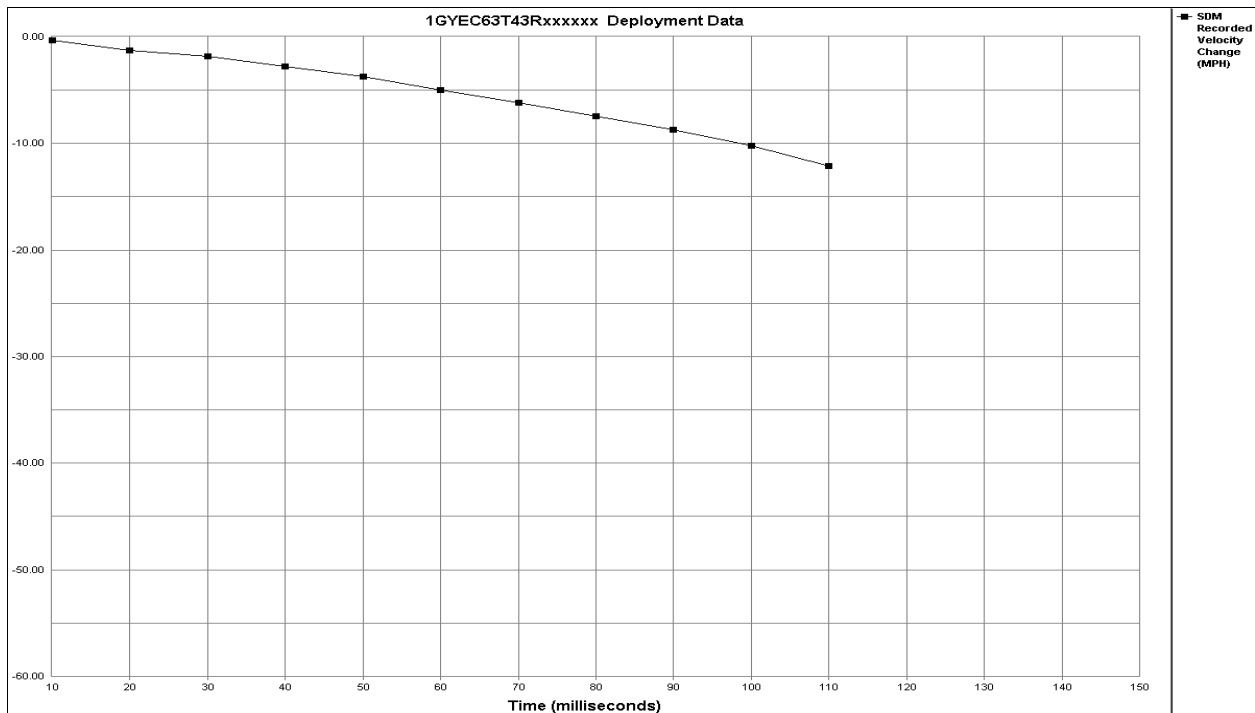


Figure 21: Case vehicle's deployment SDM Recorded Velocity Change graph

