

Advanced Air Bag Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS03008
2003 Chevrolet Avalanche
Texas
February, 2003

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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

1. Report No. DS03008		2. Government Accession No.		3. Recipient Catalog No.	
4. Title and Subtitle Advanced Air Bag Investigation				5. Report Date November 3, 2003	
				6. Performing Organization Report No.	
7. Author(s) Dynamic Science, Inc.				8. Performing Organization Report No.	
9. Performing Organization name and Address Dynamic Science, Inc. 530 College Parkway, Ste. K Annapolis, MD 21401				10. Work Unit No. (TRAIS)	
				11. Contract or Grant no. DTNH22-94-D-27058	
12. Sponsoring Agency Name and Address U.S. Dept. of Transportation (NRD-32) National Highway Traffic Safety Administration 400 7th Street, SW Washington, DC 20590				13. Type of report and period Covered [Report Month, Year]	
				14. Sponsoring Agency Code	
15. Supplemental Notes					
16. Abstract <p>This four vehicle, rear end chain reaction crash occurred in February, 2003 at 0900 hours in Texas. The crash occurred on a divided four-lane highway. This case involved an Advanced 208 Compliant vehicle.</p> <p>The case vehicle was a 2003 Chevrolet Avalanche 1500 pickup crew cab 2WD pickup truck driven by a restrained 44-year-old male. The case vehicle was equipped with dual stage front air bags. The first other vehicle was a 1997 Chevrolet 2500 series pickup driven by a 23-year-old male. The front right seat was occupied by a 35-year-old male. The second other vehicle was a 1999 Toyota Camry four-door sedan driven by a 44-year-old female. The third other vehicle was a 1999 Chevrolet Blazer sport utility vehicle driven by a 57-year-old male. The Blazer was stopped in the third lane from the right facing south. The Toyota Camry was behind the Blazer and was slowing. The case vehicle was behind the Camry and was slowing. The Chevrolet 2500 series pickup was traveling behind the case vehicle. The driver of the pickup failed to stopped in time and rear-ended the case vehicle. The case vehicle was pushed forward into the rear of the Camry. The Camry was then pushed forward into the rear of the Blazer just as it was beginning to pull forward with traffic. The case vehicle's air bags did not deploy.</p> <p>The driver of the case vehicle sustained muscle spasms to his neck, back, and both arms and legs. He has had several back surgeries and is currently under medical treatment for spasms. He was transported from the scene by ambulance to a local hospital. He was examined and underwent an MRI. He was released a few hours after the crash.</p>					
17. Key Words Air bag, 208 compliant, advanced, non-deployment.			18. Distribution Statement		
19. Security Classif. (of this report)		20. Security Classif. (of this page)		21. No of pages	22. Price

Dynamic Science, Inc.
Accident Investigation
Case Number: DS03008

TABLE OF CONTENTS

Background 1
 Description 1
 Investigation Type 1
 Crash Location 1
 Crash Date 1
 Notification Date 1
 Field Work Completed 1

Summary 1

Scene Diagram 3

Detailed Information 4
 Vehicles 4
 Occupant Protection System Discussion 5
 Occupants 10
 Injuries and Injury Mechanisms 14
 Occupant Kinematics 15

Attachment 1. Vetronix Report 16

BACKGROUND:

Description: This Advanced 208 Compliant case was identified by the local National Automobile Sampling System Primary Sampling Unit. The case was reported to DSI on February 28, 2003. All field activities were completed on March 4, 2003. The case vehicle was inspected and the System Diagnostic Module (SDM) downloaded. The vehicle had been torn down by the body shop.

Investigation Type: On-scene
Crash Location: Texas
Crash Date: February, 2003
Notification Date: February 28, 2003
Field Work Completed: March 4, 2003

SUMMARY:

This four vehicle, rear end, chain reaction crash occurred in February, 2003 at 0900 hours in Texas. The crash occurred on a divided four-lane highway. The speed limit is 97 km/h (60 mph).

The case vehicle was a 2003 Chevrolet Avalanche 1500 pickup crew cab 2WD pickup truck driven by a restrained 44-year-old male (183 cm/72 in, 95 kg/210 lbs). The case vehicle was equipped with dual stage front air bags. The front right passenger air bag includes a "Passenger Sensing System". The system is designed to automatically switch the air bag on or off based on a passenger's weight.

The first other vehicle was a 1997 Chevrolet 2500 series pickup driven by a 23-year-old male. The front right seat was occupied by a 35-year-old male.



Figure 1. Overview of crash scene (south).



Figure 2. Front left, case vehicle (insurance photo)

The second other vehicle was a 1999 Toyota Camry four-door sedan driven by a 44-year-old female.

The third other vehicle was a 1999 Chevrolet Blazer sport utility vehicle driven by a 57-year-old male.

The Blazer was stopped in the third lane from the right facing south. The Toyota Camry was behind the Blazer and was slowing. The case vehicle was behind the Camry and was slowing. The Chevrolet 2500 series pickup was traveling behind the case vehicle. The driver of the pickup failed to stop in time and rear-ended the case vehicle (06BDEW1). The case vehicle was pushed forward and struck the rear of the Camry with its front end (12FYLW1). The Camry was then pushed forward into the rear of the Blazer just as it was beginning to pull forward with traffic.

The driver of the case vehicle sustained muscle spasms to his neck, back, and both arms and legs. He has had several back surgeries prior to this crash and is currently under medical treatment for spasms. He was transported from the scene by ambulance to a local hospital. He was examined and underwent an MRI. He was released a few hours after the crash.

The case vehicle was towed from the scene. It was completely torn down at the time of the inspection.



Figure 3. Rear left, case vehicle (insurance photo)



Figure 4. Driver's seated position

Scene Diagram

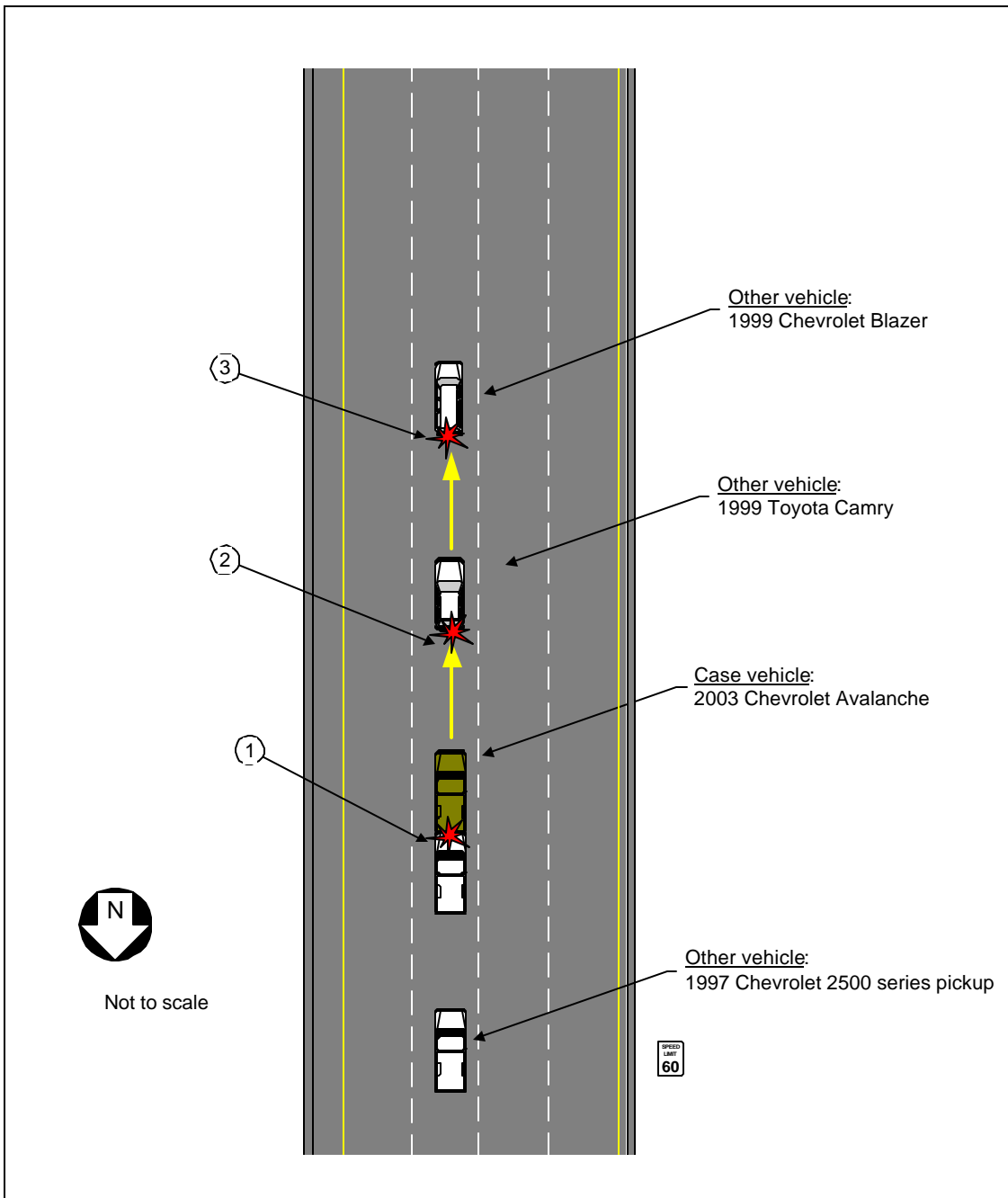


Figure 5. Scene diagram

DETAILED INFORMATION

Vehicles

Case vehicle

Description: 2003 Chevrolet Avalanche 1500 ½ ton sport utility vehicle. Vehicle can be converted from a six-passenger SUV to a full-size pickup with an eight-foot protected cargo box. Vehicle was equipped with the Z66 On-road package.

VIN: 3GNEC13T13Gxxxxxx

Odometer: Unknown

Engine: 5.3 L, V8

Reported Defects: None noted

Cargo: None

Damage Description: Minor front and rear end damage. PAR vehicle damage rating=BD2, FD2. Vehicle towed from the scene

CDC: Impact 1: 06BDEW1
Impact 2: 12FYLW1

Delta V:	Total	Estimated to be >= 10.0 km/h (6.2 mph) but < 25.0 km/h (15.5 mph)
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown



Figure 6. Left bumper mounting bracket—minor scuffing/scratches

Occupant Protection System Discussion

This vehicle was equipped with an advanced occupant protection system. The system consists of the SDM, dual stage front air bags, a front right passenger sensing system, and a driver's seat belt latch usage detector. The system is controlled by the 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. The system will also record, as it did in this case, 150 milliseconds of data after algorithm enable (AE).

The downloaded data indicated that the case vehicle had a maximum recorded velocity change of -6.4 km/h (-4.04 mph) at the 100 ms mark as a result of the forward impact. The result appears slightly low given that there was residual damage to the bumper mounting bracket.

The Vetronix report further indicates that:

1. The driver's belt switch status was: buckled.
2. The AE to maximum recorded velocity change was: 100 milliseconds
3. There were no air bag deployments.
4. The brake switch status was OFF at 5 second interval before algorithm enable (AE), was ON for the next 3 second intervals, and then was OFF 1 second before AE.
5. There were 25 ignition cycles between the non-deployment event and the time of investigation. This number seems high, but the vehicle may have been driven after the crash.
6. The vehicle speed was 47 km/h (29 mph) five seconds before AE, decelerating to 10 km/h (6 mph) before AE.

Based on the brake switch status changes, the vehicle speed changes, and the absence of any throttle activity a reasonable conjecture would be that this vehicle was slowing prior to the initial rear end impact. At impact, the driver reacted by moving rearward. This took his foot off the brake. After impact, the vehicle was forced forward. The driver then braked, causing the brake switch status to return to ON, and decelerating the vehicle to 10 km/h (6 mph).

The case vehicle was equipped with frontal air bags mounted in the steering wheel and top mounted in the instrument panel of the front right seat position. The front right passenger air bag includes a "Passenger Sensing System". The system is designed to automatically switch the air bag on or off based on a passenger's weight. The system also uses a sensor in the passenger-side seat belt to measure how much tension is exerted by the seat belt when it is being cinched down, providing a means of subtracting seat loading due to the belt in order to accurately determine what may be on the seat.

There is an indicator on the center rear-view mirror that alerts vehicle occupants to the status of the system at all times. If the light reads "Passenger Air Bag ON," the air bag is programmed to deploy in a frontal crash of sufficient severity. If it reads "Passenger Air Bag OFF," the system has turned off the air bag because it determined either that there is no occupant on the front passenger seat, or that a rear-facing infant seat, a forward-facing child restraint, a booster seat or a smaller person, such as a child who has outgrown child restraints, is present. The sensing system is standard on most 2003 full-size pickups and sport-utility vehicles. There were no air bag deployments. The vehicle was equipped with seat integrated seat belts. There were no indications of seat belt loading.

The front dual-stage air bags in this vehicle are designed to detect vehicle deceleration and, based on the deceleration data, provide an appropriate amount of air-bag inflation. Dual-stage air bags are designed to help reduce the occurrence of inflation-induced injuries by deploying the air bag less forcefully in lower-speed crashes.



Figure 7. Passenger sensing system (photo from GM web site www.gm.com/company/gmability/safety/images/pss.jpg)

Other vehicle (Chevrolet 2500 series)

Description:	1997 Chevrolet 2500 series pickup	
VIN:	1GCGC24R9VZxxxxxx	
Odometer:	Unknown	
Engine:	5.7 V8	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Front end damage. PAR vehicle damage rating=FD3	
CDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Other vehicle (Toyota Camry)

Description:	1999 Toyota Camry 4-door sedan	
VIN:	4T1BG22K1XUxxxxxx	
Odometer:	Unknown	
Engine:	4 cylinder, 2.2 L	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Minor front and rear end damage. PAR vehicle damage rating=BD3, FD1. Vehicle towed from the scene.	
CDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Other vehicle (Chevrolet Blazer)

Description:	1999 Chevrolet Blazer sport utility	
VIN:	1GNCS13W2XXXXXXX	
Odometer:	Unknown	
Engine:	6 cylinder, 4.3 L	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Minor rear end damage. PAR vehicle damage rating=BD1. Vehicle driven from scene.	
CDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Occupants

<u>Case vehicle</u>	Occupant 1
Age/Sex:	44/Male
Seated Position:	Front left
Seat Type:	40/20/40 cloth covered split bench ¹ seat. Slightly reclined. Seat at rear most track position.
Height:	183 cm (72in)
Weight:	95 kg (210 lbs)
Occupation:	Project manager
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Presumed to be > 10 years
Body Posture:	Normal, upright
Hand Position:	Both hands on steering wheel, unknown clock position
Foot Position:	Right foot on brake, left on floor.
Restraint Usage:	Lap and shoulder belt available, used.
Air bag:	Steering wheel mounted air bag available–did <u>not</u> deploy.

¹Per Chevrolet specifications

<u>Other vehicle (Chevrolet 2500 series)</u>	Occupant 1	Occupant 2
Age/Sex:	23/Male	35/Male
Seated Position:	Front left	Front right
Seat Type:	Unknown	Unknown
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	Landscaper	Unknown
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Unknown	NA
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report	Lap and shoulder belt used, per police report

<u>Other vehicle (Toyota Camry)</u>	Occupant 1
Age/Sex:	44/Female
Seated Position:	Front left
Seat Type:	Unknown
Height:	Unknown
Weight:	Unknown
Occupation:	Licensed visiting nurse
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report

<u>Other vehicle (Chevrolet Blazer)</u>	Occupant 1
Age/Sex:	57/Male
Seated Position:	Front left
Seat Type:	Unknown
Height:	Unknown
Weight:	Unknown
Occupation:	Sound engineer
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report

Injuries and Injury Mechanisms

Case vehicle

	<u>INJURY</u>	<u>OIC CODE</u>	<u>ICD-9</u>	<u>SOURCE</u>
Driver:	Muscle spasms to his neck, back, and both arms and legs. No codeable injuries.			

Other vehicle (Chevrolet 2500 series)

Driver:	Not injured, per police report.			
Front right occupant:	Possible injury, per police report.			

Other vehicle (Toyota Camry)

Driver:	Possible injury, per police report.			
---------	-------------------------------------	--	--	--

Other vehicle (Chevrolet Blazer)

Driver:	Not injured, per police report.			
---------	---------------------------------	--	--	--

Occupant Kinematics

The 44-year-old male driver of the case vehicle was seated in a normal, upright fashion in the cloth covered split bench seat. The seat was adjusted to the rear most track position. The seat back was slightly reclined. The adjustable head rest was in the full down position. The driver was wearing the integral lap and shoulder belt. Prior to impact, the case vehicle was slowing and the driver had his foot on the brake. The case vehicle was then struck in the rear by the Chevrolet 2500 series pickup. The driver moved rearward in response to the 6 o'clock direction of force. The vehicle was pushed forward. The driver reacted to this motion by braking once again. The vehicle then decelerated to 10 km/h (6 mph) before striking the rear of the Toyota Camry. He moved slightly forward in response to the 12 o'clock direction of force. His left knee contacted the left lower instrument panel. There was no injury related to this contact.

There was no steering wheel deformation, no steering column compression, and no damage to the seat or headrest. The seat back angle remained the same after the crash.



Figure 9. Driver's integral seat belt

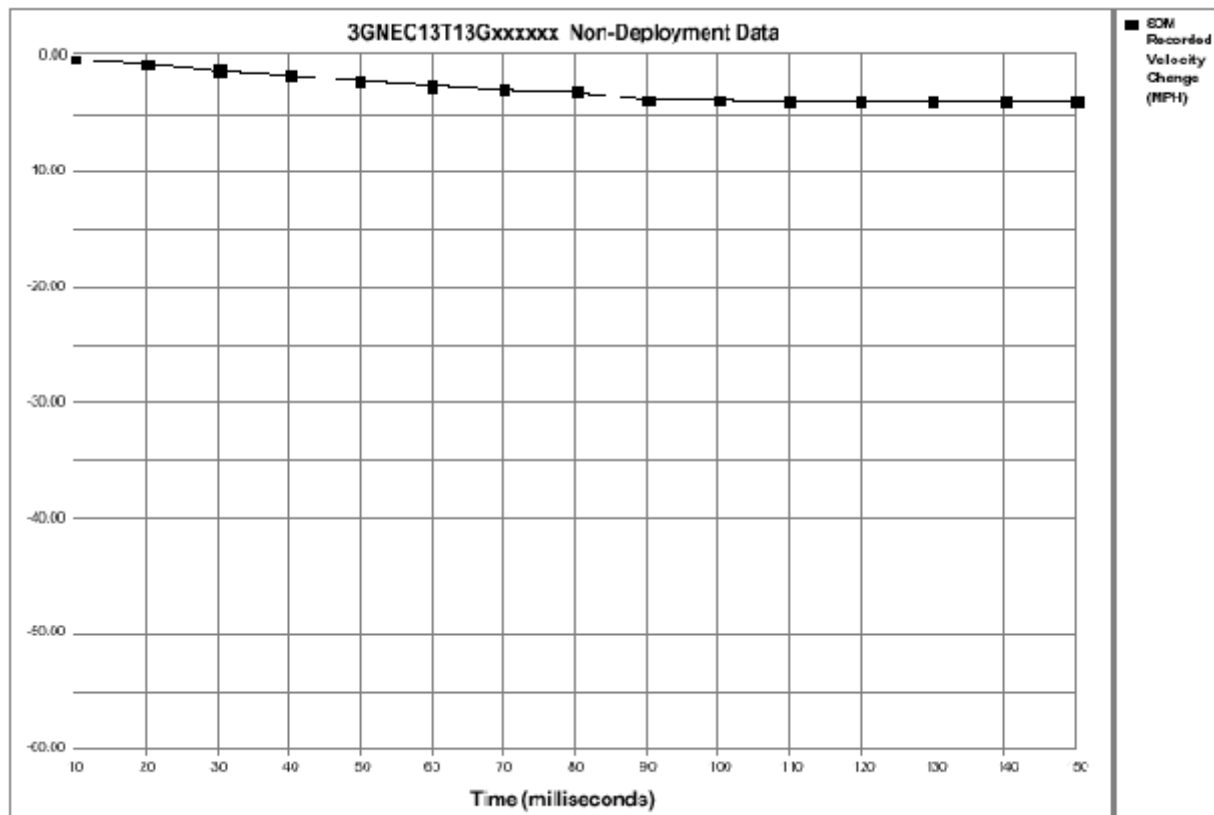


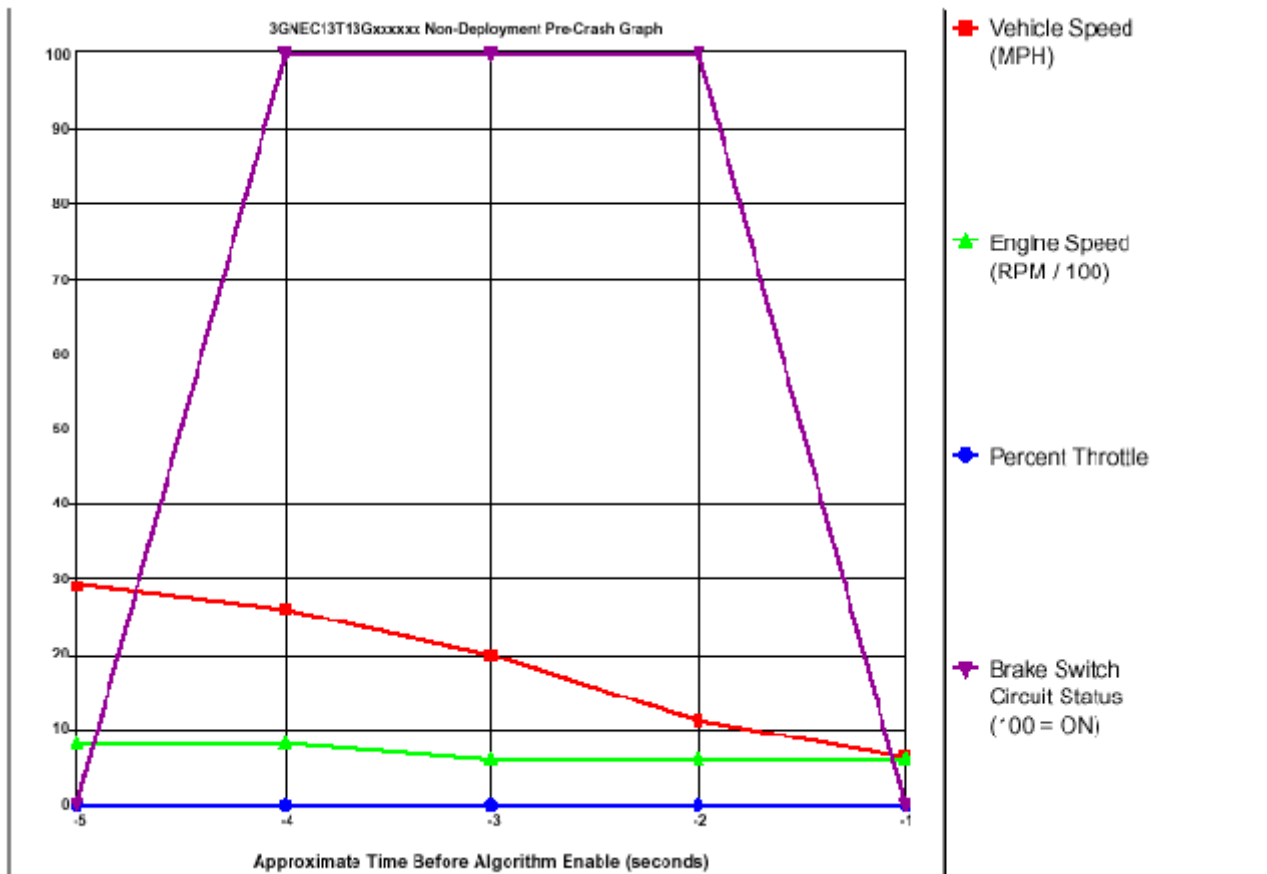
Figure 8. Left knee contact

Attachment 1. Vetronix Report

System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Non-Deployment	484
Ignition Cycles At Investigation	509
Maximum SDM Recorded Velocity Change (MPH)	-4.04
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	100
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	29	768	0	OFF
-4	26	768	0	ON
-3	20	576	0	ON
-2	11	640	0	ON
-1	6	640	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	-0.62	-1.24	-1.55	-2.17	-2.48	-2.79	-3.10	-3.72	-3.72	-4.03	-4.03	-4.03	-4.03	-4.03