

Certified Advanced 208 Compliant Vehicle Investigation/ Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: 2004-75-153E
2004 Chevrolet Silverado
Colorado
October, 2004

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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 two vehicle crash was identified by the local National Automobile Sampling System (NASS) Primary Sampling Unit (PSU). This was an SCI/NASS Combination case. This investigation focused on the performance of the air bag system in a Certified Advanced 208-Compliant (CAC) vehicle (2004 Chevrolet Silverado). The Chevrolet Silverado regular cab pickup was being driven by a restrained 42 year-old male. The Chevrolet rear-ended a 1989 Ford CF 8000 medium duty flat bed truck. The impact resulted in sufficient longitudinal deceleration of the Chevrolet to command the deployment of the frontal air bag system. The driver of the Chevrolet sustained minor injuries. He was transported to a local trauma center where he was treated and released.					
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Dynamic Science, Inc.
Crash Investigation
Case Number:2004-75-153E

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BACKGROUND:

This combination investigation focused on the performance of the air bag system in a Certified Advanced 208-Compliant (CAC) vehicle (2004 Chevrolet Silverado). The multi-stage air bags were certified by the manufacturer to meet the advanced air bag requirement of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The Chevrolet Silverado regular cab pickup was being driven by a restrained 42 year-old male (173 cm/68 in-110 kg/220 lbs). The driver was the lone occupant. The truck was equipped with a cap that enclosed the open bed of the truck. The Chevrolet rear-ended a 1989 Ford CF 8000 medium duty flat bed truck. The impact resulted in sufficient longitudinal deceleration of the Chevrolet to command the deployment of the frontal air bag system. The driver of the Chevrolet sustained minor injuries. He was transported to a local trauma center where he was treated and released.



Figure 1. Front, 2004 Chevrolet Silverado

This CAC Vehicle Investigation was identified by the local National Automobile Sampling System (NASS) Primary Sampling Unit (PSU). The case was assigned to DSI on December 4, 2004.

SUMMARY

Crash Site

This two vehicle crash occurred in Colorado in 2004, at 1307 hours. Both vehicles were traveling westbound on a divided, two lane interstate. The westbound lanes were separated from the eastbound lanes by a grassy, depressed center median. The posted speed limit was 105 km/h (65 mph). At the time of the crash the atmospheric conditions were conducive for travel. The asphalt pavement was dry and defect free. The roadway in the crash vicinity was straight, and free of any traffic control devices. There was a downhill negative grade of more than 2% noted at the crash location. The location of the crash was not a junction; there were no ramps within the area of the crash location for westbound vehicles operating on this side of the center median.



Figure 2. Approach to area of impact (west)

Pre-Crash

Both vehicles were proceeding westbound. The flatbed truck had been traveling in the outside through lane. The police estimated this vehicle's speed at 72 km/h (45 mph). The case vehicle was following some distance behind the truck, at a police determined travel speed of approximately 113 km/h (70 mph).

Crash

The case vehicle was following behind the flat bed truck. The driver of the case vehicle pulled into the inside passing lane, but was unable to overtake the flat bed truck due to a non-contact vehicle also traveling in the inside lane, which prevented his ability to pass the truck. Upon encountering this non-contact vehicle, the driver of the case vehicle swerved to the right in an attempt to avoid a collision with that vehicle. As the Chevrolet Silverado reentered the right outside lane, the front of this pick-up truck immediately struck the back plane of the flat bed truck (Event #1).

The front of the case vehicle (12FYAA6) struck and then under rode the rear of the Ford flat bed truck. There was extensive above bumper damage and the hood buckled rearward into the windshield. This generated a deployment event. The Electronic Data Recorder (EDR) reported a maximum Sensing and Diagnostic Module (SDM) recorded velocity change of -24.17 km/h (-15.02 mph). The driver's air bag deployed but the passenger air bag did not. The cut off switch was in the OFF position. There was a non-deployment event that was generated while both vehicles were engaged. A comparison of the pre-crash vehicle speeds found in the deployment and non deployment events would seem to indicate that the Silverado had decelerated from 113 km/h (70 mph) to 89 km/h (53 mph) at about the time of the non-deployment event.

Post-Crash

After rear-ending the other vehicle, the case vehicle came to final rest straddling the right through lane and paved right shoulder. The vehicle was facing in a northwesterly direction. The other vehicle came to a controlled stop on the right paved shoulder, some distance ahead of the case vehicle.

After the case vehicle came to a stop, the restrained driver was unable to exit his vehicle. This was the result of the driver's door being jammed shut, and the lateral intrusions of the toe pan in the area where he was seated. Although he was conscious, he was extricated by the fire department. He was subsequently transported to a trauma center, where he was treated for bilateral knee contusions (AIS1). Upon his arrival, he had a Glasgow Coma Scale score of 15- indicating appropriate eye, verbal, and motor responses. After being evaluated in the emergency room he was subsequently discharged. He lost one working day as a direct result of the crash.

Neither of the occupants in the Ford flat bed truck were injured.

VEHICLE DATA - 2004 Chevrolet Silverado

The 2004 Chevrolet Silverado 1500 regular cab pick-up truck was identified by the Vehicle Identification Number (VIN: 1GCEK14V24xxxxxx) at the time of the vehicle inspection.

The 2004 Chevrolet Silverado was equipped with a standard 4.8 L, V-8 MFI engine, an automatic transmission with 4 speed overdrive, ABS power brakes and power steering. It also was equipped with manual 3-point lap and shoulder belts in the outboard seating positions, and dual stage front air bags and a front-right passenger air bag shut off switch.

The odometer was observed to be 8,868 km (5,510 miles) at the time of the inspection.

The 2004 Chevrolet Silverado was equipped with Goodyear tires, with a numbers on the sidewall indicating they were all P245/75R16. This size conforms with the manufacturers label located on the inside of the door area. The specific tire data is as follows:

Tire	Tread	Measured pressure	Manufacturer recommended pressure
FL	7 mm (0.28 in)	Flat/holed	241 kPa (35 psi)
BL	7 mm (0.28 in)	276 kPa (40 psi)	241 kPa (35 psi)
FR	7 mm (0.28 in)	234 kPa (34 psi)	241 kPa (35 psi)
BR	6 mm (0.24 in)	Flat	241 kPa (35 psi)

The front seating positions in this Silverado were configured with a fabric split bench seat with folding backs. The outboard seats were equipped with adjustable head restraints. The seat track in the driver's area had the track position at the rearmost position, but this may have been altered by the fire department to facilitate the driver's removal during his extrication. There were no seat performance failures noted within the passenger compartment.

VEHICLE DAMAGE

Exterior Damage - 2004 Chevrolet Silverado

The case vehicle sustained considerable damage to the hood and other softer areas above the rigid bumper. Due to the height differential displayed by the direct contact with the back of the flat bed truck, crush measurements were taken at both the bumper and the stiffer above-bumper component, and then averaged in accordance with established protocols. The final crush measurements reflected these averaged values.

Damage Description: The vehicle sustained moderate damage. The bumper sustained only one area of crush; maximum crush of 2.0 cm (0.78 in) was measured at the front-left corner (C1), while the above bumper crush measured 17.0 cm (6.7 in)

CDC: 12FYAA6

Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

The vehicle sustained minor, almost non-existent damage to the bumper area. The only crush at this level was recorded at the front-left corner (C1) and was an insignificant 2.0 cm (0.8 in) in depth. The majority of the direct damage fell above the bumper, in the region of the hood. The hood was displaced rearward, which resulted in this vehicle component striking the windshield. The hood did not penetrate the glazing; no integrity loss resulted. Since the hood represented no structural rigidity, upper level C values were obtained by measuring the stiffer radiator support.

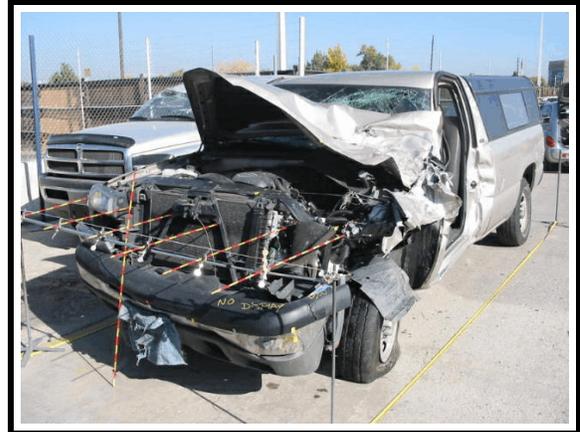


Figure 3. Front left, 2004 Chevrolet Silverado

The Direct L was 68.0 cm (26.8 in) and began at the front-left corner. The Field L encompassed the entire frontal plane, and was recorded as 186.0 cm (73.2 in), which was also width of the undeformed end plane. There was continual engagement between the front of the case vehicle and the back of the truck; the direct contact extended onto the A pillar and past the driver's door. Because the flat bed truck fell well outside the parameters of any acceptable speed reconstruction programs, and given the additional fact that the majority of the crush to the case vehicle occurred high up in the hood area, the Win Smash Reconstruction Program was not utilized. A review of the EDR data shows that the Chevrolet Silverado was traveling at 114.3 km/h (71 mph), 5 seconds prior to the Algorithm Enable (AE), and that there was no braking. This continued until 2 seconds before AE, when the braking switch circuit switch was now on, and the vehicle was

now traveling at 112.7 km/h (70 mph). Just prior to impact (AE at -1 second) braking continued, and the vehicle speed was now 85.3 km/h (53 mph).

Interior Damage - 2004 Chevrolet Silverado

The interior of the vehicle revealed a fabric split bench seat with folding back cushions which facilitated access to the storage area behind the front seat backs.

Position	Intruded Component	Magnitude of Intrusion	Direction
Front-left	Steering assembly	>=8 to <15 cm(3.1-5.9 in)	Vertical
Front-left	A pillar	Unknown	Unknown
Front-left	Hood	23.0 cm (9.1 in)	Longitudinally
Front-left	Windshield	29.0 cm (11.4 in)	Longitudinally
Front-left	L instrument panel	37.0 cm (14.6 in)	Longitudinally
Front-left	Toe pan	27.0 cm (10.6 in)	Longitudinally
Front-left	Windshield header	9.0 cm (3.5 in)	Longitudinally
Front-center	Windshield	17.0 cm (6.7 in)	Longitudinally
Front-right	Windshield	15.0 cm (5.9 in)	Longitudinally
Front-center	Windshield header	3.0 cm (1.2 in)	Longitudinally
Front-center	C Instrument panel	5.0 cm (2.0 in)	Longitudinally
Front-right	R Instrument panel	4.0 cm (1.6 in)	Longitudinally

Although the A pillar had been displaced rearward for approximately 20.0 cm (7.9 in), it must be noted that the A pillar falls outside of the normal passenger compartment area. Therefore, this longitudinal displacement was not encoded on the intrusion table. As the A pillar was moving rearward, it may have also been displaced both laterally and vertically; the amount of the intrusion could not be ascertained from the accompanying photos.



Figure 4. Left side, 2004 Chevrolet Silverado

MANUAL RESTRAINT SYSTEMS - 2004 Chevrolet Silverado

The vehicle is equipped with 3-point manual lap and shoulder safety belts in the outboard seating positions, and a lap belt in the center area. There are no shoulder belt adjusters present in this vehicle.

The driver side lap and shoulder belt had been worn during the collision. At the time of the inspection the webbing had been cut by the emergency medical personnel to facilitate in the removal of the driver. No seat belt failures were noted.

FRONTAL AIR BAG SYSTEM - 2004 Chevrolet Silverado

The case vehicle was equipped with advanced, dual stage driver and front right passenger air bags. The driver's air bag was mounted in the steering wheel hub. The deployed driver's air bag was round. The dual module cover flaps opened in an "I" type configuration. There were no indications of any damage to driver's air bag or the module cover flaps. The front right passenger air bag was a mid instrument panel mount. The front right air bag switch was set in the OFF position and the air bag was suppressed.



Figure 5. Driver's air bag

The case vehicle was equipped with advanced occupant protection systems. The systems consists of the SDM, dual stage driver and front right passenger air bags with a passenger air bag Off Switch, 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 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. For non-deployments the SDM will record the first 150 milliseconds after algorithm enable. The SDM data was downloaded using the Vetronix Crash Data Retrieval System. The Vetronix report indicates that there were two events. The first event was with the Ford Truck. This event was then locked into the recorder. The second event occurred while both vehicles were still engaged and the vehicles were decelerating. Both events occurred within the same ignition cycle.



Figure 6. Front right passenger area—shows non deployment of front right passenger air bag

Deployment Event

1. The SIR warning lamp status was OFF.
2. The driver's belt switch circuit status was BUCKLED.
3. Ignition cycles at deployment were 3186.
4. Ignition cycles at investigation were 3187.
5. Maximum SDM recorded velocity change was -24.17 km/h (-15.02 mph).
6. The time from algorithm enable (AE) to maximum recorded velocity change was 215 milliseconds
7. Driver first stage time algorithm enabled to deployment command criteria met was 12.5 milliseconds.
8. Driver's second stage time algorithm enable to deployment command criteria met was not applicable.
9. Passenger first stage time algorithm enabled to deployment command was SUPPRESSED.
10. Passenger second stage time algorithm enabled to deployment command was not applicable.
11. The brake switch circuit status was OFF five seconds before AE.
12. The vehicle speed was a 114 km/h (71 mph) km/h from five seconds before AE to 113 km/h (70 mph) one second before AE.

Non Deployment Event

1. The SIR warning lamp status was OFF.
2. The driver's belt switch circuit status was BUCKLED.
3. Ignition cycles at deployment were 3186.
4. Ignition cycles at investigation were 3187.
5. Maximum SDM recorded velocity change was -1.59 km/h (-0.99 mph).
6. The time from algorithm enable (AE) to maximum recorded velocity change was 110 milliseconds.
7. The brake switch circuit status was OFF five seconds before AE and continued OFF until two seconds prior to AE.
8. The vehicle speed was 114 km/h (71 mph) five seconds before AE. The vehicle speed decelerated to 85 km/h (53 mph) one second before AE.

VEHICLE DATA - 1989 Ford flat bed truck

Description:	1989 Ford CF 8000 flat bed truck	
VIN:	9BFXH81A9Kxxxxxx	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	None reported on the PAR	
Cargo:	Unknown	
Damage Description:	Unknown	
TDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

This vehicle falls outside the parameters of the NASS researcher program; it is a medium size flat bed truck. It was therefore not inspected, nor were the occupants in the vehicle interviewed. The information encoded within this report has been provided from the police report.

OCCUPANT DEMOGRAPHICS - 2004 Chevrolet Silverado

	Driver
Age/Sex:	42/Male
Seated Position:	Front-left (driver)
Seat Type:	Fabric split bench with folding back
Height:	173 cm (68 in)
Weight:	100 kg (220 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None reported
Alcohol/Drug Involvement:	None per the PAR
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Right foot on the brake
Restraint Usage:	Lap and shoulder belt
Air bag:	Yes-steering wheel mounted air bag deployed. The front-right air bag did not deploy

The restrained driver was the lone occupant in the case vehicle.

OCCUPANT DEMOGRAPHICS - 1989 Ford flat bed truck

Age/Sex:	Unknown/Male	Unknown/Unknown
Seated Position:	Front-left (driver)	front-right
Seat Type:	Unknown	Unknown
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	Unknown	Unknown
Pre-existing Medical Condition:	Unknown	Unknown
Alcohol/Drug Involvement:	None	Did not indicate
Driving Experience:	Unknown	Unknown
Body Posture:	Unknown	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Unknown	Unknown

This vehicle contained a total of two occupants. There is no additional information available, other than the fact that neither of them were injured.

OCCUPANT INJURIES - 2004 Chevrolet Silverado

Driver: Injuries were obtained both from the emergency room records and an interview with the driver.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Lower extremity skin contusion	8904021	Knee bolster	Certain
Lower extremity skin contusion	8904021	Knee bolster	Certain

This restrained driver sustained knee bruising from contacting the rigid plastic knee bolster. Although he was conscious after the collision, he remained inside the vehicle until his extrication by the fire department and emergency medical personnel. After being transported by ambulance to a local trauma center, he was treated in the emergency room and then discharged. He subsequently lost one day of work as a result of this crash.

OCCUPANT KINEMATICS - 2004 Chevrolet Silverado**Driver kinematics**

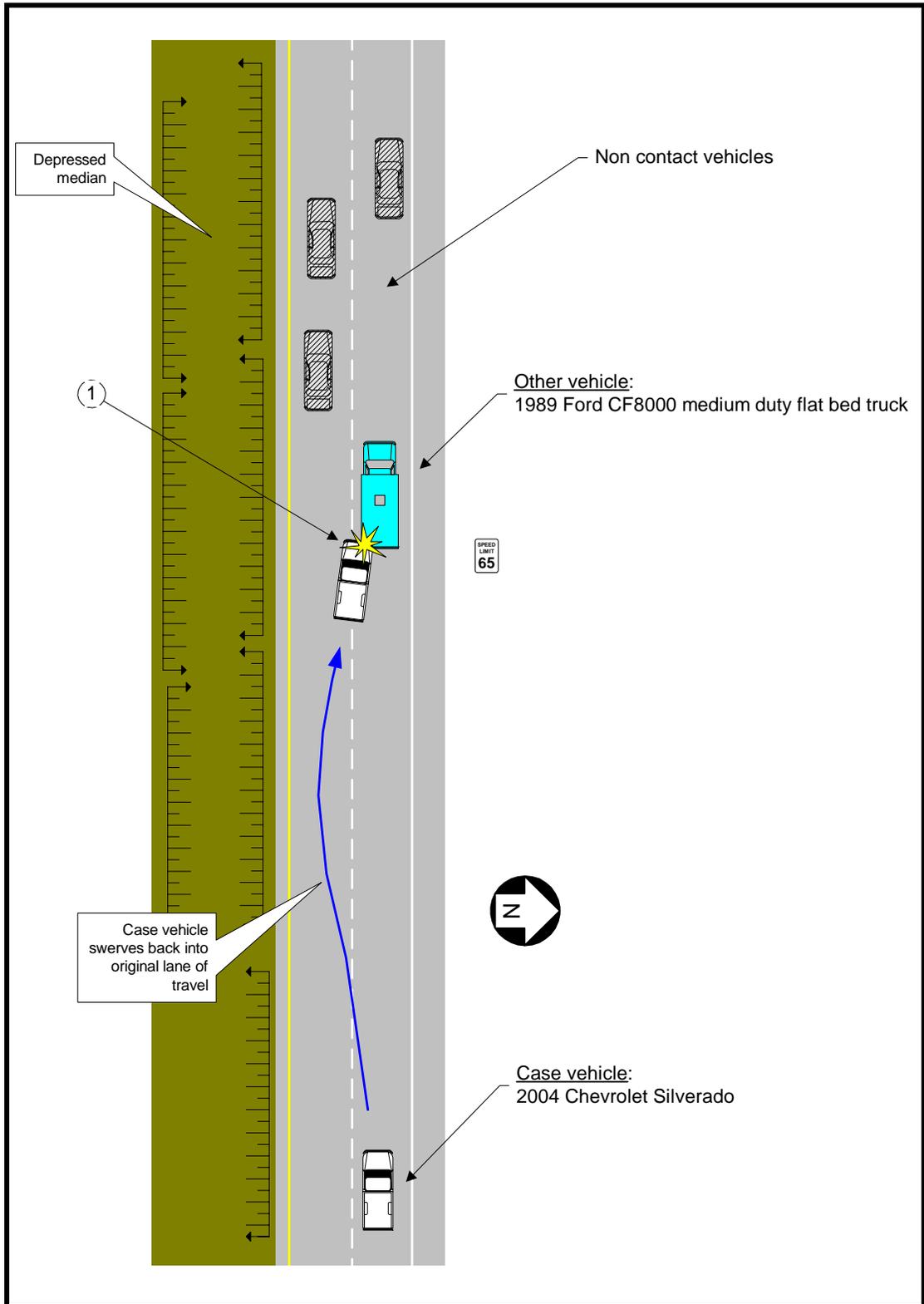
Prior to the crash, the upright driver had been seated squarely behind the wheel, with his seat back slightly reclined for comfort. He reported that his back was against the seat back at impact. Both his hands were on the wheel, and his right foot had gone to the brake pedal just prior to the collision. He was wearing the available 3-point manual lap and shoulder safety belt system.

The driver likely loaded the shoulder and lap belt webbing as he moved forward during the 12 o'clock impact. The manual 3-point lap and shoulder belt also performed very well. It kept the driver behind the wheel, and in his seat, through impact to final rest. The webbing had to be cut from around the driver to facilitate his removal from the case vehicle, indicating that it remained attached throughout the crash sequence. None of the seat belt systems failed during the frontal impact with the rear of the flat bed truck.

At impact the steering wheel mounted air bag deployed. This component prevented the driver's head, which had initiated a forward trajectory, from sustaining any trauma; it did not allow his upper extremities to come into contact with the steering wheel. The air bag performed as designed; no defects were observed.

While this safety system prevented the driver from moving forward into the instrument panel, there were longitudinal intrusions from the rigid knee bolster, the windshield, and the steering assembly which were decreasing the size of the passenger compartment in which the driver was seated. As a result of these intrusions, the driver sustained knee contusions from coming into contact with the rigid plastic knee bolster.

Attachment 1. Scene Diagram

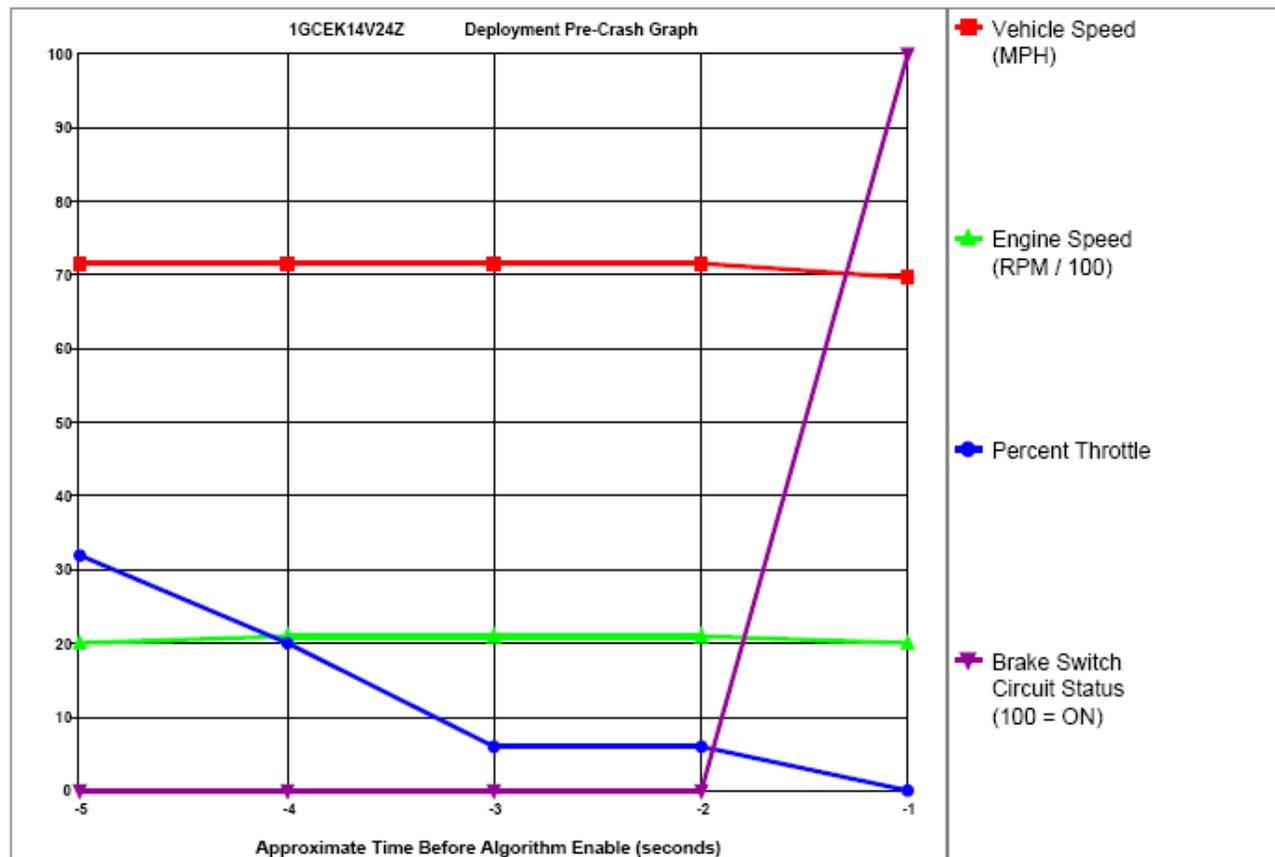


Attachment 2. Vertronix report**CDR File Information**

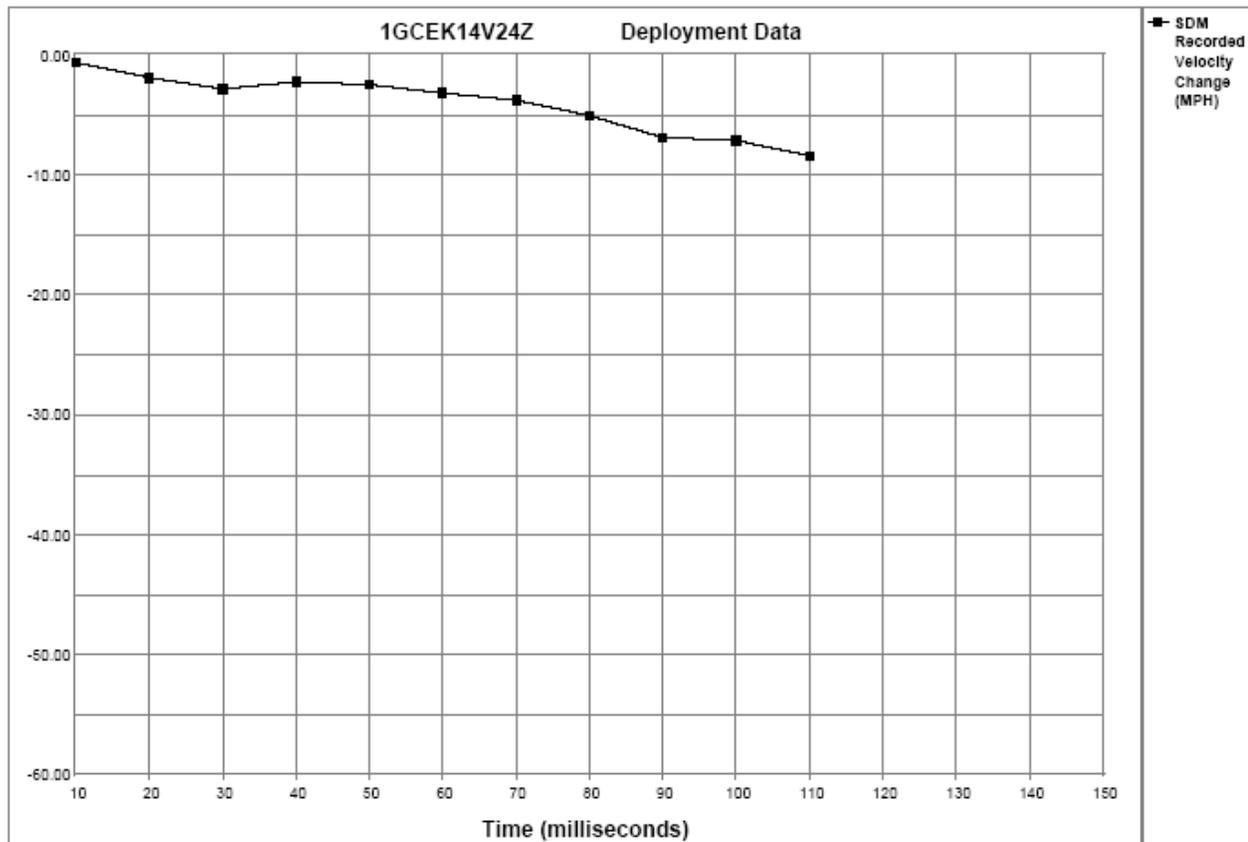
Vehicle Identification Number	.GCEK14V24Z
Investigator	
Case Number	153f
Investigation Date	Tuesday, October 12 2004
Crash Date	Tuesday, October 5 2004
Filename	2004-78-153 WITHOUT SEQUENCE NUMBER.CDR
Saved on	Tuesday, October 12 2004 at 08:59:28 AM
Data check information	22280739
Collected with CDR version	Crash Data Retrieval Tool 2.24
Collecting program verification number	70CD83DD
Reported with CDR version	Crash Data Retrieval Tool 2.50
Reporting program verification number	30CAB595
Interface used to collected data	Block number: 00 Interface version: 39 Date: 10-09-03 Checksum: 0300
Event(s) recovered	Deployment Non-Deployment

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	3186
Ignition Cycles At Investigation	3187
Maximum SDM Recorded Velocity Change (MPH)	-15.02
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	215
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	12.5
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)	N/A
Frontal Deployment Level Event Counter	1
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No



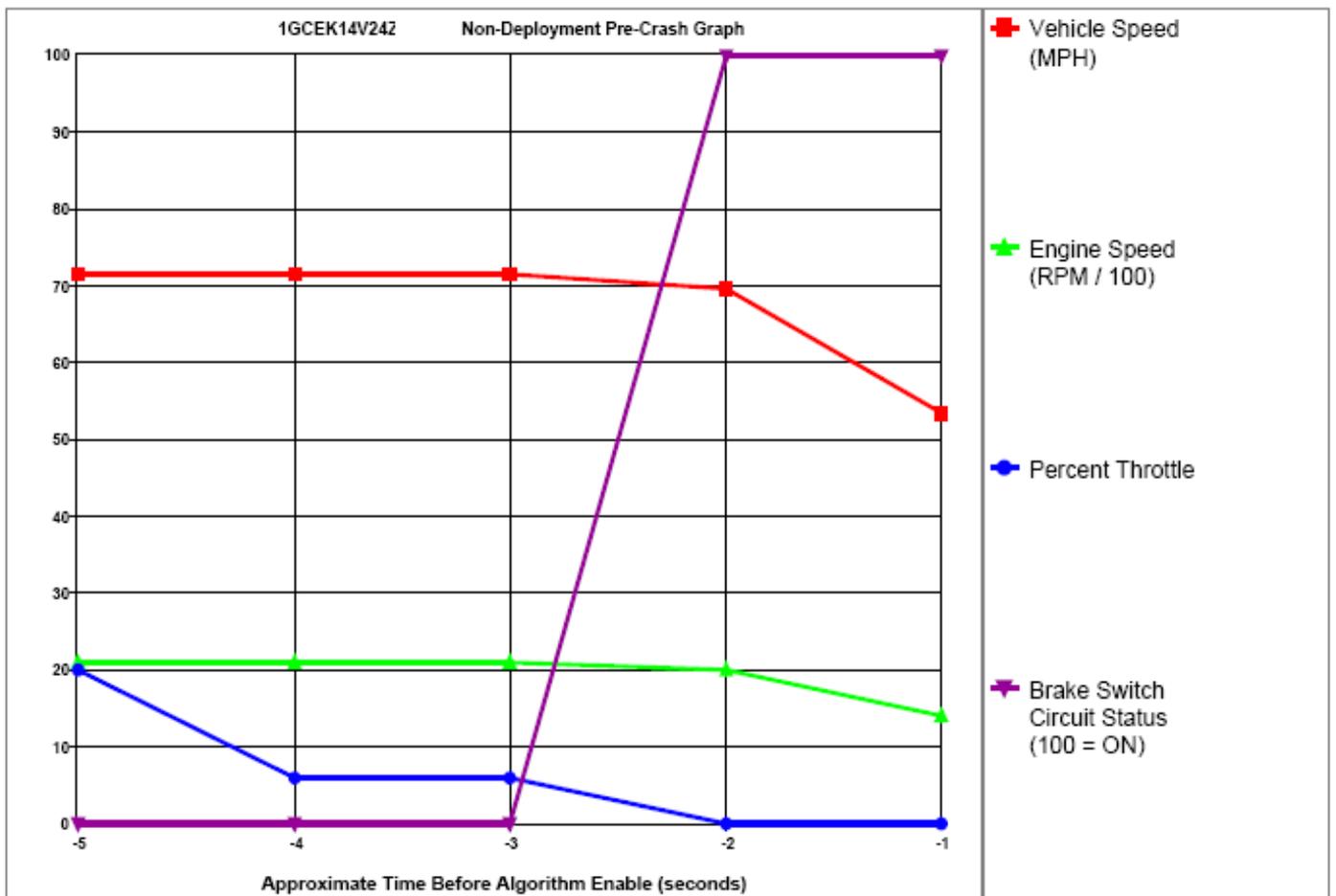
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	71	2048	32	OFF
-4	71	2112	20	OFF
-3	71	2112	6	OFF
-2	71	2112	6	OFF
-1	70	1984	0	ON



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.62	-1.86	-2.79	-2.17	-2.48	-3.10	-3.72	-4.96	-6.82	-7.13	-8.37	N/A	N/A	N/A	N/A

System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Non-Deployment	3186
Ignition Cycles At Investigation	3187
Maximum SDM Recorded Velocity Change (MPH)	-0.99
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	110
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	71	2112	20	OFF
-4	71	2112	6	OFF
-3	71	2112	6	OFF
-2	70	1984	0	ON
-1	53	1408	0	ON



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	0.00	-0.31	-0.31	-0.31	-0.31	-0.62	-0.62	-0.62	-0.62	-0.62	-0.93	N/A	N/A	N/A	N/A