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ON-SITE ADVANCED OCCUPANT PROTECTION SYSTEM INVESTIGATION

CASE NUMBER - IN-02-017
LOCATION - TEXAS
VEHICLE - 2002 CHEVROLET TAHOE
CRASH DATE - November 2002

Submitted:

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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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16. <i>Abstract</i> This report covers an on-site investigation of an air bag deployment crash involved a 2002 Chevrolet Tahoe (case vehicle) and a 1986 Jeep Wagoneer Limited (other vehicle). This crash is of special interest because the case vehicle was equipped with multiple <u>A</u> dvance <u>O</u> ccupant <u>P</u> rotection <u>S</u> ystem (AOPS) features as well as an <u>E</u> vent <u>D</u> ata <u>R</u> ecorder (EDR) and the case vehicle's driver (36-year-old, male) did not sustain any injuries as a result of this crash. The trafficway on which both vehicles were traveling was a ten-lane, divided, Interstate trafficway, traversing in a north-northwesterly and south-southeasterly direction. Both the northern and southern roadways had five through lanes. The case vehicle was traveling in a southerly direction in the inside center through lane of the southern roadway. The Jeep was disabled (i.e., stopped), heading south-southeast in the inside center lane of the same southern roadway. The crash occurred in the inside center southerly lane of the southern roadway. The front of the case vehicle impacted the back of the Jeep, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Furthermore, the right front and left front, seat back-mounted side impact air bags did not deploy. The case vehicle's driver was seated with his seat track located in its rearmost position, and the tilt steering wheel was located in its down-most position. He was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system, and he did not sustain any injuries as a result of this crash.					
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TABLE OF CONTENTS

IN-02-017

	<u>Page No.</u>
BACKGROUND	1
SUMMARY	1
CRASH CIRCUMSTANCES	5
CASE VEHICLE: 2002 CHEVROLET TAHOE	7
CASE VEHICLE DAMAGE	8
AUTOMATIC RESTRAINT SYSTEM	10
CRASH DATA RECORDING	11
CASE VEHICLE DRIVER KINEMATICS	12
CASE VEHICLE DRIVER INJURIES	13
OTHER VEHICLE: 1986 JEEP WAGONEER LIMITED	13
EVENT DATA RECORDER DATA	15
CRASH DIAGRAM	17
SELECTED PHOTOGRAPHS	
Figure 1: Case vehicle’s southerly travel path in inside center lane	5
Figure 2: Case vehicle’s frontal damage with contour gauge present at bumper level	6
Figure 3: Case vehicle’s frontal damage viewed from left of front	6
Figure 4: Jeep’s back damage with contour gauge present at bumper level	6
Figure 5: Jeep’s back damage viewed from right of back	6
Figure 6: Case vehicle’s second seating area showing missing adjustable head restraint	7
Figure 7: Lap portion of case vehicle’s driver integral safety belt anchored within seat cushion	7
Figure 8: Tether attached to torso portion of case vehicle’s second seat left safety belt	7
Figure 9: Case vehicle’s non-deployed left front seat back-mounted side impact air bag	8

SELECTED PHOTOGRAPHS (Continued)		<u>Page No.</u>
Figure 10:	Case vehicle’s non-deployed right front seat back-mounted side impact air bag	8
Figure 11:	Overhead view of case vehicle’s frontal damage showing width of direct damage	8
Figure 12:	Case vehicle’s frontal damage viewed along reference line from right	9
Figure 13:	Case vehicle’s driver seating area show no apparent contact evidence	10
Figure 14:	Case vehicle’s front right seating area showing no apparent contact evidence	10
Figure 15:	Front surface of case vehicle’s deployed driver air bag showing no apparent evidence of occupant contact	11
Figure 16:	Front surface of case vehicle’s front right passenger air bag showing no apparent evidence of occupant contact	11
Figure 17:	Top surface of case vehicle’s front right passenger air bag showing no apparent evidence of occupant contact	11
Figure 18:	Loading evidence on webbing of shoulder portion of case vehicle’s driver safety belt	12
Figure 19:	Overhead view of Jeep’s back damage	13
Figure 20:	Jeep’s back damage viewed along reference line from left	13
Figure 21:	EDR–Speed, brake switch status, restraint usage, and Delta V	15
Figure 22:	EDR–Case vehicle’s pre-crash travel speed and brake switch status	16
Figure 23:	EDR–Case vehicle’s Delta V versus Delta T	16

This investigation was brought to NHTSA's attention on November 20, 2002 by NASS CDS/GES sampling activities. This crash involved a 2002 Chevrolet Tahoe (case vehicle) and a 1986 Jeep Wagoneer Limited (other vehicle). The crash occurred in November 2002, at 2:45 a.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with multiple Advance Occupant Protection System (AOPS) features as well as an Event Data Recorder (EDR) and the case vehicle's driver [36-year-old, White (Hispanic) male] did not sustain any injuries as a result of this crash. This contractor inspected the scene and vehicles on 25-26 November 2002 and downloaded the data from the onboard **EDR**. This contractor interviewed the driver of the case vehicle on November 26, 2002. This summary is based on the Police Crash Report, an interview with the case vehicle's driver, scene and vehicle inspections, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

Crash Environment: The trafficway on which both vehicles were traveling was a ten-lane, divided, Interstate trafficway, traversing in a north-northwesterly and south-southeasterly direction. Both the northern and southern roadways had five through lanes. At the time of the crash the light condition was dark, but illuminated by overhead lamps at the area of impact, the atmospheric condition was cloudy, and the roadway pavement was dry. Traffic density was most likely light, and the site of the crash was urban commercial; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle was traveling in a southerly direction in the inside center through lane of the southern roadway and intended to proceed straight ahead. The Jeep was disabled (i.e., stopped), heading south-southeast in the inside center lane of the same southern roadway. According to his interview, the case vehicle's driver braked and, based on the offset nature of the impact, most likely steered slightly to the left, attempting to avoid the crash. The crash occurred in the inside center southerly lane of the southern roadway.

Crash: The front of the case vehicle impacted the back of the Jeep, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Furthermore, the right front **and** left front, seat back-mounted side impact air bags did not deploy.

Post-Crash: The exact final rest position of both vehicles is unknown (i.e., the Police Crash Report is silent, the case vehicle's driver has no recollection, and no physical evidence was present at the scene). Based on the crash dynamics, the case vehicle most likely continued south-southeastward post-impact and came to rest heading in a southerly direction in the same, inside center, through lane. The Jeep was pushed forward an unknown distance and most likely also came to rest heading in a southerly direction in the inside center through lane of the southern roadway.

Case Vehicle: The 2002 Chevrolet Tahoe was a rear wheel drive, four-door sport utility vehicle (VIN: 1GNEC13ZX2R-----). The case vehicle was equipped with four-wheel, anti-lock brakes, redesigned front air bags, and front seat back-mounted side impact air bags. In addition, the case

vehicle was equipped with Child seat tether anchors for the second seating area. Finally, the case vehicle was also equipped with an Event Data Recorder (**EDR**).

Vehicle Exterior: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-2 (0 degrees)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The preliminary Total, Longitudinal, and Lateral Delta Vs are, respectively: 32.0 km.p.h. (19.9 m.p.h.), -32.0 km.p.h. (-19.9 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was towed due to damage.

Exterior Damage: The case vehicle's contact with Jeep involved the entire front with the damage distributed all the way across. Direct damage began at the front right bumper corner and extended 130 centimeters (51.2 inches) inward along the front bumper. Crush measurements were taken on the bumper and along the upper radiator support and, where appropriate, the values were averaged. Residual maximum crush at the bumper was measured as 28 centimeters (11.0 inches) at C₆. Above the bumper the residual maximum crush was measured as 50 centimeters (19.7 inches) at C₆. The average residual maximum crush at C₆ was 39 centimeters (15.4 inches). The wheelbase on the case vehicle's left side was shortened approximately 1 centimeter (0.4 inches) while the right side was extended approximately 2 centimeters (0.8 inches). The case vehicle's front bumper, bumper fascia, grille, hood, radiator, and the right headlight and turn signal assemblies were directly damaged and crushed rearward. The left headlight and turn signal assemblies sustained induced damage as well as both the right and left fenders. The windshield glazing was cracked from contact by the back edge of the hood. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

The case vehicle manufacturer's recommended tire size was: P245/75R16, but tire size: P265/70R16, was optional; the case vehicle was equipped with tire size: P265/70R16. The case vehicle's tire data are shown in the table below. In addition, the case vehicle's right front tire was damaged (i.e., cut sidewall), deflated, and physically restricted.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	207	30	241	35	7	9	None	No	No
RF	0	0	241	35	8	10	Sidewall cut	Yes	Yes
LR	200	29	241	35	8	10	None	No	No
RR	200	29	241	35	8	10	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior revealed that there was no evidence of occupant contact on the interior surfaces of the case vehicle. In addition, there was no evidence of intrusion to the case vehicle's interior, no evidence of compression to the energy absorbing shear capsules in the steering column, and no deformation to the steering wheel rim.

Supplemental Restraints: The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with four tethers, each approximately 10 centimeters (3.9 inches) in width. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 63 centimeters (24.8 inches). An inspection of the driver's air bag fabric revealed no contact evidence readily apparent on the air bag's fabric.

The front right passenger's air bag was located in the middle of the instrument panel. An inspection of the front right air bag module's cover flap and the air bag's fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 4 centimeters (1.6 inches) in diameter, located at the 9:30 and 2:30 clock positions. The deployed front right air bag was rectangular with a height of approximately 54 centimeters (21.3 inches) and a width of approximately 57 centimeters (21.7 inches). An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the front right air bag's fabric.

Crash Data Recording: The data downloaded from the case vehicle's **EDR** showed the vehicle's SIR warning lamp status, driver's seat belt buckle status, ignition cycles at deployment, time from algorithm enable to deployment (i.e., air bag deployments) and velocity change (i.e., Delta V). Downloaded data of interest indicated the following. The case vehicle was traveling at a speed of 151 km.p.h. (94 m.p.h.), the driver's seat belt status showed it was buckled, and the Delta V had reached a value of 23.3 km.p.h. (14.5 m.p.h.) at the 110 millisecond mark of recorded data; see **EVENT DATA RECORDER DATA** below. This contractor believes that the recorded Delta V seems reasonable considering the amount of deformation to both vehicles and the limitations on the **EDR**'s recording time.

Other Vehicle: The 1986 Jeep Wagoneer Limited was a rear wheel drive, four-door sport utility vehicle (VIN: 1JCHC7565GT-----). The Jeep was not equipped with anti-lock brakes. Based on the vehicle inspection, the CDC for the Jeep was determined to be: **06-BDEW-4 (180 degrees)**. The WinSMASH reconstruction program, damage only algorithm, was used on the Jeep's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 54.0 km.p.h. (33.6 m.p.h.), +54.0 km.p.h. (+33.6 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The Jeep was towed due to damage.

Exterior Damage: The Jeep's contact with the case vehicle involved the entire back with the damage distributed all the way across. Direct damage began at the back left corner and extended inward a distance of 141 centimeters (55.5 inches) along the back bumper. Residual maximum crush was 61.0 centimeters (24.0 inches) at C₁. The wheelbase on the Jeep's left side was shortened 38 centimeters (15.0 inches) while the right side was shortened 7 centimeters (2.8 inches). The Jeep's back bumper, bumper fascia, liftgate, backlite, and the left and right brake lights, reverse light, and turn signal assemblies were directly damaged and crushed forward. Both

the right and left quarter panels sustained induced damage as well as both left doors, the left outside rearview mirror, and the right rear door. Remote buckling was also found on the left roof, just forward of the left “B”-pillar.

The Jeep manufacturer’s recommended tire size was: P205/75R15, but the Jeep was equipped with tire size: P225/75R15. The Jeeps’s tire data are shown in the table below.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	138	20	207	30	4	5	None	No	No
RF	83	12	207	30	2	3	None	No	No
LR	0	0	207	30	4	5	Cut	Yes	Yes
RR	0	0	207	30	6	8	None	No	Yes

Case Vehicle’s Driver: Immediately prior to the crash the case vehicle's driver [36-year-old, White (Hispanic) male; 170 centimeters and 86 kilograms (67 inches, 190 pounds)] was seated in a slightly reclined posture with his back against the seat back, his left foot on the floor, his right foot on the brake, and at least one hand was most likely on the steering wheel. Based on the driver’s interview, he does not recall either the exact positions of his hands or the position of his seat track just prior to the crash. During the vehicle inspection, the driver’s seat track was located in its rearmost position, the seat back was slightly reclined, the tilt steering wheel was located in its down-most position.

Based on this contractor’s vehicle inspection and supported by the **EDR** data, the case vehicle's driver was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system. Furthermore, the inspection of the driver’s seat belt webbing, shoulder belt guide, and latch plate showed trace evidence of loading (i.e., a very slight scuff/burn to the webbing).

The case vehicle's driver braked (without lock-up) and most likely steered slightly to his left, attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the use of his available safety belts, he most likely moved slightly forward just prior to impact. The case vehicle's primary impact with the Jeep enabled the case vehicle’s driver to continue forward toward the case vehicle’s 0 degree Direction of Principal Force as the case vehicle decelerated. As a result, the driver loaded his safety belts and subsequently contacted his deploying driver air bag. The driver’s probable seat track location combined with his restraint usage allowed the driver to minimize his interaction with the deploying driver air bag. The case vehicle’s driver rebounded backward toward his seat back as a result of loading his safety belts and interacting with the deploying air bag. The exact posture of the case vehicle’s driver at final rest is unknown, but he

was most likely seated in his seat near his original pre-crash position. The driver exited the case vehicle without assistance.

The driver was not transported by ambulance to a medical facility and did not seek medical treatment. The case vehicle's driver did not sustain any injuries as a result of this crash.

Jeep's Occupants: Based on the Police Crash Report, there were no occupants in the Jeep at the time of the crash.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was a ten-lane, divided, Interstate trafficway, traversing in a north-northwesterly and south-southeasterly direction. Both the northern and southern roadways had five through lanes (**Figure 1**). The interstate highway was straight at the location of the impact and level (i.e., actual slope was 1.6%, negative to the south) near the area of impact. The pavement was bituminous, but traveled, and the width of the travel lanes (i.e., all five) for both vehicles was most likely 3.7 meters (12 feet). The shoulders were improved (i.e., bituminous), but their width was not determined. On the western side of the southern roadway there was a grassy area that began after the shoulder and this area separated the roadway from a frontage road. On the eastern side of the southern roadway a longitudinal barrier (i.e., concrete) near the middle of the unknown width, paved median protected the southern roadway from the northern roadway. Pavement markings for the roadway consisted of a solid yellow edge line on the eastern side and a solid white edge line on western side. In addition, the five through lanes were each separated by a dashed white line and raised pavement markers. The estimated coefficient of friction was 0.70. There were no visible traffic controls in the immediate area of the crash. The statutory speed limit was 97 km.p.h. (60 m.p.h.). No regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was dark, but illuminated by overhead lamps at the area of impact, the atmospheric condition was cloudy, and the roadway pavement was dry. Traffic density was most likely light, and the site of the crash was urban commercial; see **CRASH DIAGRAM** at end.

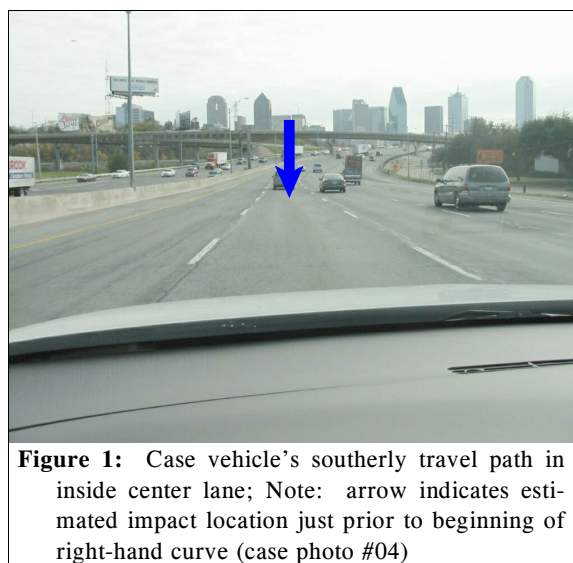


Figure 1: Case vehicle's southerly travel path in inside center lane; Note: arrow indicates estimated impact location just prior to beginning of right-hand curve (case photo #04)

Pre-Crash: The case vehicle was traveling in a southerly direction in the inside center through lane of the southern roadway and intended to proceed straight ahead (**Figure 1**). The Jeep was disabled (i.e., stopped), heading south-southeast in the inside center lane of the same southern roadway. According to his interview, the case vehicle's driver braked and, based on the offset nature of the impact, most likely steered slightly to the left, attempting to avoid the crash. The crash occurred in the inside center southerly lane of the southern roadway.

Crash: The front (Figures 2 and 3) of the case vehicle impacted the back (Figures 4 and 5) of the Jeep, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Furthermore, the right front and left front, seat back-mounted side impact air bags did not deploy.



Figure 2: Case vehicle's frontal damage with contour gauge present at bumper level; Note: rightward shift to hood, slight upward rotation of front bumper, and yellow tape (arrows) marks width of direct damage on bumper (case photo #06)



Figure 3: Case vehicle's frontal damage viewed from left of front with contour gauge present at bumper level; Note: rightward offset nature of impact, resulting in rightward shift of hood and more crush to front right corner (case photo #15)



Figure 4: Jeep's back damage with contour gauge present at bumper level; Note: crush to left "D"-pillar and obliterated liftgate and backlite (case photo #72)



Figure 5: Jeep's back damage viewed from right of back with contour gauge at bumper level showing leftward offset nature of impact, greater crush to back left corner, and damaged left "D"-pillar (case photo #73)

Post-Crash: The exact final rest position of both vehicles is unknown (i.e., the Police Crash Report is silent, the case vehicle's driver has no recollection, and no physical evidence was present at the scene). Based on the crash dynamics, the case vehicle most likely continued south-southeastward post-impact and came to rest heading in a southerly direction in the same, inside center, through lane. The Jeep was pushed forward an unknown distance and most likely also came to rest heading in a southerly direction in the inside center through lane of the southern roadway.

The 2002 Chevrolet Tahoe was a rear wheel drive, eight-passenger, four-door sport utility vehicle (VIN: 1GNEC13ZX2R-----) equipped with a 5.3L, V-8 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front disc and rear disc, four-wheel, anti-lock system. The case vehicle was equipped with advanced occupant protection system features including redesigned air bags, and front seat back-mounted side impact air bags. In addition, the case vehicle was equipped with child seat tether anchors for the second seating area. Finally, the case vehicle was also equipped with an Event Data Recorder (EDR). The case vehicle's wheelbase was 295 centimeters (116.0 inches), and the odometer reading at inspection is unknown because the case vehicle was equipped with an electronic odometer.

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; a non-adjustable second row bench seat with adjustable head restraints for the second seat's outboard seating positions; and a non-adjustable back bench seat with adjustable head restraints for the back outboard seating positions. It should be noted that the adjustable head restraint for the second seat right seating position was not present (**Figure 6**). This head restraint had been removed prior to the crash. The exact position adjustment for any of the adjustable head restraints was not determined. There were continuous loop, three-point, lap-and-shoulder, safety belt systems at the front, second seat, and back outboard positions; and a two-point, lap belt system at the second seat center and back center positions. For the front and back seats, the safety belt systems were integral. Furthermore, for the front seats, the lap portion was anchored on the side of the seat's cushion (**Figure 7**). In addition, the torso portion of the second seat's safety belt system was tethered to the "C"-pillar (**Figure 8**). The seat belt systems were not equipped with upper anchorage adjusters for the "D"-rings. The



Figure 6: Case vehicle's second seating area showing missing adjustable head restraint (see arrows) for right-most seating position and non-integral safety belt system (case photo #55)



Figure 7: Lap portion of case vehicle's driver integral safety belt anchored within seat cushion (case photo #39)



Figure 8: Tether attached to torso portion of Case vehicle's second seat left safety belt; Note: integral safety belt for back left seating position in background (case photo #56)

vehicle was equipped with knee bolsters for both the driver and front right seating positions, and neither of which showed evidence of contact or deformation. Automatic restraint was provided by a Supplemental Restraint System (SRS) that consisted of a redesigned frontal air bag for the driver and front right passenger seating positions. In addition, the vehicle was equipped with front, seat back-mounted, side impact air bags. Both frontal air bags deployed as a result of the case vehicle's frontal impact with the Jeep. Neither of the front seat back-mounted side impact air bags deployed as a result of the case vehicle's frontal impact with the Jeep (**Figures 9 and 10**).



Figure 9: Case vehicle's non-deployed left front seat back-mounted side impact air bag (case photo #37)

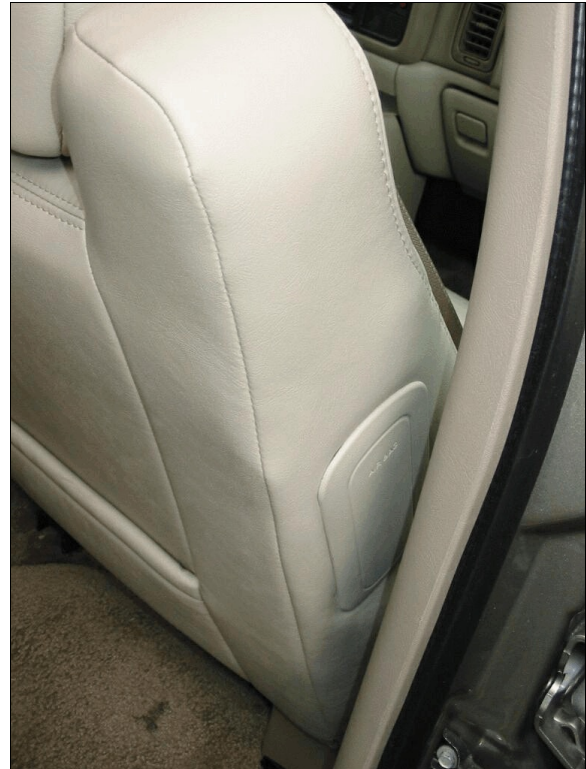


Figure 10: Case vehicle's non-deployed right front seat back-mounted side impact air bag (case photo #36)

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's contact with Jeep involved the entire front with the damage distributed all the way across (**Figures 2 and 3** above). Direct damage began at the front right bumper corner and extended 130 centimeters (51.2 inches) inward along the front bumper (**Figure 11**). Crush measurements were taken on the bumper and along the upper radiator support

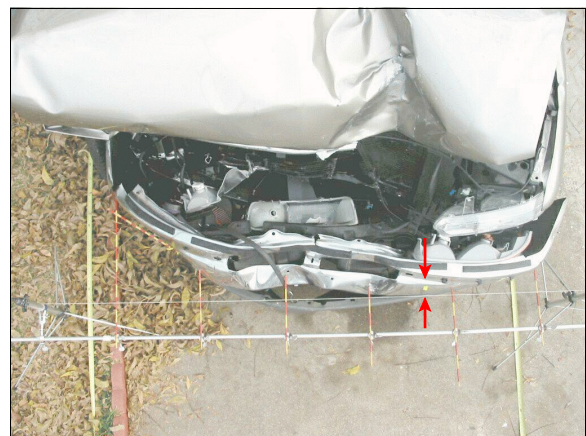


Figure 11: Overhead view of case vehicle's frontal damage with contour gauge present at bumper level; Note: yellow tape (arrows) marks width of direct damage, rightward shift of hood, more extensive crush to front right corner, and imprint in hood—most likely from Jeep's left "D"-pillar (case photo #09)

and, where appropriate, the values were averaged. Residual maximum crush at the bumper was measured as 28 centimeters (11.0 inches) at C₆ (**Figure 12**). Above the bumper the residual maximum crush was measured as 50 centimeters (19.7 inches) at C₆. The average residual maximum crush at C₆ was 39 centimeters (15.4 inches). The table below shows the case vehicle’s crush profile.

Units	Event	Direct Damage		Field L	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	130	39	178	0	7	20	26	29	39	20	0
in		51.2	15.4	70.1	0.0	2.8	7.9	10.2	11.4	15.4	7.9	0.0

The wheelbase on the case vehicle’s left side was shortened approximately 1 centimeter (0.4 inches) while the right side was extended approximately 2 centimeters (0.8 inches). The case vehicle’s front bumper, bumper fascia, grille, hood, radiator, and the right headlight and turn signal assemblies were directly damaged and crushed rearward. The left headlight and turn signal assemblies sustained induced damage as well as both the right and left fenders. The windshield glazing was cracked from contact by the back edge of the hood. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle’s exterior.

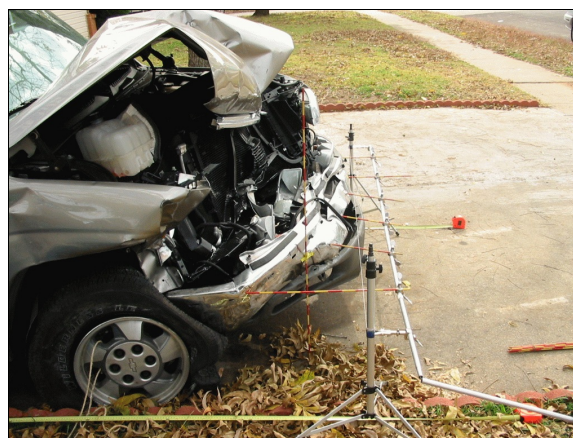


Figure 12: Case vehicle’s frontal damage viewed along reference line from right; Note: crush more extensive to front right corner (case photo #07)

The case vehicle manufacturer’s recommended tire size was: P245/75R16, but tire size: P265/70R16, was optional; the case vehicle was equipped with tire size: P265/70R16. The case vehicle’s tire data are shown in the table below. In addition, the case vehicle’s right front tire was damaged (i.e., cut sidewall), deflated, and physically restricted.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 nd of an inch			
LF	207	30	241	35	7	9	None	No	No
RF	0	0	241	35	8	10	Sidewall cut	Yes	Yes
LR	200	29	241	35	8	10	None	No	No
RR	200	29	241	35	8	10	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior revealed that there was no evidence of occupant contact on the interior surfaces of the case vehicle (**Figures 13** and **14**). In addition, there was no evidence of intrusion to the case vehicle's interior, no evidence of compression to the energy absorbing shear capsules in the steering column, and no deformation to the steering wheel rim.



Figure 13: Case vehicle's driver seating area showing no apparent occupant contact evidence on steering wheel, instrument panel, or greenhouse areas (case photo #30)



Figure 14: Case vehicle's front right seating area showing no apparent driver contact evidence to center console, instrument panels, or greenhouse areas (case photo #32)

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-2 (0 degrees)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The preliminary Total, Longitudinal, and Lateral Delta Vs are, respectively: 32.0 km.p.h. (19.9 m.p.h.), -32.0 km.p.h. (-19.9 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal redesigned air bags at the driver and front right passenger positions. In addition, the vehicle was equipped with front, seat back-mounted, side impact air bags. Both frontal air bags deployed as a result of the frontal impact with the Jeep. Neither of the front seat back-mounted side impact air bags deployed as a result of the case vehicle's frontal impact. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of symmetrical "I"-configuration cover flaps made of thick vinyl with overall dimensions of 7 centimeters (2.8 inches) at the left and right horizontal seams and 11 centimeters (4.3 inches) vertically. The distance between the mid-center of the driver's seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 49 centimeters (19.3 inches). An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with four tethers, each approximately 10 centimeters (3.9 inches) in width. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 11 and 1 o'clock

positions. The deployed driver's air bag was round with a diameter of 63 centimeters (24.8 inches). An inspection of the driver's air bag fabric revealed no contact evidence readily apparent on the air bag's fabric (**Figure 15**).

The front right passenger's air bag was located in the middle of the instrument panel. There was a single, essentially rectangular, modular cover flap. The cover flap was made of a semi-pliable vinyl. The flap's dimensions were 39 centimeters (15.4 inches) at the lower horizontal seam and 14 centimeters (5.5 inches) along both vertical seams. The profile of the case vehicle's instrument panel was flush with the leading edge of the cover flap. The distance between the mid-center of the front right seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 22 centimeters (8.7 inches). An inspection of the front right air bag module's cover flap and the air bag's fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 4 centimeters (1.6 inches) in diameter, located at the 9:30 and 2:30 clock positions. The deployed front right air bag was rectangular with a height of approximately 54 centimeters (21.3 inches) and a width of approximately 57 centimeters (21.7 inches). An inspection of the front right passenger's air bag fabric revealed no contact evidence readily apparent on the front right air bag's fabric (**Figures 16 and 17**).

CRASH DATA RECORDING

The data downloaded from the case vehicle's EDR showed the vehicle's SIR warning lamp status, driver's seat belt buckle status, ignition cycles at deployment, time from algorithm enable to deployment (i.e., air bag deployments) and



Figure 15: Front surface of case vehicle's deployed driver air bag showing no apparent evidence of occupant contact; Note: steering wheel rim is rotated approximately 90 degrees clockwise (case photo #41)



Figure 16: Front surface of case vehicle's front right passenger air bag showing no apparent evidence of occupant contact (case photo #48)



Figure 17: Top surface of case vehicle's deployed front right passenger air bag showing no apparent evidence of occupant contact to top surface or air bag module's cover flap (case photo #49)

velocity change (i.e., Delta V). Downloaded data of interest indicated the following. The case vehicle was traveling at a speed of 151 km.p.h. (94 m.p.h.), the driver's seat belt status showed it was buckled, and the Delta V had reached a value of 23.3 km.p.h. (14.5 m.p.h.) at the 110 millisecond mark of recorded data; see **EVENT DATA RECORDER DATA (Figures 21 through 23)** below. This contractor believes that the recorded Delta V seems reasonable considering the amount of deformation to both vehicles and the limitations on the **EDR's** recording time.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [36-year-old, White (Hispanic) male; 170 centimeters and 86 kilograms (67 inches, 190 pounds)] was seated in a slightly reclined posture with his back against the seat back, his left foot on the floor, his right foot on the brake, and at least one hand was most likely on the steering wheel. Based on the driver's interview, he does not recall either the exact positions of his hands or the position of his seat track just prior to the crash. During the vehicle inspection, the driver's seat track was located in its rearmost position, the seat back was slightly reclined, the tilt steering wheel was located in its down-most position.

Based on this contractor's vehicle inspection and supported by the **EDR** data, the case vehicle's driver was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system. Furthermore, the inspection of the driver's seat belt webbing, shoulder belt guide, and latch plate showed trace evidence of loading (i.e., a very slight scuff/burn to the webbing—**Figure 18**).

The case vehicle's driver braked (without lock-up) and most likely steered slightly to his left, attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the use of his available safety belts, he most likely moved slightly forward just prior to impact. The case vehicle's primary impact with the Jeep enabled the case vehicle's driver to continue forward toward the case vehicle's 0 degree Direction of Principal Force as the case vehicle decelerated. As a result, the driver loaded his safety belts and subsequently contacted his deploying driver air bag. The driver's probable seat track location combined with his restraint usage allowed the driver to minimize his interaction with the deploying driver air bag. The case vehicle's driver rebounded backward toward his seat back as a result of loading his safety belts and interacting with the deploying air bag. The exact posture of the case vehicle's driver at final rest is unknown, but he was most likely seated in his seat near his original pre-crash position. The driver exited the case vehicle without assistance.



Figure 18: Slight scuff/burn on webbing of shoulder belt portion of case vehicle's driver safety belt (case photo #38)

The driver was not transported by ambulance to a medical facility and did not seek medical treatment. The case vehicle's driver did not sustain any injuries as a result of this crash.

OTHER VEHICLE

The 1986 Jeep Wagoneer Limited was a rear wheel drive, five-passenger, four-door sport utility vehicle (VIN: 1JCHC7565GT-----) equipped with a 2.5L, L-4 engine and a four-speed automatic transmission. The Jeep was not equipped with anti-lock brakes. The Jeep’s wheelbase was 258 centimeters (101.4 inches), and the odometer reading is unknown because the Jeep’s interior was not inspected. Furthermore, Jeep was equipped with an air bag for the driver’s seat position only and manual, three-point, lap-and-shoulder, safety belt systems for the front and back outboard seating positions. The back center seat had a manual, two-point, lap belt. The interior was equipped with bucket seats for the driver and front right passenger, and the back bench seat was non-adjustable.

Exterior Damage: The Jeep’s contact with the case vehicle involved the entire back with the damage distributed all the way across (**Figure 19**). Direct damage began at the back left corner and extended inward a distance of 141 centimeters (55.5 inches) along the back bumper. Residual maximum crush was measured as 61 centimeters (24.0 inches) at C₁ (**Figure 20**). The table below shows the Jeep’s crush profile.



Figure 19: Overhead view of Jeep’s back damage with contour gauge present at bumper level; Note: crush more extensive to back left corner (case photo #71)



Figure 20: Jeep’s back damage viewed along reference line from left with contour gauge present at bumper level showing crush profile; Note: crush more extensive to back left corner (case photo #69)

Units	Event	Direct Damage		Field L	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	141	61	164	61	51	54	53	29	8	0	0
in		55.5	24.0	64.6	24.0	20.1	21.3	20.9	11.4	3.2	0.0	0.0

The wheelbase on the Jeep’s left side was shortened 38 centimeters (15.0 inches) while the right side was shortened 7 centimeters (2.8 inches). The Jeep’s back bumper, bumper fascia,

liftgate, backlite, and the left and right brake lights, reverse light, and turn signal assemblies were directly damaged and crushed forward. Both the right and left quarter panels sustained induced damage as well as both left doors, the left outside rearview mirror, and the right rear door. Remote buckling was also found on the left roof, just forward of the left “B”-pillar.

The Jeep manufacturer’s recommended tire size was: P205/75R15, but the Jeep was equipped with tire size: P225/75R15. The Jeeps’s tire data are shown in the table below.

<i>Tire</i>	<i>Measured Pressure</i>		<i>Recommend Pressure</i>		<i>Tread Depth</i>		<i>Damage</i>	<i>Restricted</i>	<i>Deflated</i>
	kpa	psi	kpa	psi	milli- meters	32 nd of an inch			
LF	138	20	207	30	4	5	None	No	No
RF	83	12	207	30	2	3	None	No	No
LR	0	0	207	30	4	5	Cut	Yes	Yes
RR	0	0	207	30	6	8	None	No	Yes

Damage Classification: Based on the vehicle inspection, the CDC for the Jeep was determined to be: **06-BDEW-4 (180 degrees)**. The WinSMASH reconstruction program, damage only algorithm, was used on the Jeep's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 54.0 km.p.h. (33.6 m.p.h.), +54.0 km.p.h. (+33.6 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The Jeep was towed due to damage.

Jeep’s Occupants: Based on the Police Crash Report, there were no occupants in the Jeep at the time of the crash.

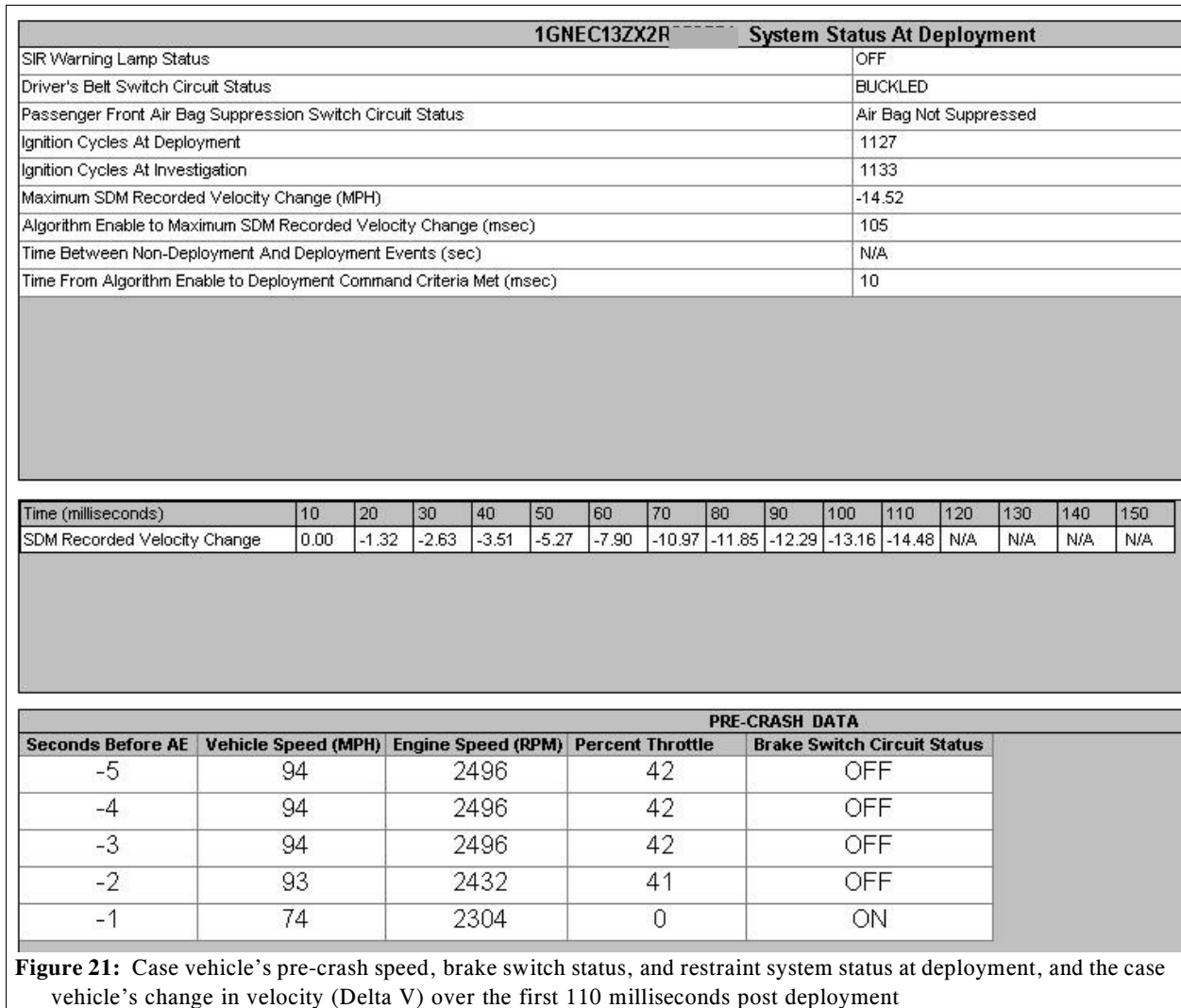


Figure 21: Case vehicle’s pre-crash speed, brake switch status, and restraint system status at deployment, and the case vehicle’s change in velocity (Delta V) over the first 110 milliseconds post deployment

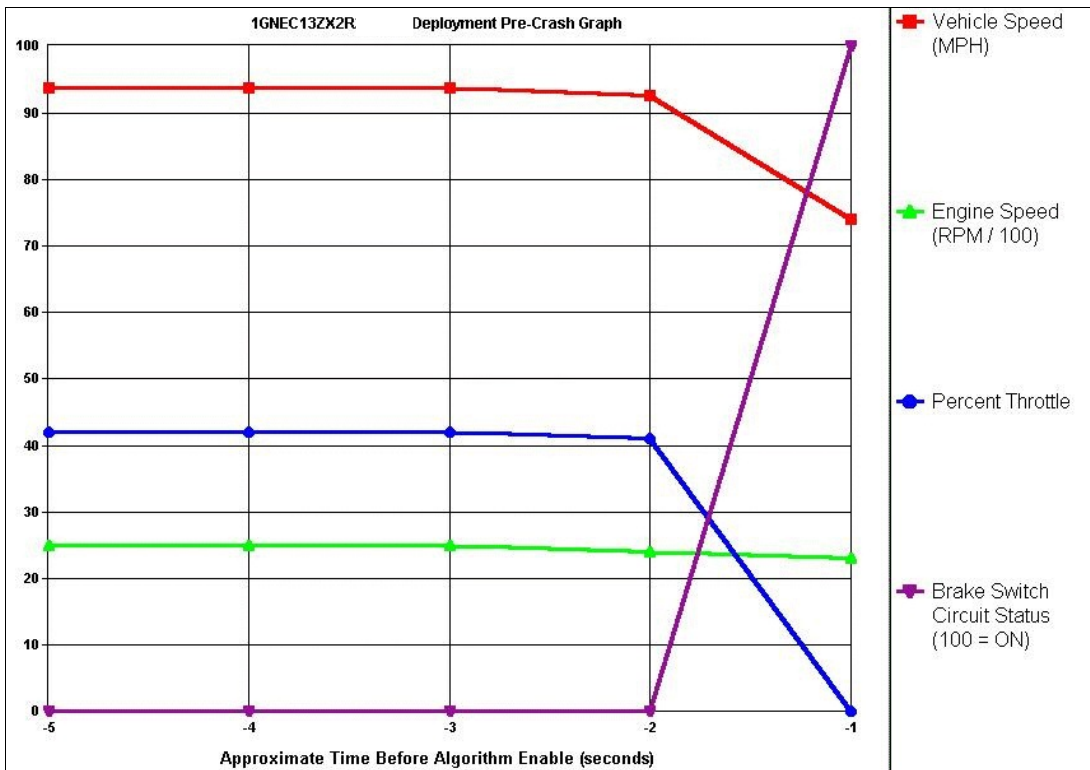


Figure 22: Case vehicle's pre-crash speed and brake switch circuit status showing that the vehicle's speed was recorded at 151 km.p.h. (94 m.p.h.) when the brake was activated approximately 2 seconds prior to algorithm enable.

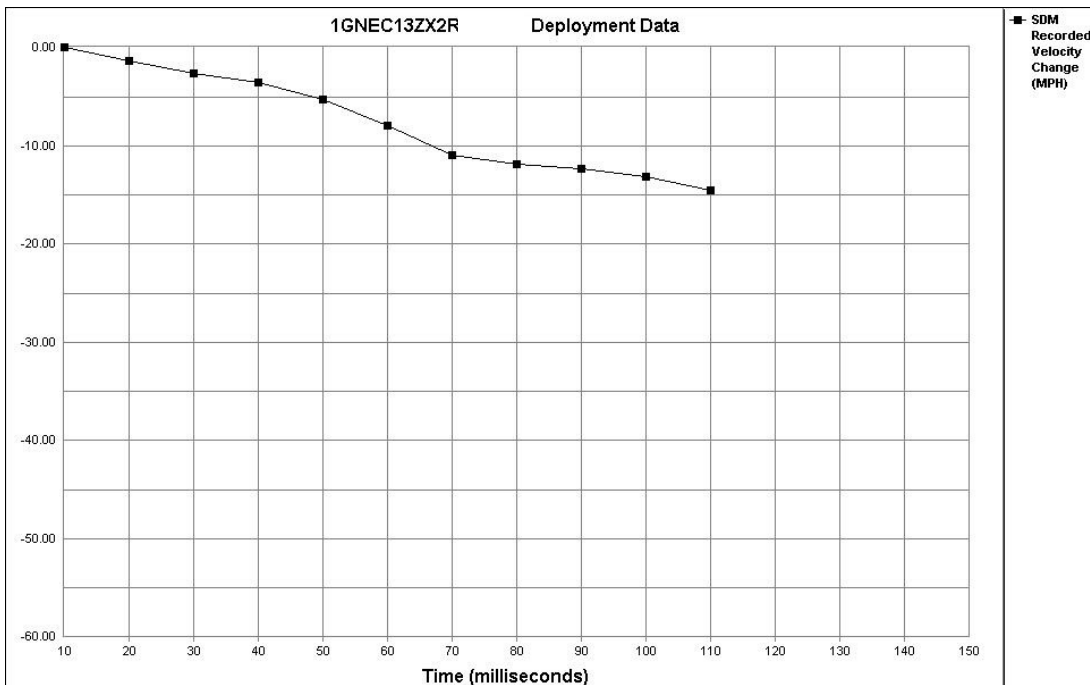


Figure 23: The case vehicle sustained a velocity change of approximately 23.3 km.p.h. (14.5 m.p.h.) during the first 110 milliseconds after the algorithm was enabled; maximum velocity change was recorded as 14.52 km.p.h. (23.37 m.p.h.) at 105 milliseconds

