INDIANA UNIVERSITY
TRANSPORTATION RESEARCH CENTER
School of Public and Environmental Affairs
222 West Second Street
Bloomington, Indiana 47403-1501
(812) 855-3908 Fax: (812) 855-3537

ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-04-011
LOCATION - TEXAS
VEHICLE - 2003 CHEVROLET C1500 SILVERADO
CRASH DATE - April 2004

Submitted:

August 16, 2007

Contract Number: DTNH22-01-C-07002

Prepared for:

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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. *Supplementary Notes* On-site air bag deployment investigation involving a 2003 Chevrolet C1500 Silverado, two-door pickup, with manual safety belts and dual front advanced air bags, and a 2002 Ford Focus ZC3, two-door coupe			
16. *Abstract* This report covers an on-site investigation of an air bag deployment crash that involved a 2003 Chevrolet C1500 Silverado (case vehicle) and a 2002 Ford Focus ZX3 (other vehicle). This crash is of special interest because the case vehicle was equipped with multiple Advanced Occupant Protection System (AOPS) features, including certified advanced 208-compliant air bags, as well as an Event Data Recorder (EDR) and the case vehicle's, restrained, front center passenger (6-year-old, female) sustained only minor injuries as a result of the crash. The trafficway on which the case vehicle had been traveling was a three-lane, divided, entrance/exit ramp, traversing in an east-west direction, and the case vehicle was entering a left-hand curve, approaching a "Y"-shaped split of the ramp. Prior to the ramp's split, the eastern roadway of the divided ramp had two through lanes while the western roadway had one through lane. As the ramp trafficway began to curve to the left, the outside (i.e., right-hand) through lane split off at a gore and continued eastward. The inside (i.e., left-hand) eastern lane curved leftward and split off at the gore to travel northward over an Interstate highway. The east-to-north roadway remained divided with the roadway on the opposite side traveling south-to-west through a right-hand curve. The roadways were separated by a concrete, raised, paved median. The southbound roadway of the divided ramp had one-lane. The case vehicle had been traveling east-to-north in the outside eastbound lane and intended to negotiate the left-hand curve and travel northward. The Ford was traveling south in the southerly lane of the southbound roadway and was approaching a right-hand curve. The case vehicle's driver lost control while negotiating the left-hand curve and traveled through the gore area and then obliquely across the northbound roadway where it mounted and crossed the median before entering the southbound roadway where the crash occurred. The front left half of the case vehicle impacted the front left corner of the Ford, causing only the case vehicle's driver supplemental restraint (air bag) to deploy. The front center passenger (driver's daughter) was seated on a non-adjustable bench seat and was restrained by her available, active, two-point, lap belt system. She sustained, according to the interview with the case vehicle's driver (i.e., father) and her medical records, minor facial lacerations most likely caused by her contact with the case vehicle's center instrument panel. The case vehicle's driver (40-year-old, male) was seated with his seat track located in its rearmost position, and the tilt steering wheel was located in between its center and upmost positions. He was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system and sustained, according to his interview, a minor a laceration to his left wrist.			
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TABLE OF CONTENTS IN-04-011

Page No.

SELECTED PHOTOGRAPHS (Continued)

Page No.

SELECTED PHOTOGRAPHS (Continued)

This on-site investigation was brought to NHTSA's attention on or before May 6, 2004 by NASS CDS/GES sampling activities. This crash involved a 2003 Chevrolet C1500 Silverado (case vehicle) and a 2002 Ford Focus ZX3 (other vehicle). The crash occurred in April 2004, at 10:45 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 **A**dvanced **O**ccupant **P**rotection **S**ystem (**AOPS**) features, including certified advanced 208-compliant air bags, as well as an **E**vent **D**ata **R**ecorder (**EDR**) and the case vehicle's front center passenger [6-year-old, White (non-Hispanic) female] sustained a police-reported "B" (non-incapacitating-evident) injuries as a result of the crash. This contractor inspected the scene and case vehicle on May 11, 2004 and downloaded the data from the onboard **EDR**. This contractor interviewed the driver on May 13, 2004. This report is based on the Police Crash Report, an interview with the case vehicle's driver, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

SUMMARY

The trafficway on which the case vehicle had been traveling was a three-lane, divided, entrance/exit ramp for a state highway, traversing in an east-west direction, and the case vehicle was entering a left-hand curve, approaching a "Y"-shaped split of the ramp. Prior to the ramp's split, the eastern roadway of the divided ramp had two through lanes while the western roadway had one through lane. As the ramp trafficway began to curve to the left, the outside (i.e., right-hand) through lane of the eastern roadway split off at a gore and continued eastward, forming the eastern entrance ramp to an Interstate highway. The inside (i.e., left-hand) eastern lane curved leftward and split off at the gore to travel northward over the Interstate highway, beginning the formation of the western entrance ramp to the same Interstate highway. The east-to-north roadway remained divided with the roadway on the opposite side traveling south-to-west through a right-hand curve. The median that separated these two roadways was 0.8 meters (2.6 feet) wide and was a raised [i.e., 17 cm (6.7 in)], unprotected, concrete type of median. The southbound roadway of the divided Interstate ramp was a one-lane exit ramp for an Interstate highway. This roadway approached a right-hand curve and then traveled westward becoming an entrance ramp for a State highway. At the time of the crash the light condition was daylight, the atmospheric condition was raining (misting), and the road pavement was wet; see **CRASH SCENE OVERVIEW** and **CRASH DIAGRAM** at end.

The case vehicle had been traveling east-to-north in the outside eastbound lane of the east-west entrance/exit ramp and intended to negotiate the left-hand curve and travel northward on the western entrance ramp to the Interstate highway. The Ford was traveling south in the southerly lane of the southbound roadway and was approaching a right-hand curve, intending to negotiate the curve and travel west on the entrance ramp to the State highway. According to the Police Crash Report, the case vehicle's driver lost control while negotiating the left-hand curve. Based on the preponderance of the evidence, this contractor believes that the case vehicle's driver was most likely in the outside eastern lane and realized that he had to change lane to the left to negotiate the left-hand curve and travel on the western entrance ramp. As a result the case vehicle traveled through the gore area and entered the dirt portion of the gore while the driver was

steering leftward to re-enter the roadway. As the case vehicle re-entered the roadway it was most likely in a counterclockwise yaw. The case vehicle traveled obliquely across the northbound roadway, mounted and crossed the median, and entered the southbound roadway. The case vehicle's driver steered to the right, attempting to avoid the crash. The crash occurred within the interchange area, in the through lane of the southbound roadway. It should be noted that the exact location of the crash could not be determined.

The front left half of the case vehicle impacted the front left corner of the Ford, causing only the case vehicle's driver supplemental restraint (air bag) to deploy. Based on the downloaded **EDR** data, only one stage of the driver's multi-stage air bag was activated. The case vehicle was equipped with a switchable (i.e., a cutoff switch) front right passenger supplemental restraint (air bag) that was set to the "auto" position. The case vehicle's front right passenger air bag did not deploy during the crash sequence.

As a result of the impact, the case vehicle rotated slightly counterclockwise. The case vehicle most likely came to rest, obliquely oriented, straddling the median separating the Interstate ramp. The Ford most likely rotated counterclockwise and traveled southwestward before coming to rest in the right-hand curve, straddling the roadway's edge line, heading in an easterly direction. The case vehicle and the Ford were both towed due to damage from the scene.

The 2003 Chevrolet C1500 Silverado was a rear wheel drive (4x2), two-door, regular cab, standard bed pickup truck (VIN: 1GCEC14X93Z------) and was **CERTIFIED ADVANCED 208-COMPLIANT**. The case vehicle was equipped with four wheel, anti-lock brakes, dual stage driver and front right passenger air bag inflators, and an air bag **ON/OFF** switch. In addition, the case vehicle was also equipped with an **E**vent **D**ata **R**ecorder (**EDR**).

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-2** (**10** degrees). The WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 31.0 km.p.h. (19.3 m.p.h.), -30.5 km.p.h. (-19.0 m.p.h.), and -5.4 km.p.h. (-3.4 m.p.h.). The case vehicle was towed due to damage.

The data downloaded from the case vehicle's **EDR** showed that the driver's seat belt status was buckled, the second stage of the multi-stage air bags was not activated and, for the deployment event (1st event), the Delta V reached a value of 27.44 km.p.h. (17.05 m.p.h.) at the 120 millisecond mark of recorded data.

The 2002 Ford Focus ZX3 was a front wheel drive, three-door hatchback (VIN: 3FAFP31392R------) and was equipped with **ADVANCED OCCUPANT PROTECTION SYSTEM** features, including redesigned driver and front right passenger air bags. According to the Police Crash Report, the driver air bag, at least, deployed as a result of the crash.

The case vehicle's front center passenger [driver's daughter; 6-year-old, White (non-Hispanic) female] was seated on the front "40/20/40"split bench seat; this occupant's seating position was not adjustable (i.e., no seat track). The front center passenger was restrained by her

available, active, two-point, lap belt system and sustained, according to the interview with her father and her medical records, multiple facial lacerations. This occupant's facial injuries were most likely caused by her contact with the case vehicle's center instrument panel.

The case vehicle's driver [i.e., father of front center passenger; 40-year-old, White (non-Hispanic) male] was seated with his seat track located in its rearmost position, and the tilt steering wheel was located in between its center and upmost positions. He was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system and sustained, according to his interview, a minor laceration to the anterior surface of his left wrist.

According to the Police Crash Report, the Ford's driver (29-year-old, Black female), back left passenger (5-year-old, female), and back right passenger (10-year-old, female) were all restrained by their available, active, three-point, lap-and-shoulder, safety belt systems. The driver was not transported by ambulance to the hospital, and she did not sustain any injuries as a result of this crash. The back seat passengers were transported by ambulance to the hospital with police-reported "C" (possible) and "B" (non-incapacitating-evident) injuries, respectively. The specific nature of their injuries and level of medical treatment are unknown.

Figure 1: Case vehicle's eastward travel path on a divided State entrance/exit ramp, most likely in outside eastbound lane, approaching a "Y"-shaped split, within a left-hand curve, comprised of two Interstate entrance ramps (case photo #01)

Figure 2: Case vehicle's east-northeasterly travel path, most likely in outside lane, in left-hand curving State entrance/exit ramp approaching a "Y"-shaped split where two Interstate entrance ramps begin (case photo #02)

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which the case vehicle had been traveling was a three-lane, divided, entrance/exit ramp for a state highway, traversing in an east-west direction, and the case vehicle was entering a left-hand curve, approaching a "Y"-shaped split of the ramp (**Figure 1**). Prior to the ramp's split, the eastern roadway of the divided ramp had two through lanes while the western roadway had one through lane. As the ramp trafficway began to curve to the left, the outside (i.e., right-hand) through lane of the eastern roadway (**Figure 2**) split off at a gore and continued eastward, forming the eastern entrance ramp to an Interstate highway (**Figure 3** below). The inside (i.e., left-hand) eastern lane curved leftward and split off at the gore to travel northward over the Interstate highway, beginning the formation of the western entrance ramp to the same Interstate highway (**Figure 3** below). The east-to-north roadway remained divided with the roadway on the opposite side traveling south-to-

west through a right-hand curve. The median that separated these two roadways was 0.8 meters (2.6 feet) wide and was a raised [i.e., 17 cm (6.7 in)], unprotected, concrete type of median. The southbound roadway of the divided Interstate ramp was a one-lane exit ramp for an Interstate highway (**Figure 4**). This roadway approached a right-hand curve and then traveled westward becoming an entrance ramp for a State highway.

Figure 3: Case vehicle's travel path in left-hand curving "Y"-shaped split ramp showing gore area that separates the beginning of two Interstate entrance ramps; Note: physical evidence indicates that case vehicle traveled into gore area between entrance ramps, indicating that case vehicle was most likely in outside easterly lane of divided State ramp and swerved leftward from the eastern Interstate entrance ramp intending to travel northward on the western Interstate entrance ramp (case photo #03)

Figure 4: Ford's southward travel path on divided Interstate entrance/exit ramp showing approximate location (arrow) of impact with case vehicle in southbound lane (case photo #11)

Figure 5: Case vehicle's travel path through gore area separating eastern and western Interstate entrance ramps; Note: case vehicle departs gore area in counterclockwise yaw prior to crossing median that divides western Interstate ramp and travels into ramp's southbound lane where it impacts (arrow) Ford (case photo #04)

The state/interstate highway entrance/exit ramp was curved to the left for east-to-northbound traffic and had a 2.2% grade positive to the northeast (i.e., an upgrade in the case vehicle's direction of travel), near the area of impact (**Figure 3**). The pavement was bituminous, but polished, and the width of the northbound lane (i.e., at the area of impact) was 5.1 meters (16.7 feet) and the southbound lane was 4.4 meters (14.4 feet). The shoulders were improved (i.e., bituminous), with a 1.8 meter (5.9 foot) wide paved shoulder on the east side of the ramp trafficway and 2.8 meter (9.2 foot) wide shoulder on the west side of the trafficway. Both the western side of the northbound roadway and the eastern side of the southbound roadway had an approximate 0.15 to 0.20 meter (6-8 inch) wide shoulder prior to the raised, paved median discussed above. Neither roadway was bordered by curbs. Pavement markings consisted of a single solid yellow centerline and a solid white edge line for both the northern and southern roadways, augmented by yellow and white raised pavement markers placed along the center and

edge lines, respectively, for both roadways (**Figure 4** above). The estimated coefficient of friction was 0.55. There were no visible traffic controls in the immediate area of the crash. The speed limit was 48 km.p.h. (30 m.p.h.). No regulatory speed limit sign was posted near the crash site. At the time of the crash the light condition was daylight, the atmospheric condition was raining (misting), and the road pavement was wet. Traffic density was moderate, and the site of the crash, which was within an interchange area, was primarily undeveloped; see **CRASH SCENE OVERVIEW** and **CRASH DIAGRAM** at end.

Pre-Crash: Based on the available evidence, the case vehicle had been traveling east-to-north in the outside eastbound lane of the east-west entrance/exit ramp and intended to negotiate the left-hand curve and travel northward on the western entrance ramp to the Interstate highway (**Figure 5** above). The Ford was traveling south in the southerly lane of the southbound roadway and was approaching a right-hand curve (**Figure 4** above), intending to negotiate the curve and travel west on the entrance ramp to the State highway (**Figure 1** above). According to the Police Crash Report, the case vehicle's driver lost control while negotiating the left-hand curve. Based on the preponderance of the evidence, this contractor believes that the case vehicle's driver was most likely in the outside eastern lane and realized that he had to change lane to the left to negotiate the left-hand curve and travel on the western entrance ramp (**Figure 3** above). As a result the case vehicle traveled through the gore area and entered the dirt portion of the gore while the driver was steering leftward to re-enter the roadway (**Figure 5** above). As the case vehicle re-entered the roadway it was most likely in a counterclockwise yaw. The case vehicle traveled obliquely across the northbound roadway, mounted and crossed the median, and entered the southbound roadway (**Figure 6**). The case vehicle's driver steered to the right, attempting to avoid the crash. The crash occurred within the interchange area, in the through lane of the southbound roadway (**Figure 4** above). It should be noted that the exact location of the crash could not be determined.

Figure 6: Case vehicle's north-northwesterly travel path from gore area across median into southern lane of divided Interstate entrance/exit ramp; Note: arrow indicates approximate impact area with Ford (case photo #05)

Figure 7: Case vehicle's frontal damage from impact with Ford; Note: contour gauge positioned at bumper level (case photo #16)

Crash: The front left half (**Figure 7** and **Figure 8** below) of the case vehicle impacted the front left corner of the Ford, causing only the case vehicle's driver supplemental restraint (air bag) to deploy. Based on the downloaded **EDR** data, only one stage of the driver's multi-stage air bag was activated. The case vehicle was equipped with a switchable (i.e., a cutoff switch) front right

passenger supplemental restraint (air bag) that was set to the "auto" position (**Figure 9**). The case vehicle's front right passenger air bag did not deploy during the crash sequence.

Figure 8: Reference line view of case vehicle's frontal damage viewed from left; Note: case vehicle's left front wheel is restricted by damage (case photo #19)

Figure 9: Close-up of case vehicle's front right passenger air bag switch located in lower right portion of center instrument panel; Note: switch located in "Auto" position (case photo #41)

Post-Crash: The location of the crash and final rest positions are estimated. As a result of the impact, the case vehicle rotated slightly counterclockwise. This contractor's believes that the case vehicle came to rest, obliquely oriented, straddling the median separating the Interstate ramp. The post-crash trajectory for the Ford is unknown, but it can be assumed that the Ford rotated counter-clockwise and traveled southwestward before coming to rest. This contractor believes that it is most likely that the Ford came to rest in the right-hand curve, straddling the roadway's edge line, heading in an easterly direction.

CASE VEHICLE

The 2003 Chevrolet C1500 Silverado was a rear wheel drive (4x2), three-passenger, two-door, regular cab, standard bed pickup truck (VIN: 1GCEC14X93Z------) equipped with a 4.3L, V-6 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front and rear disc, four-wheel, anti-lock system. The case vehicle's wheelbase was 302 centimeters (119.0 inches), and the odometer reading at inspection is unknown because the case vehicle was equipped with an electronic odometer.

The case vehicle was **CERTIFIED ADVANCED 208-COMPLIANT** and was equipped with dual stage driver and front right passenger air bag inflators, and driver and front right passenger seat belt buckle switch sensors. Furthermore, the case vehicle was equipped with an air bag **ON/OFF** switch, and there was an occupant detection and automatic air bag suppression system for the front right passenger seating position, as evident by the aforementioned air bag **ON/OFF** switch (**Figure 9**). In addition, the case vehicle was not equipped with either front seat back-mounted side impact air bags or right or left side curtain air bags. 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 seat belt usage to determine the front air bag inflation level

appropriate for the severity of the crash. For the front right seating position, 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). The case vehicle was equipped with height adjustable head restraints for the front outboard positions and a LATCH system for the front right seat. Finally, the case vehicle was also equipped with an **E**vent **D**ata **R**ecorder (**EDR**).

Inspection of the vehicle's interior revealed a "40/20/40" split bench seat with separate back cushions, adjustable head restraints for the front outboard seating positions; continuous loop, three-point, integrated lap-and-shoulder, safety belt systems at the front outboard positions; and a two-point, lap belt system at the front center position. The case vehicle was not equipped with any upper anchorage adjusters. The vehicle was equipped with knee bolsters for both the driver and front right seating positions, neither of which showed evidence of occupant contact or deformation. Automatic restraint was provided by a Supplemental Restraint System (**SRS**) that consisted of a frontal air bag for the driver and front right passenger seating positions. Only the driver's frontal air bag deployed as a result of the case vehicle's frontal impact with the Ford.

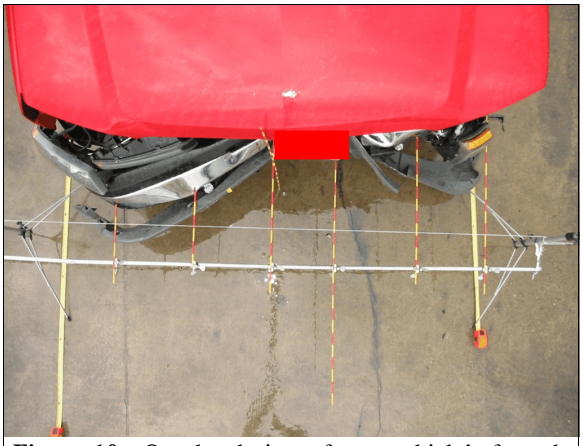


Figure 10: Overhead view of case vehicle's frontal damage showing contour gauge positioned at bumper level; Note: case vehicle was in counter-clockwise yaw at impact (case photo #27)

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's contact with Ford involved the entire front. Direct damage began at the front left bumper corner and extended 112 centimeters (44.1 inches), along the front bumper (**Figure 10**). The undeformed end width was determined to be 176 centimeters (69.3 inches). Residual maximum crush was measured as 39 centimeters (15.4 inches) at C_3. 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	112	39	176	32	26	39	24	2	0	-17	0
in		44.1	15.4	69.3	12.6	10.2	15.4	9.4	0.8	0.0	-6.7	0.0

The wheelbase on the case vehicle's left side was shortened 14 centimeters (5.5 inches) while the right side was extended 3 centimeters (1.2 inches). The case vehicle's front bumper, bumper fascia, grille, radiator, hood, left headlight and turn signal assemblies, and left fender were directly damaged and crushed rearward. There was induced damage to the right headlight and turn signal assemblies as well as the hood and left fender. Remote buckling was also found on the truck bed (**Figure 11**). No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

Figure 11: Induced damage to case vehicle's truck bed (case photo #21)

The recommended tire size was: P235/ 75R16, and the case vehicle tires were the recommended size. The case vehicle's tire data are shown in the table below. In addition, the case vehicle's left front tire was forced rearward and its rotation was obstructed.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	207	30	241	35	7	9	None	Yes	No
RF	214	31	241	35	8	10	None	No	No
LR	214	31	241	35	7	9	None	No	No
RR	221	32	241	35	7	9	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 (**Figure 12** and **Figures 13** and **14** below). Although the interviewee (case vehicle's driver) stated the front center passenger struck her head on the center dash area, no evidence of occupant contact was found (**Figures 15** and **16** below). It should be noted that some sort of fluid was splayed over the center instrument panel (**Figure 9** above). It is possible that the front center passenger had a cup of some sort of liquid in her hands just prior to the crash; however, no confirmation of this hypothesis was obtained. Finally, there was no evidence of intrusion to the

Figure 12: Case vehicle's front seating area showing deployed driver air bag and greenhouse area and rear view mirror above front center seat (case photo #28)

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 deployed driver air bag, greenhouse, left instrumental panel and knee bolster left of steering column, and toe pan areas (case photo #30)

Figure 14: Case vehicle's front right seating area showing non-deployed front right passenger air bag, greenhouse, center and right instrument panel, and right toe pan areas (case photo #32)

Figure 15: Case vehicle's deployed driver air bag and left and center instrument panel areas; Note: no obvious evidence of contact to instrument panel areas (case photo #28a)

Figure 16: Case vehicle's center instrument panel area showing possible contact evidence; Note: splatters are not blood stains (case photo #40)

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-2** (**10** degrees). The WinSMASH reconstruction program, missing

vehicle algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 31.0 km.p.h. (19.3 m.p.h.), -30.5 km.p.h. (-19.0 m.p.h.), and -5.4 km.p.h. (-3.4 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 dual stage frontal air bags at the driver and front right passenger positions. Only the driver's frontal air bag deployed as a result of the frontal impact with the Ford. Only one stage of the multi-stage air bag was activated. The case vehicle's driver air bag was located in the steering wheel hub (**Figure 12** et al. above). The module cover consisted of symmetrical "I"-configuration cover flaps made of thick vinyl with overall dimensions of 5.5 centimeters (2.2 inches) at the left and right horizontal seams and 12 centimeters (4.7 inches) vertically. 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 two tethers, each approximately 12 centimeters (4.7 inches) in width. The driver's air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located slightly inward from the outer circumference at the 10:30 and 1:30 clock positions. The deployed driver's air bag was round with a diameter of 65 centimeters (25.6 inches). 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 40 centimeters (15.7 inches). An inspection of the driver's air bag fabric revealed a faint blood stain on the air bag's fabric near its outer edge at approximately the 4 o'clock position (**Figure 17**). Because the front center passenger sustained facial lacerations, it is very likely that the "stain" is blood and it came from the front center passenger.

Figure 17: Case vehicle's deployed driver air bag showing possible blood evidence (arrow) on air bag's fabric near 4 o'clock area (case photo #33)

The front right passenger's air bag was located in the middle of the instrument panel (**Figure 13** above). It should be noted that there was no occupant in the front right seat and that the air bag for this position did not deploy. In addition, there was an air bag cutoff switch on the center instrument panel, but the switch was turned to it's "Auto" position (**Figures 9** and **16** above).

CRASH DATA RECORDING

The data downloaded from the case vehicle's **EDR** showed that both a deployment and a non-deployment event were recorded. For the deployment event the **EDR** showed the vehicle's SIR warning lamp status, driver's seat belt buckle status, vehicle's speed and brake switch status for the five recorded sample periods preceding the **ALGORITHM ENABLE**, ignition cycles at deployment, time from algorithm enable to deployment (i.e., air bag deployments) for only the

system's first stage, and velocity change (i.e., Delta V). Downloaded data of interest indicated the following. The case vehicle was traveling at a speed of approximately 48 km.p.h. (30 m.p.h.), the driver's seat belt status showed it was buckled, the second stage of the multi-stage air bags was not activated, and the Delta V reached a value of 27.44 km.p.h. (17.05 m.p.h.) at the 120 millisecond mark of recorded data; see **EVENT DATA RECORDER DATA** (**Figures 22** through **24**) below. This contractor believes that the recorded Delta V seems reasonable considering the amount of deformation to the case vehicle's front.

For the non-deployment event the **EDR** showed the vehicle's SIR warning lamp status, driver's seat belt buckle status, vehicle's speed and brake switch status for the five recorded sample periods preceding the **ALGORITHM ENABLE**, ignition cycles at non-deployment, time from algorithm enable to maximum **SDM** (i.e., ***SENSING AND DIAGNOSTIC MODULE***) recorded velocity change, and velocity change (i.e., Delta V). Downloaded data of interest indicated the following. The command criteria was met approximately within 1 second following the system's wake-up for the deployment event. The case vehicle was traveling at a speed of approximately 48 km.p.h. (30 m.p.h.), the driver's seat belt status showed it was buckled, and the Delta V reached a value of 0.06 km.p.h. (0.04 m.p.h.) at the 10 millisecond mark of recorded data; see **EVENT DATA RECORDER DATA** (**Figures 25** through **27**) below. This contractor believes that the wake-up event for the deployment event occurred when the case vehicle impacted the Ford, and the wake-up event for the non-deployment event occurred when the case vehicle's rear wheels contacted the raised, paved median. The **EDR** data indicates that the activation of the brake switch (i.e., approximately 3 and 4 seconds prior to algorithm enable for the deployment event, respectively) most likely occurred when the case vehicle was in the gore area or re-entering the roadway.

CASE VEHICLE FRONT CENTER PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's front center passenger [driver's daughter; 6-year-old, White (non-Hispanic) female; 107 centimeters and 23 kilograms (42 inches, 51 pounds)] was seated in an upright posture with her back against the seat back, her feet on the transmission tunnel and, according to the driver, both hands to her sides, resting on the seat. This portion of the front "40/20/40" split bench seat had no seat track, and the seat back was not adjustable. Furthermore, the seat back also served as a fold down armrest between the left and right portions of the front bench seat.

Figure 18: Webbing from case vehicle's lap only center seat belt showing blood on webbing (case photo #42)

Based on this contractor's vehicle inspection and the interview with the case vehicle's driver, the case vehicle's front center passenger was restrained by her available, active, two-point, lap belt system. There was no mention by the driver of belt pattern bruising and/or abrasions to the front center passenger's torso, and the inspection of the front center passenger's seat belt webbing and latch plate showed minor blood stains on the

belt's webbing but no evidence of loading (**Figure 18** above and **Figure 19**).

Figure 19: Overhead view of case vehicle's front center seat cushion and seat belt webbing; Note: blood (circled) on belt's webbing (case photo #45)

The case vehicle's driver most likely steered to the left and braked when the vehicle was in or near the dirt portion of the gore area. As a result the case vehicle re-entered the roadway in a counterclockwise yaw and headed for the raised, paved median that separated the two roadways of the Interstate ramp. As the case vehicle was rotating counterclockwise, and most likely while simultaneously crossing the median, the driver steered to the right, attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the use of the front center passenger's lap safety belt, initially she most likely moved slightly to her right, slightly upward, and forward. Secondly, just prior to impact, the front center passenger moved slightly to her left while remaining bent forward, angled over her safety belt which restricted her forward and upward movement. The case vehicle's impact with the Ford enabled the case vehicle's front center passenger to continue forward and slightly rightward and upward along a path opposite the case vehicle's **10** degree Direction of Principal Force as the case vehicle decelerated. According to the case vehicle's driver, as a result of the impact the front center passenger's face contacted the center instrument panel causing several facial lacerations. When the case vehicle reached maximum engagement, the case vehicle rotated counterclockwise to final rest. As a result, the front center passenger most likely moved further to her right, but this movement was restricted by her safety belt. When the vehicle came to rest, the front right passenger most likely moved backward and to her left. The faint blood stain near the 4 o'clock area of the driver air bag's fabric was most likely deposited during this occupants movement to final rest. The exact posture of the front center passenger at final rest is unknown, but she was able to exit the case vehicle without assistance.

CASE VEHICLE FRONT CENTER PASSENGER INJURIES

The front center occupant was transported by ambulance to the hospital. She sustained minor injuries and was treated and released. According to the interview with her father and her medical records, the injuries sustained by the case vehicle's front center passenger included: a laceration {cut} above her right eye and lacerations {cuts} to her gums, lower lip, and chin. This occupant's facial injuries were most likely caused by her contact with the case vehicle's center instrument panel.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Laceration, 1.5 cm (0.6 in) on right forehead over right eye	minor 290602.1,7	Center instrument panel and below	Probable	Emergency room records

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
2	Laceration intra-oral buccal mucosa, not further specified	minor 243204.1,8	Center instrument panel and below	Probable	Emergency room records
3	Laceration, 3 cm (1.2 in), lower lip on left through frenulum	minor 290602.1,8	Center instrument panel and below	Probable	Emergency room records
4	Laceration, 1 cm (0.4 in), beneath chin, not further specified	minor 290602.1,8	Center instrument panel and below	Probable	Emergency room records

CASE VEHICLE DRIVER KINEMATICS

The case vehicle's driver [i.e., father of front center passenger; 40-year-old, White (non-Hispanic) male; 183 centimeters and 93 kilograms (72 inches, 205 pounds)] was seated in an upright posture with his back against the seat back, his left foot on the floor, his right foot on the brake, and both hands on the steering wheel. His seat track was located in its rearmost position, the seat back was upright, and the tilt steering wheel was located in between its center and upmost positions.

The case vehicle's driver was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system; the belt system was not equipped with a pretensioner. This usage conclusion was substantiated by the **EDR** data. Furthermore, there was no mention by the driver of belt pattern bruising and/or abrasions to the driver's torso, but inspection of the driver's seat belt webbing, shoulder belt guide, and latch plate showed loading evidence on the belt's webbing near the retractor port (**Figure 20** and **Figure 21** below).

Figure 20: Elevated view of webbing from case vehicle's integrated driver seat belt showing loading evidence near retractor port (case photo #37)

The case vehicle's driver most likely steered to the left and braked when the vehicle was in or near the dirt portion of the gore area. As a result the case vehicle re-entered the roadway in a counterclockwise yaw and headed for the raised, paved median that separated the two roadways of the Interstate ramp. As the case vehicle was rotating counterclockwise, and most likely while simultaneously crossing the median, the driver steered to the right, attempting to avoid the crash. As a result of these attempted avoidance maneuvers and the driver's use of his available safety

belts, he initially most likely moved slightly to his right, slightly upward, and forward. Secondly, just prior to impact, he most likely moved slightly to his left while remaining bent forward, loading the torso portion of his safety belt, which restricted his forward and upward movement. The case vehicle's impact with the Ford enabled the case vehicle's driver to continue forward and slightly rightward and upward along a path opposite the case vehicle's **10** degree Direction of Principal Force as the case vehicle decelerated. According to the case vehicle's driver, as a result of the impact, he loaded his safety belts and contacted his deploying air bag. When the case vehicle reached maximum engagement, the case vehicle rotated counterclockwise to final rest. As a result, the driver most likely moved further to his right, but this movement was restricted by his safety belt. When the vehicle came to rest, the driver most likely moved backward and to his left. The exact posture of the driver at final rest is unknown, but he was able to exit the case vehicle without assistance.

Figure 21: Close-up of loading evidence (i.e., "pinched" area) on webbing of case vehicle's integrated driver seat belt near retractor port (case photo #39)

CASE VEHICLE DRIVER INJURIES

The driver was not transported by ambulance to the hospital. According to his interview, he sustained a minor soft tissue injury and did not seek or receive any medical treatment. The case vehicle's driver sustained a laceration {scratch} to the inside of his left wrist, most likely from his deploying driver air bag.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Laceration {scratch}, < 2.5 cm (< 1 in), anterior (inside) left wrist, not further specified	minor 790602.1,2	Air bag, driver's	Probable	Interviewee (same person)

OTHER VEHICLE

Based on the VIN and manufacturer's specifications, the 2002 Ford Focus ZX3 was a front wheel drive, five-passenger, three-door hatchback (VIN: 3FAFP31392R------) equipped with a 2.0L, I-4 engine and either the standard five-speed manual or an optional four-speed automatic transmission. Four-wheel, anti-lock brakes are an option for this model, but it is unknown if the this vehicle was so equipped. The Ford's wheelbase was 262 centimeters (103.0 inches), and the odometer reading is unknown because the Ford's interior was not inspected. The Ford was equipped with **A**DVANCED **O**CCUPANT **P**ROTECTION **S**YSTEM features including redesigned driver

and front right passenger air bags. According to the Police Crash Report, the driver air bag, at equipped with 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. Standard interior equipment included bucket seats for the driver and front right passenger, and a non-adjustable back bench seat.

Damage Classification: With no available vehicle photographs, the CDC for the Ford is not estimable. The WinSMASH reconstruction program, missing vehicle algorithm, was used on the Ford's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 47.0 km.p.h. (29.2 m.p.h.), -47.0 km.p.h. (-29.2 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The Ford was towed due to damage.

Ford's Occupants: According to the Police Crash Report, the Ford's driver [29-year-old, Black (unknown if Hispanic) female] was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. The driver was not transported by ambulance to the hospital, and she did not sustain any injuries as a result of this crash.

The Ford's back left passenger [5-year-old (unknown race and/or ethnic origin) female] was restrained by her available, active, three-point, lap-and-shoulder safety belt system. This occupant was transported by ambulance to the hospital with police-reported "C" (possible) injuries. The specific nature of her injuries and level of medical treatment are unknown.

The Ford's back right passenger [10-year-old (unknown race and/or ethnic origin) female] was also restrained by her available, active, three-point, lap-and-shoulder, safety belt system. This occupant was transported by ambulance to the hospital with police-reported "B" (non-incapacitating-evident) injuries. Once again, the specific nature of her injuries and level of medical treatment are unknown.

1GCEC14X93Zxxxxxx System Status At Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	962
Ignition Cycles At Investigation	964
Maximum SDM Recorded Velocity Change (MPH)	-17.36
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	125
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	25
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
Suppression System Status Before AE	Air Bag Suppressed
Event Recording Complete	Yes
Multiple Events Associated With This Record	No

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.62	-2.17	-3.72	-5.27	-7.13	-9.92	-13.33	-15.19	-15.81	-15.50	-16.12	-17.05	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	29	1408	16	OFF
-4	30	1600	24	OFF
-3	30	1152	0	ON
-2	27	832	0	ON
-1	19	832	0	ON

Figure 22: Case vehicle's at deployment data including: pre-crash speed, brake switch status, restraint system status, and activation data for vehicle's dual inflation air bags, and the case vehicle's change in velocity (Delta V) over the first 120 milliseconds post deployment

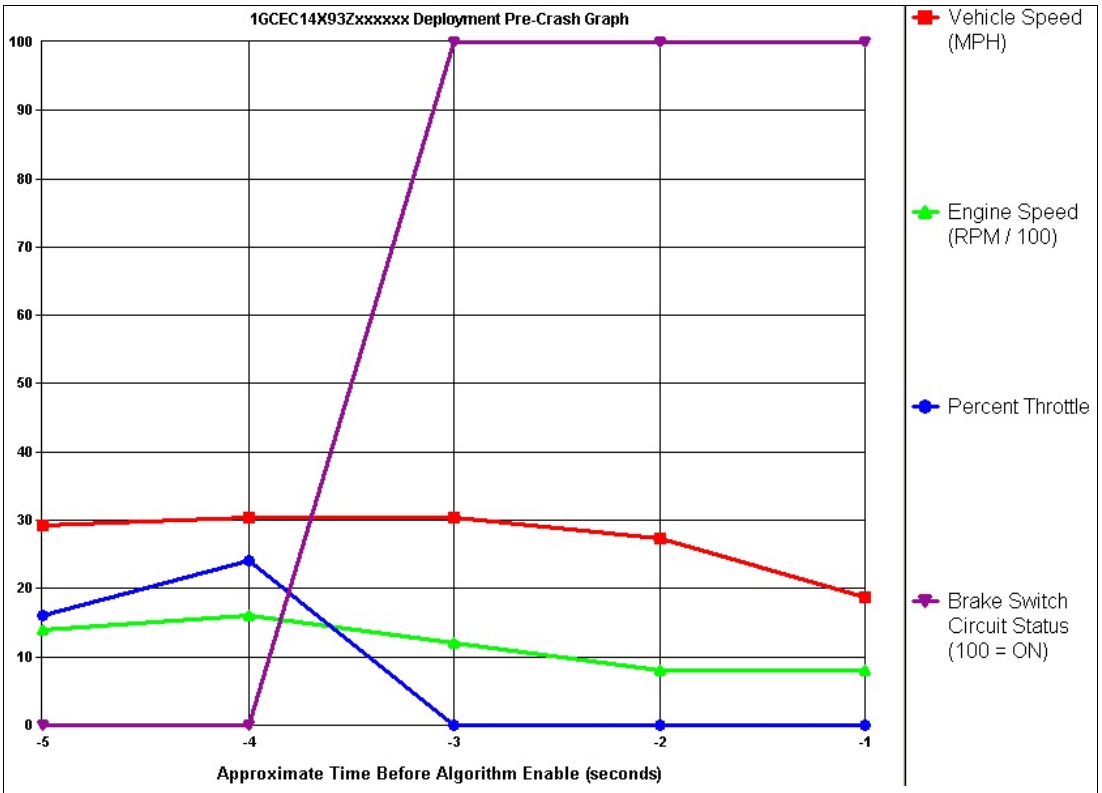


Figure 23: Case vehicle's pre-crash speed and brake switch circuit status showing that the vehicle's speed was recorded at 48 km.p.h. (30 m.p.h.) when the brake was activated approximately 3 seconds prior to algorithm enable.

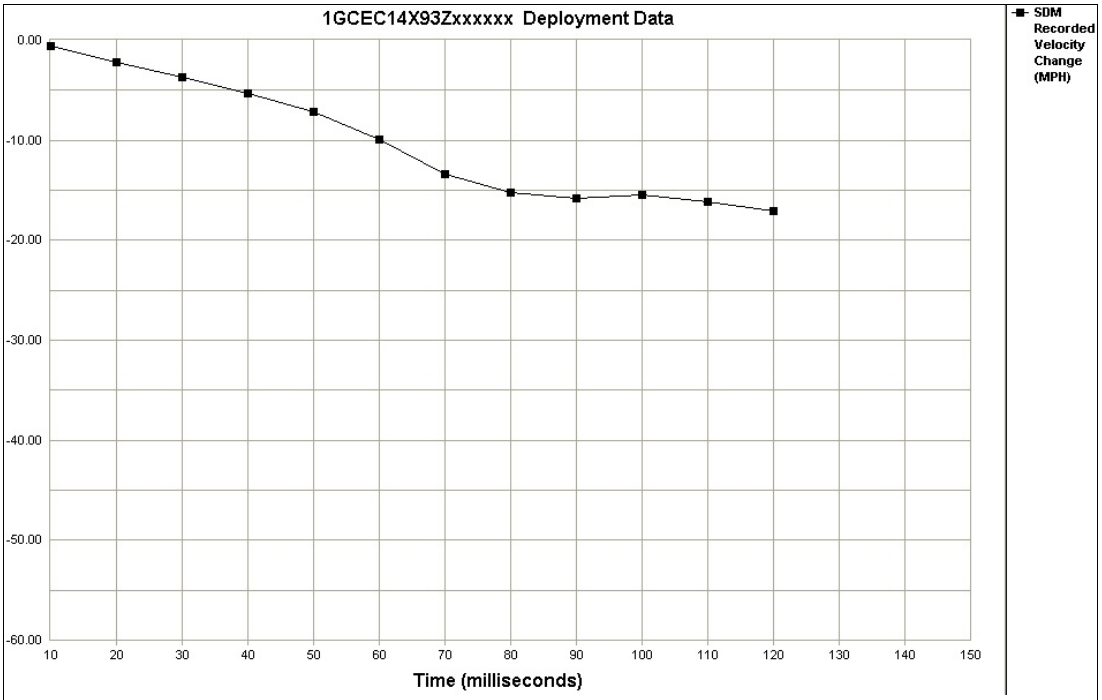


Figure 24: The case vehicle sustained a velocity change of approximately 27.4 km.p.h. (17.1 m.p.h.) during the first 120 milliseconds after the algorithm was enabled; maximum velocity change was recorded as 27.9 km.p.h. (17.4 m.p.h.) at 125 milliseconds.

1GCEC14X93Zxxxxxx System Status At Non-Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Non-Deployment	962
Ignition Cycles At Investigation	964
Maximum SDM Recorded Velocity Change (MPH)	-0.04
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	10
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)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	N/A	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	30	Invalid	24	OFF
-4	30	Invalid	0	ON
-3	27	832	0	ON
-2	19	512	0	ON
-1	14	0	0	ON

Figure 25: Case vehicle's non-deployment data including: pre-crash speed, brake switch status, restraint system status, time (in milliseconds) from algorithm enable to maximum SDM recorded velocity change, and the case vehicle's change in velocity (Delta V) over the first 100 milliseconds post algorithm enablement

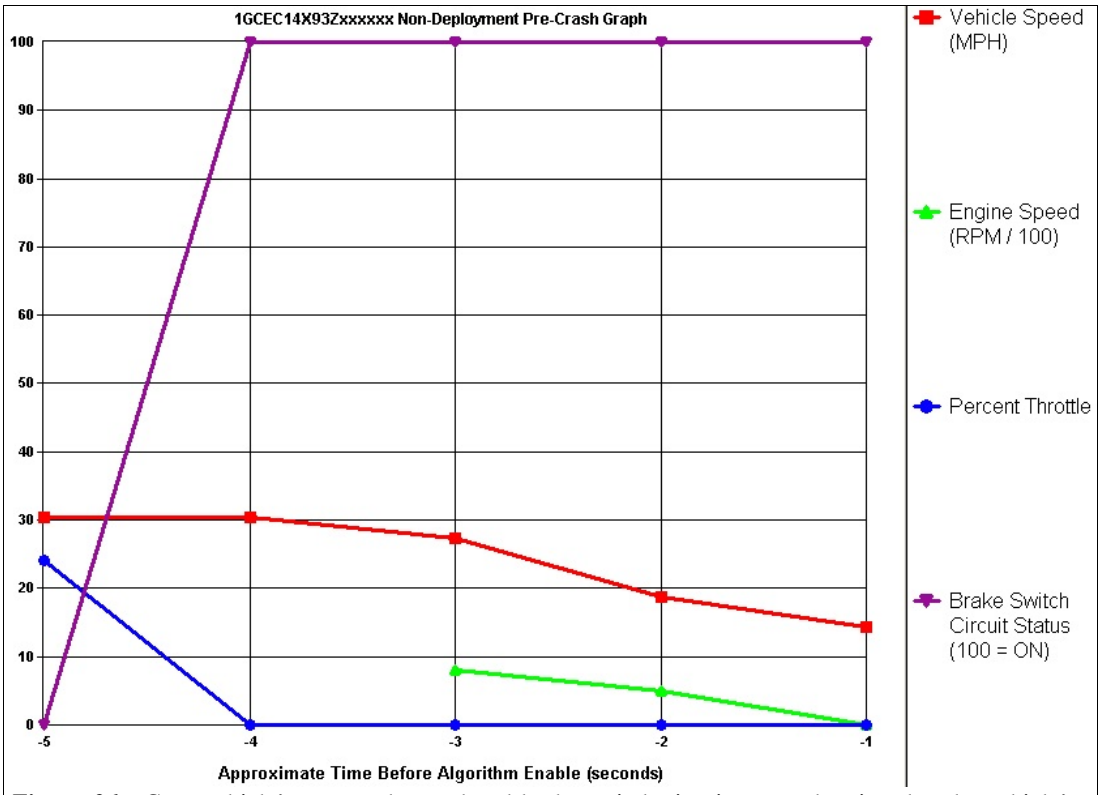


Figure 26: Case vehicle's pre-crash speed and brake switch circuit status showing that the vehicle's speed was recorded at 48 km.p.h. (30 m.p.h.) when the brake was activated approximately 4 seconds prior to algorithm enable.

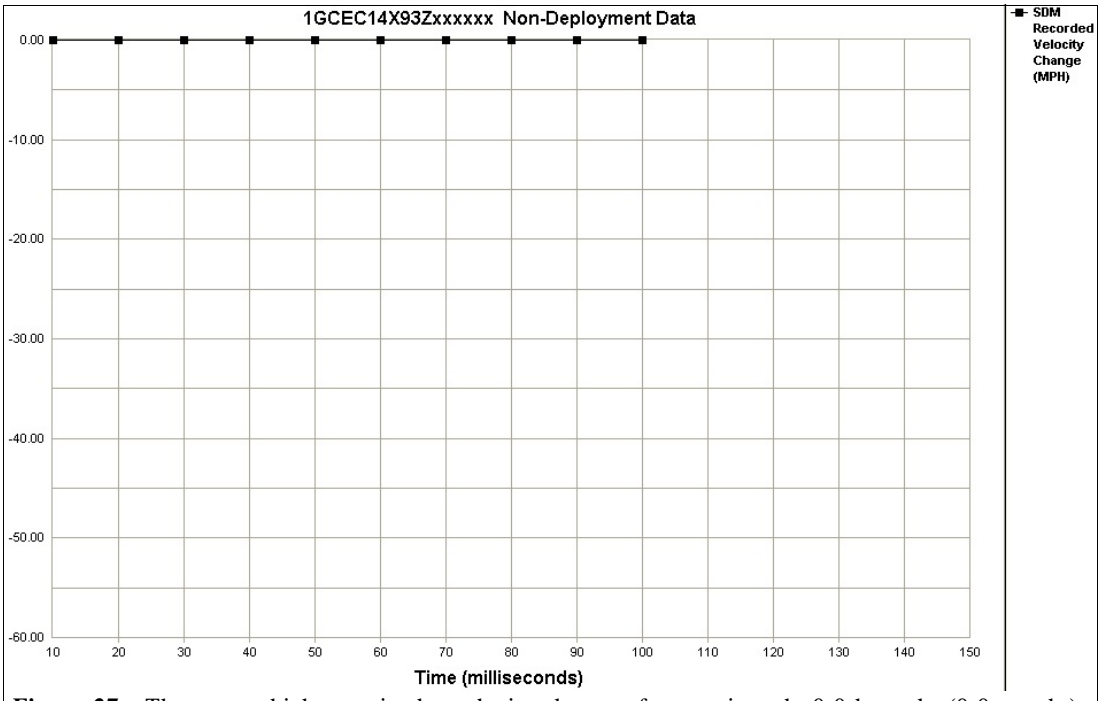
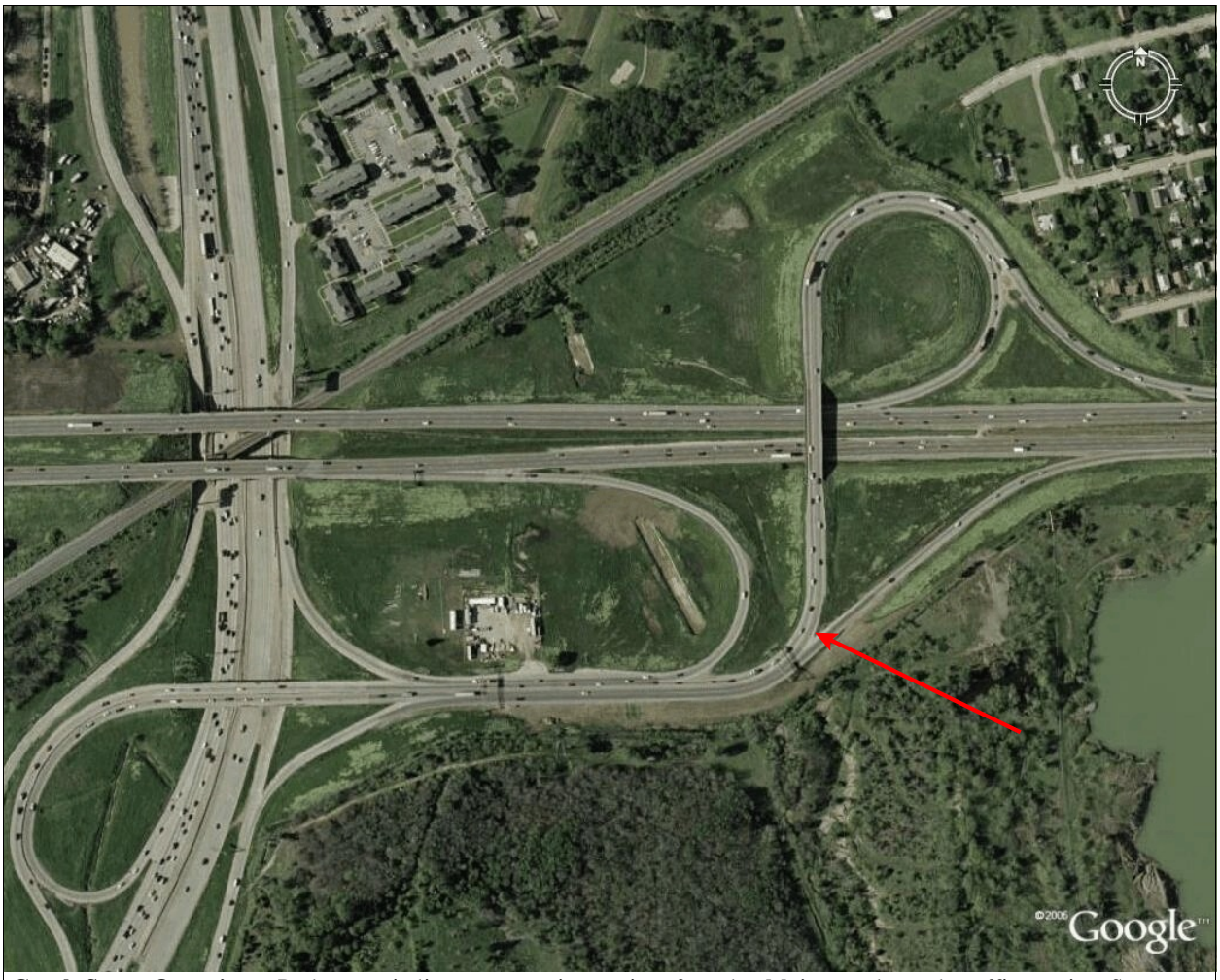
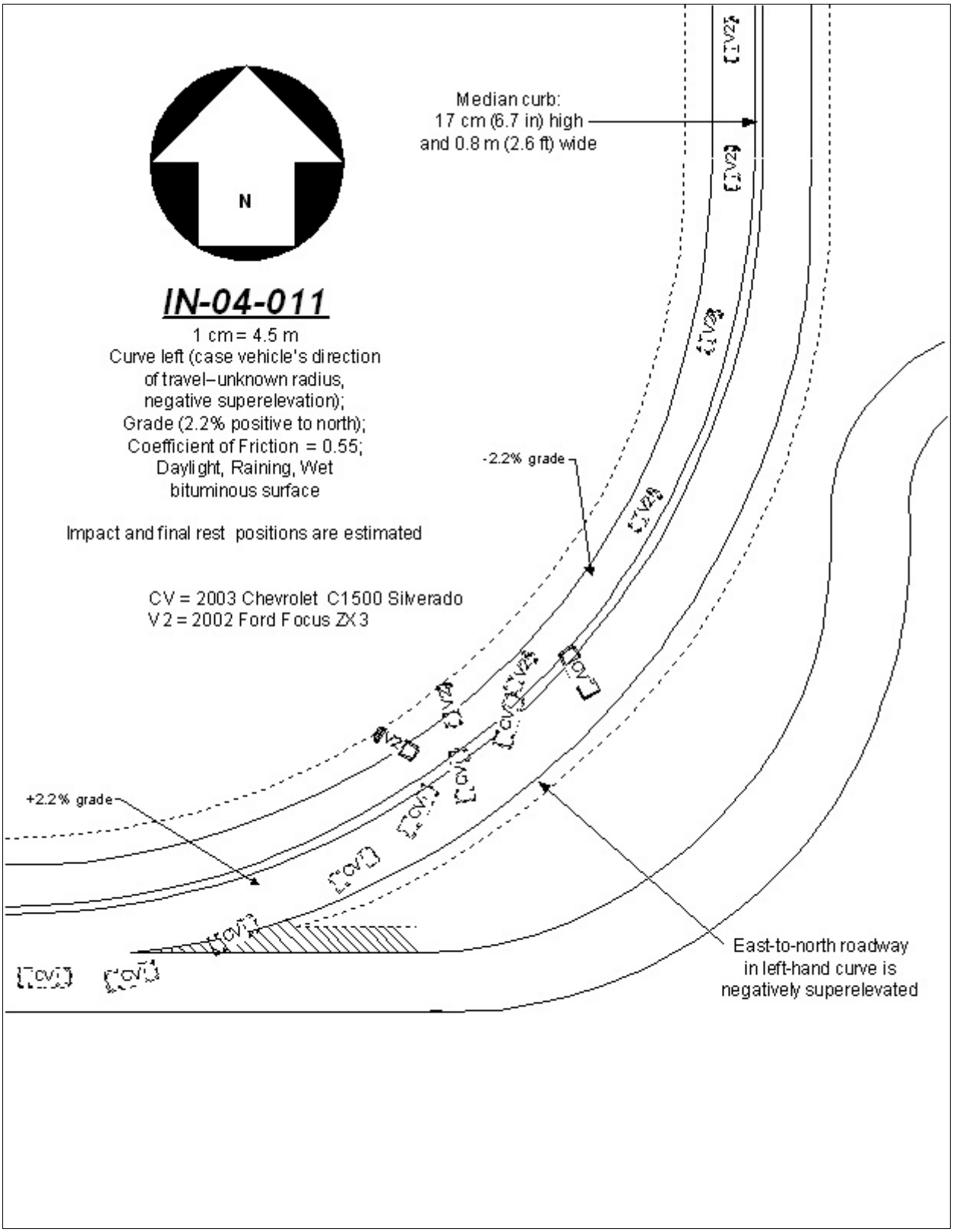


Figure 27: The case vehicle sustained a velocity change of approximately 0.0 km.p.h. (0.0 m.p.h.) during the first 100 milliseconds after the algorithm was enabled; maximum velocity change was recorded as 0.06 km.p.h. (0.04 m.p.h.) at 10 milliseconds



Crash Scene Overview: Red arrow indicates approximate site of crash. Major north-south trafficway is a State highway. Major east-west trafficway is an Interstate highway. Case vehicle entered the ramp complex from the State highway's northbound service road.


N
IN-04-011
1 cm = 4.5 m
Curve left (case vehicle's direction of travel–unknown radius, negative superelevation);
Grade (2.2% positive to north);
Coefficient of Friction = 0.55;
Daylight, Raining, Wet bituminous surface
Impact and final rest positions are estimated
CV = 2003 Chevrolet C1500 Silverado
V2 = 2002 Ford Focus ZX3
Median curb:
17 cm (6.7 in) high
and 0.8 m (2.6 ft) wide
-2.2% grade
+2.2% grade
East-to-north roadway in left-hand curve is negatively superelevated