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ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE INVESTIGATION

CASE NUMBER - IN-03-005
LOCATION - ILLINOIS
VEHICLE - 2003 CHEVROLET K1500 TAHOE
CRASH DATE - January 2003

Submitted:

August 10, 2007

Contract Number: DTNH22-01-C-07002

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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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On-site air bag deployment investigation involving a 2003 Chevrolet K1500 Tahoe, four-door sport utility, with manual safety belts and dual front advanced air bags, and a 2002 Volvo S40, four-door sedan

16. *Abstract*

This report covers an on-site investigation of an air bag deployment crash involved a 2003 Chevrolet Tahoe (case vehicle) and a 2002 Volvo S40 (other vehicle). This crash is of special interest because the case vehicle was equipped with multiple **A**dvance **O**ccupant **P**rotection **S**ystem (AOPS) features, including advanced 208-compliant air bag sensing, as well as well as an **E**vent **D**ata **R**ecorder (**EDR**) and neither the case vehicle's driver (23-year-old, female) nor the front right passenger ([26-year-old, male) sustained injury from their deploying driver and front right passenger air bags. The trafficway on which both vehicles were traveling was a ten-lane, divided, Interstate highway, traversing in a northerly and southerly direction (i.e., the trafficway had three roadways). Both the local southern and northern roadways had four through lanes respectively, while the third, center express roadway had two, reversible, through lanes and was physically located between the northern and southern roadways. The case vehicle was traveling south in the inside through lane of the four-lane southern roadway. The Volvo was also traveling southward in the right center through lane. A noncontact vehicle traveling in the left center lane swerved into the same lane as the case vehicle. The case vehicle's driver, in an attempt to avoid any contact, veered to the left and back to the right an undetermined number of times before losing control of the vehicle. The case vehicle rotated clockwise and crossed into the right center lane of the local southern roadway where the crash was initiated. The front of the case vehicle impacted the left side of the Volvo. The case vehicle continued in its southwesterly direction, and the front of the case vehicle impacted the concrete longitudinal barrier along the west side of the trafficway, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. The case vehicle's driver was seated with her seat track located in its forward-most position, and the tilt steering wheel was located in its middle position. The front right passenger was seated with his seat track located in its rearmost position. Both front passengers were restrained by their available, active, three-point, integral lap-and-shoulder, safety belt system. The second seat left passenger (61-year-old, female) and right passenger (7-year-old, female) were both seated on a non-adjustable bench seat, and the seat back was not adjustable. Both were restrained by their available, active, three-point, lap-and-shoulder, safety belt systems. The second seat center passenger (5-month-old, male) was seated facing rearward in a child (infant) safety seat on the same non-adjustable bench seat whose the seat back was not adjustable. This passenger was restrained by a five-point harness built into the child safety seat and the seat was secured by the available, active, three-point, lap-and-shoulder, safety belt system that was used in conjunction with the child safety seat. According to the interview with the front right passenger, none of this vehicle's occupants sustained any injuries as a result of this crash.

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This on-site investigation was brought to NHTSA's attention on January 29, 2003 by NASS CDS sampling activities. This crash involved a 2003 Chevrolet Tahoe (case vehicle) and a 2002 Volvo S40 (other vehicle). The crash occurred in January 2003, at 8:34 p.m., in Illinois and was investigated by the applicable state police department. This crash is of special interest because the case vehicle was equipped with multiple **A**dvance **O**ccupant **P**rotection **S**ystem (AOPS) features, including optional seat back-mounted side air bags, advanced 208-compliant air bag sensing, as well as well as an **E**vent **D**ata **R**ecorder (**EDR**) and neither the case vehicle's driver [23-year-old, White (Hispanic) female] nor the front right passenger [26-year-old, White (Hispanic) male] sustained injury from their deploying driver and front right passenger air bags. This contractor inspected the scene and vehicles on 10-11 February 2003 and downloaded the data from the onboard **EDR**. This contractor interviewed the front right passenger and owner of the case vehicle on 10 February 2003. This report is based on the Police Crash Report, interviews with the case vehicle's owner/passenger, 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 highway, traversing in a north-northwesterly and south-southeasterly direction (i.e., the trafficway had three roadways). Both the local southern and northern roadways had four through lanes respectively, while the third, center express roadway had two, reversible, through lanes and was physically located between the northern and southern roadways. At the time of the crash the light condition was dark, but illuminated by overhead street lamps at the area of impact, the atmospheric condition was snowing, and the roadway pavement was snow covered. Traffic density was not determined, and the site of the crash was urban commercial; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle was traveling south in the inside through lane of the four-lane southern roadway and intended to proceed straight ahead. The Volvo was also traveling southward, but it was traveling in the right center through lane and intended to proceed straight ahead. According to the case vehicle's front right passenger, a noncontact vehicle traveling just ahead of the case vehicle in the left center lane swerved from right to left into the same lane as the case vehicle. At this point, in an attempt to avoid any contact, the case vehicle's driver veered to the left and back to the right an undetermined number of times before losing control of the vehicle. According to the Police Crash Report and the occupant's interview, the case vehicle rotated approximately 60-75 degrees clockwise and crossed the left center lane prior to entering the right center lane. The crash took place on the interstate trafficway in the right center lane of the local southern roadway.

Crash: The front of the case vehicle impacted the left passenger area of the Volvo, causing the Volvo to rotate counterclockwise out of the case vehicle's travel path, while moving in a south-southwesterly direction. The Volvo's driver seat back-mounted, side air bag and the Volvo's left side curtain air bag deployed as a result its left side impact from the case vehicle.

Post-Crash: As a result of the initial impact, the case vehicle continued in its southwesterly direction, and the front of the case vehicle impacted the concrete longitudinal barrier along the west side of the trafficway, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Based on the downloaded EDR data, only one stage of the multi-stage air bags was activated. According to the case vehicle's occupant, the case vehicle rotated clockwise off the barrier and came to rest heading west, obliquely oriented to the barrier, straddling the outside southern through lane and the west shoulder of the roadway.

As the Volvo moved in a south-southwesterly direction it also continued to rotate counterclockwise after its initial impact. The Volvo had rotated approximately 85-90 degrees counterclockwise when its back right collided with the same, western, concrete longitudinal barrier. According to the case vehicle's occupant, the Volvo's rotation was reversed by the barrier and it rotated clockwise off the barrier coming to rest heading southeast primarily on the western shoulder but straddling the outside southern lane.

Case Vehicle: The 2003 Chevrolet Tahoe was a one-half ton, four wheel drive, four-door sport utility vehicle (VIN: 1GNEK13ZX3J------). The case vehicle was equipped with four wheel, anti-lock brakes, dual stage driver and front right passenger air bag inflators, and driver and front right passenger seat belt buckle switch sensors. Furthermore, there was an occupant detection and automatic air bag suppression system for the front right passenger seating position. In addition, front seat back-mounted side impact air bags were optional for this model, but this vehicle was not so equipped. Power-adjustable pedals were optional for this model, but this vehicle was not so equipped. Finally, the case vehicle was also equipped with an **E**vent **D**ata **R**ecorder (**EDR**).

Vehicle Exterior: At the time of this contractor's inspection, the case vehicle was under repair, with a notable replacement of the frame and no bumpers or fenders attached, and the damaged components were no longer available. As a result, no crush measurements were possible, and no exterior photographs of the case vehicle were taken by this contractor. However, this contractor was able to obtain exterior photographs from the vehicle's body shop, and based on the body shop-provided photographs, the CDC for the case vehicle's combined (i.e., overlapping damage is present) frontal impacts is estimated as: **12-FDEW-1** (**0** degrees). No reconstruction program was used on this crash because the NASS, CDS, WinSMASH protocol requires that actual vehicular crush measurements be obtained; however, this contractor's visually estimated Delta V for the combined frontal impacts is between 6.4 km.p.h. (4 m.p.h.) and 19.3 km.p.h. (12 m.p.h.). Based on the available owner photographs and the data from the EDR, this multiple impact collision fits the reconstruction model, and the results appear to be reasonable. The case vehicle was towed due to damage.

Exterior Damage: The case vehicle's initial contact with the Volvo involved its front. The case vehicle's front also impacted the concrete longitudinal barrier along the west side of the trafficway, causing the driver and front right passenger supplemental restraints (air bags) to deploy. As discussed above because the case vehicle was under repair, no crush measurements were possible. Because the frame had been replaced, it is unknown if the case vehicle's wheelbase had been altered from the crash. The case vehicle's front bumper, bumper fascia, grille, hood, left and right headlight and turn signal assemblies, and fenders were most likely directly damaged and

crushed rearward. In addition there was damage to the frame's front cross-member. There was induced damage to the hood, both the right and left fenders, and both the left and right front doors. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior during the inspection. The case vehicle manufacturer's recommended tire size was: P265/70R16, and the case vehicle tires were the recommended size. The case vehicle's tire data are shown in the table below. At the time of inspection, none of the case vehicle's tires were damaged, deflated, or physically restricted.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	228	33	241	35	8	10	None	No	No
RF	228	33	241	35	9	11	None	No	No
LR	228	33	241	35	9	11	None	No	No
RR	234	34	241	35	9	11	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. Finally, 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 two tethers, with each strap approximately 15 centimeters (5.9 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 65 centimeters (25.6 inches). An inspection of the driver's air bag fabric revealed a makeup smear within the 15 centimeter (5.9 inch) center circular stitching and other possible contacts located toward the left side of the air bag's fabric [i.e., 15 centimeters (5.9 inches) inboard and 5 centimeters (2.0 inches) above the lateral centerline of the air bag **and** 11 centimeters (4.3 inches) inboard and 2 centimeters (0.8 inches) below the lateral centerline].

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 with one wide tether that measured approximately 39 centimeters (15.4 inches) in width. The front right air bag had two vent ports, approximately 3 centimeters (1.2 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 60 centimeters (23.6 inches) and a width of approximately 50 centimeters (19.7 inches). An inspection of the front right passenger's air bag fabric revealed that there was some kind of fluid stain evidence apparent on the front surface of the air bag's fabric near the center of the lower right quadrant [i.e., 10 centimeters (3.9 inches) from the bottom and 6 centimeters (2.4 inches) inboard from the right edge]. In addition, there was some irregular scuffing at the lower center of the bag [i.e., 8 centimeters (3.1 inches) from the bottom and 18 centimeters (7.1 inches) inboard from the right edge].

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, vehicle's speed and brake switch status for the five recorded sample periods preceding the **ALGORITHM ENABLE**, ignition cycles at deployment (2nd event), 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 85 km.p.h. (53 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 12.47 km.p.h. (7.75 m.p.h.) at the 110 millisecond mark of recorded data. This contractor believes that the recorded Delta V seems reasonable considering the amount of deformation pictured to the case vehicle's front.

Likewise for the non-deployment event (1st event), the data downloaded from the case vehicle's **EDR** also 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 case vehicle was traveling at a speed of 87 km.p.h. (54 m.p.h.), the driver's seat belt status showed it was buckled, and the Delta V reached a value of 6.98 km.p.h. (4.34 m.p.h.) at the 150 millisecond mark of recorded data. This contractor believes that the recorded Delta V seems reasonable considering the amount of deformation pictured to the case vehicle's front.

In this contractor's opinion, the non-deployment event occurred prior to the deployment event (i.e., the case vehicle's impacted with the Volvo was the non-deployment event while the impacted with the longitudinal barrier deployed the air bags). The **EDR** showed that there was a 0.9 second interval between the two events.

Child Safety Seat: The second seat center passenger was seated in a rear facing infant child safety seat with a separable base. The child safety seat was manufactured by Evenflo, on April 18, 2002, and was identified by Model name"Cozy Carry" and Model number **4771273P1**. The infant seat was designed with a five-point harness. There were three slots in the seat's back for positioning the harness straps; the harness was positioned in the top slots. The child seat was in the reclined position.

According to the case vehicle's inspection, the latch plate for this seating position's safety belt was the "sliding" type. The case vehicle's safety belt system had a switchable retractor which, at the time of the crash according to the case vehicle's front right passenger, was in the

Automatic Locking Retractor (ALR) mode. According to the case vehicle's front right passenger, the belt webbing had been extended completely out of the retractor, buckled, and then slowly released back into the retractor housing.

The infant child safety seat consisted of a plastic one-piece shell and a one piece plastic base. The vehicle's safety belts were positioned through the base and the removable shell locked into the base when in use in the vehicle. A manufacturer's label was affixed to the top of the child seat's base, illustrating the proper way to install the vehicle's safety belts when the seat is in a rear center seat or front passenger seat. The warning continues to explain the importance of securing the child restraint with a vehicle's safety belt as specified in the vehicle manufacturer's instructions. This warning label was dated 1/02. There were also two large white, multicolored, warning labels–one on each side of the shell, warning the user parent to not place this child seat in a vehicle's front right seat when the vehicle is equipped with a front right passenger air bag. The warning labels were primarily bright white with black writing, advising that serious injury or death could occur if an air bag inflated against this child restraint. The manufacturer's label provided the child seat's height and weight limitations [i.e., approximately 2.3-10 kilograms and 48-65 centimeters (5-22 pounds, 19-26 inches)]. This warning label was dated 10/01. A close inspection of the child safety seat revealed no apparent damage or fractures to the base or the seat's shell.

Other Vehicle: The 2002 Volvo S40 was a front wheel drive, four-door sedan (VIN: YV1VS29532F------). The Volvo was equipped with four wheel, anti-lock brakes. The Volvo was equipped with knee bolsters for both the driver and front right passenger, neither of which were deformed. 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. In addition, the vehicle was equipped with front, seat back-mounted, side impact air bags and side-inflatable curtain air bags which extend from each of the roof side rails. Neither frontal air bag deployed as a result of the Volvo's left side impact with the case vehicle. On the other hand, the driver's seat back-mounted side air bag and the left side inflatable curtain did deploy as a result of the Volvo's left side impact with the case vehicle.

Exterior Damage: Based on the vehicle inspection, the CDCs for the Volvo were estimated as: **08-LZEW-2** (**250** degrees) and **04-BDEW-1** (**130** degrees). No crush profile or maximum crush were taken on the Volvo's left side impact because the door surface was cut by pneumatic shears. No crush profile was taken on the impact to the Volvo's back because this impact occurred with a longitudinal barrier and the case vehicle was not involved. The Volvo was towed due to damage.

Case Vehicle's Driver: Immediately prior to the crash the case vehicle's driver [23-year-old, White (Hispanic) female; 163 centimeters and 64 kilograms (54 inches, 140 pounds)] was seated in a slightly reclined posture with her back against the seat back, her left foot on the floor, her right foot on the accelerator, and both hands on the steering wheel. Her seat track was located in its forward-most position, the seat back was slightly reclined, and the tilt steering wheel was located in its middle position.

Based on this contractor's vehicle inspection and supported by the interview with the case vehicle's front right passenger and the **EDR** data, the driver was restrained by her available, active, three-point, integral lap-and-shoulder, safety belt system; the belt system was not equipped with a pretensioner. There was no mention by the front right passenger of belt pattern bruising and/or abrasions to the driver's torso, and while the inspection of the driver's seat belt webbing, shoulder belt guide, and latch plate found no obvious loading evidence on the integrated safety belt's webbing or latch plate, the webbing was slightly rippled indicating trace loading.

According to the case vehicle's front right passenger, the driver steered to the left to avoid colliding with the alleged noncontact vehicle and then swerved back to the right and left an undetermined number of times, attempting to regain control of the vehicle. As a result and independent of the use of her available safety belts, her pre-impact body position may have shifted from right to left but, most likely, was well within the confines of her seat position. The case vehicle's impact with the Volvo enabled the case vehicle's driver to continue forward and slightly rightward, probably loading her safety belts, as the case vehicle decelerated The driver most likely remained near her original seating position but leaning slightly forward as the case vehicle departed the roadway toward the concrete longitudinal barrier. The case vehicle's impact with the concrete longitudinal barrier enabled the driver to continue forward and slightly rightward as the case vehicle decelerated. As a result, she contacted her deploying driver air bag, depositing a makeup smear in the bag's center circular area. The driver most likely rebounded rearward toward her seat back as a result of the air bag's deployment. As a result of the barrier impact, the case vehicle rotated clockwise. The driver most likely moved back forward and to her left as the case vehicle slid to final rest. The exact posture of the driver at final rest is unknown, but she was able to exit the vehicle without assistance.

The case vehicle's driver was not transported by ambulance to the hospital. Although she was mildly shaken by the crash, she did not sustain any injuries as a result of this crash. According to the case vehicle's front right passenger, she was examined by EMS personnel at the crash scene and did not seek any further medical treatment.

Case Vehicle's Front Right Passenger: The case vehicle's front right passenger [26-year-old, White (Hispanic) male;175 centimeters and 86 kilograms (69 inches, 190 pounds)] was seated in an upright posture with his torso turned to his right, possibly leaning slightly forward, his feet on the floor, his left hand on the armrest, and his right hand on the handle attached to the roof side rail. His seat track was located in its rearmost position, and the seat back was sightly reclined.

The case vehicle's front right passenger was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system; the belt system was not equipped with a pretensioner. There was no mention by this occupant of belt pattern bruising and/or abrasions to his torso, but the inspection of the front right passenger's integrated seat belt webbing, shoulder belt guide, and latch plate showed evidence of usage on the webbing during this crash.

The right front passenger was not transported to a medical facility and did not sustain any injuries as a result of this crash. According to his interview, he was examined by EMS personnel at the crash scene and did not seek any further medical treatment.

Case Vehicle's Second Seat Left Passenger: The case vehicle's second seat left passenger [61-year-old, White (Hispanic) female; 173 centimeters and 59 kilograms (68 inches and 130 pounds)] was seated in an upright posture but turned to the right feeding the infant occupant in the second seat center seat. Her feet were on the floor but her hands were holding a baby bottle. There was no seat track, and the seat back was not adjustable.

This passenger was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. There was no mention by the front right passenger of belt pattern bruising and/or abrasions to the second seat left passenger's torso, but the inspection of the second seat left passenger's seat belt webbing and latch plate showed evidence of usage (i.e., rippling) during this crash.

The second seat left passenger was not transported to a medical facility and, according to the case vehicle's front right passenger, did not sustain any injuries as a result of this crash. She was examined by EMS personnel at the crash scene and did not seek any further medical treatment.

Case Vehicle's Second Seat Center Passenger: The case vehicle's second seat center passenger [5-month-old, White (Hispanic) male; 71 centimeters and 9 kilograms (28 inches and 20 pounds)] was seated facing rearward in a child (infant) safety seat. The child's feet and hands were within the child seat. There was no seat track, and the seat back was not adjustable.

This passenger was restrained by a five-point harness built into the child safety seat and the seat was secured by the available, active, three-point, lap-and-shoulder, safety belt system that was used in conjunction with the child safety seat. There was no mention by the front right passenger of belt pattern bruising and/or abrasions to the second seat center passenger's torso, but the inspection of the second seat center passenger's seat belt webbing and latch plate showed evidence of usage on the webbing during this crash.

The second seat center infant passenger was not transported to a medical facility and, according to the case vehicle's front right passenger, did not sustain any injuries as a result of this crash. He was examined by EMS personnel at the crash scene and did not seek any further medical treatment.

Case Vehicle's Second Seat Right Passenger: The case vehicle's second seat right passenger [7-year-old, White (Hispanic) female; 114 centimeters and 31 kilograms (45 inches and 69 pounds)] was seated in an upright posture with her feet dangling over the front edge of the seat's cushion, angled downward. In addition, the exact position of her hands is unknown. There was no seat track, and the seat back was not adjustable.

The second seat right passenger was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. There was no mention by the front right passenger of belt pattern bruising and/or abrasions to the second seat right passenger's torso, but the inspection of the second seat right passenger's seat belt webbing and latch plate showed only trace evidence of usage during this crash.

Once again, the second seat right passenger was not transported to a medical facility and, according to the case vehicle's front right passenger, did not sustain any injuries as a result of this crash. She was examined by EMS personnel at the crash scene and also did not seek any further medical treatment.

Volvo's Occupants: According to the Police Crash Report, the Volvo's driver [53-year-old, (unknown race and/or ethnic origin) 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.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was a ten-lane, divided, Interstate highway, traversing in a north-northwesterly and south-southeasterly direction (i.e., the trafficway had three roadways). Both the local southern and northern roadways had four through lanes respectively, while the third, center express roadway had two, reversible, through lanes and was physically located between the northern and southern roadways (**Figure 1**). The applicable road segment of this interstate highway was straight and level (i.e., actual slope was not determined, but it was slightly positive to the north-northwest–an upgrade) in the case vehicle's direction of travel near the area of impact. The pavement was concrete, but traveled, and the width of the travel lanes for both vehicles was most likely the interstate standard of 3.7 meters (12 feet). The shoulders were improved (i.e., concrete) but their width was not measured. Both the eastern and western shoulders preceded a concrete longitudinal barrier which protected the roadside to the east and served as a median barrier to the west. The roadway was not bordered by curbs. Pavement markings for the roadway consisted of a solid yellow edge line on the western side and a solid white edge line on eastern side. In addition, the four through lanes were divided by dashed white lines and raised pavement markers. The estimated wet coefficient of friction was 0.40. Traffic controls consisted of a regulatory **SPEED LIMIT** sign (MUTCD, R2-1) in the immediate area of the crash. The posted speed limit was 72 km.p.h. (45 m.p.h.). At the time of the crash the light condition was dark, but illuminated by overhead street lamps at the area of impact, the

Figure 1: Northward view from perpendicular overpass of interstate trafficway's southbound local roadway; Note: arrows indicate pre-crash travel lanes for case vehicle–blue and Volvo–red (case photo #12)

Figure 2: Volvo's southward travel path in right center lane showing two overpasses from which elevated photographs were taken (case photo #07a)

atmospheric condition was snowing, and the roadway pavement was snow covered. Traffic density was not determined, and the site of the crash was urban commercial; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle was traveling south in the inside through lane of the four-lane southern roadway and intended to proceed straight ahead (**Figure 1** above). The Volvo was also traveling southward, but it was traveling in the right center through lane and intended to proceed straight ahead (**Figure 2** above). According to the case vehicle's front right passenger, a noncontact vehicle traveling just ahead of the case vehicle in the left center lane swerved from right to left into the same lane as the case vehicle. At this point, in an attempt to avoid any contact, the case vehicle's driver veered to the left and back to the right an undetermined number of times before losing control of the vehicle. According to the Police Crash Report and the occupant's interview, the case vehicle rotated approximately 60-75 degrees clockwise and crossed the left center lane prior to entering the right center lane. The crash took place on the interstate trafficway in the right center lane of the local southern roadway.

Figure 3: Body shop photo showing case vehicle's front right direct damage and induced damage to right fender and right front door (case photo #109)

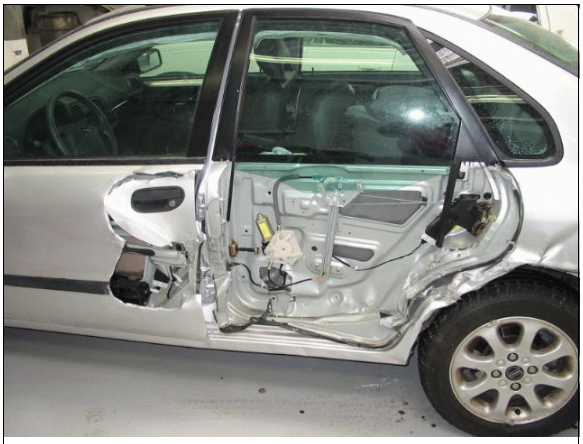


Figure 4: Impact on Volvo's left passenger area caused by front of case vehicle; Note: impact deployed Volvo's driver seat back-mounted side air bag and left side curtain air bag (case photo #63)

Crash: The front (**Figure 3**) of the case vehicle impacted the left passenger area (**Figure 4**) of the Volvo, causing the Volvo to rotate counter-clockwise out of the case vehicle's travel path, while moving in a south-southwesterly direction. The Volvo's driver seat back-mounted, side air bag and the Volvo's left side curtain air bag deployed as a result its left side impact from the case vehicle.

Figure 5: Body shop photo of case vehicle's frontal damage showing damage across entire front (case photo #108)

Post-Crash: As a result of the initial impact, the case vehicle continued in its southwesterly direction, and the front (**Figure 5** and **Figure 6** below) of the case vehicle impacted the concrete

longitudinal barrier along the west side of the trafficway, causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Based on the downloaded EDR data, only one stage of the multi-stage air bags was activated. According to the case vehicle's occupant, the case vehicle rotated clockwise off the barrier and came to rest heading west, obliquely oriented to the barrier, straddling the outside southern through lane and the west shoulder of the roadway.

Figure 6: Body shop photo showing case vehicle's front left direct damage and induced damage to left fender and left front door (case photo #111)

As the Volvo moved in a south-southwesterly direction it also continued to rotate counterclockwise after its initial impact. The Volvo had rotated approximately 85-90 degrees counterclockwise when its back right collided with the same, western, concrete longitudinal barrier (**Figure 7**). According to the case vehicle's occupant, the Volvo's rotation was reversed by the barrier and it rotated clockwise off the barrier coming to rest heading southeast primarily on the western shoulder but straddling the outside southern lane.

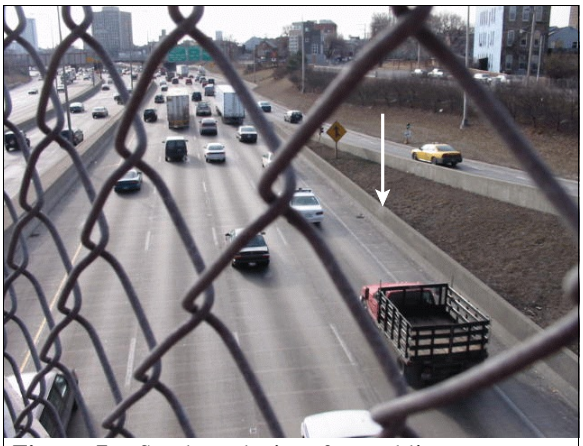


Figure 7: Southward view from oblique overpass showing approximate area of impacts and final rest for both vehicles; Note: arrow indicates suspected impact location between one of the vehicles and longitudinal barrier (case photo #11a)

CASE VEHICLE

The 2003 Chevrolet Tahoe was a one-half ton, four wheel drive, eight-passenger, four-door sport utility vehicle (VIN: 1GNEK13ZX3J------) equipped with a 5.3L, V-8 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 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, there was an occupant detection and automatic air bag suppression system for the front right passenger seating position. In addition, front seat back-mounted side impact air bags were optional for this model, but this vehicle was not so equipped. Power-adjustable pedals were also optional for this model, but this vehicle was not so equipped. Finally, the case vehicle was also equipped with an **E**vent **D**ata **R**ecorder (**EDR**). The case vehicle's wheelbase was 295 centimeters (116.0 inches). The actual odometer reading at inspection is unknown because the odometer was electronic, but the reading was estimated as 3,219 kilometers (2,000 miles).

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 weight sensor in the seat determines first, if a passenger is on the seat and, second, if the weight of the passenger is below a set value [i.e., the specific weight value is not known for the case vehicle, but must be 30 kilograms (66 pounds) or less]. If no front right occupant is seated or the occupant's weight is below the set value, then the sensor will suppress deployment of the front right passenger air bag. 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).

Inspection of the vehicle's interior revealed adjustable front bucket seats with adjustable head restraints; non-adjustable bench seats with adjustable head restraints for the outboard seating positions for both the back and second seating area; and continuous loop, three-point, lap-and-shoulder, safety belt systems at all eight front, second seat, and back positions. The front outboard safety belts were integrated within the front seats. The vehicle was equipped with knee bolsters for both the driver and front right passenger, 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. Both frontal air bags deployed as a result of the case vehicle's frontal impact with the concrete longitudinal barrier.

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's initial contact with the Volvo involved its front. The case vehicle's front also impacted the concrete longitudinal barrier along the west side of the trafficway, causing the driver and front right passenger supplemental restraints (air bags) to deploy. As discussed above because the case vehicle was under repair, no crush measurements were possible. Because the frame had been replaced, it is unknown if the case vehicle's wheelbase had been altered from the crash. The case vehicle's front bumper, bumper fascia, grille, hood, left and right headlight and turn signal assemblies, and fenders were most likely directly damaged and crushed rearward (**Figures 3**, **5**, and **6** above). In addition there was damage to the frame's front cross-member (**Figure 8**). There was induced damage to the hood, both the right and left fenders, and both the left and right front doors. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior during the inspection. The case vehicle manufacturer's recommended tire size was: P265/70R16, and the case vehicle tires were the recommended size.

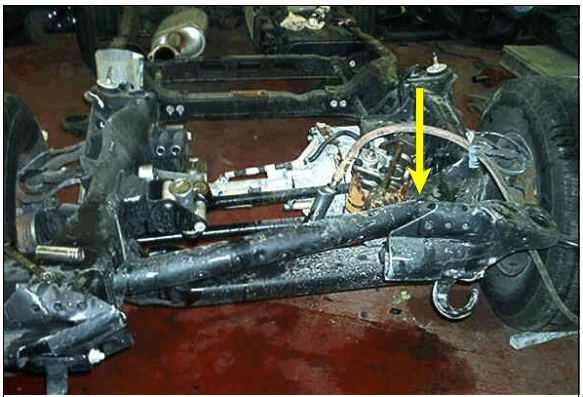


Figure 8: Body shop photo of case vehicle's frame showing damage to frame's front cross-member (case photo #113)

The case vehicle's tire data are shown in the table below. At the time of inspection, none of the case vehicle's tires were damaged, deflated, or physically restricted.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	228	33	241	35	8	10	None	No	No
RF	228	33	241	35	9	11	None	No	No
LR	228	33	241	35	9	11	None	No	No
RR	234	34	241	35	9	11	None	No	No

Interior Damage: 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 9** and **10** and **Figures 11** and **12** below). Finally, 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 9: Case vehicle's driver seating area showing no apparent evidence of occupant contact to the steering wheel, instrument panel, or green-house components (case photo #23)

Figure 10: Case vehicle's front right passenger seating area showing no apparent occupant contact evidence to the instrument panel or greenhouse components (case photo #25)

Damage Classification: At the time of this contractor's inspection, the case vehicle was under repair, with a notable replacement of the frame and no bumpers or fenders attached, and the damaged components were no longer available. As a result, no crush measurements were possible, and no exterior photographs of the case vehicle were taken by this contractor. However, this contractor was able to obtain exterior photographs from the vehicle's body shop, and based on the body shop-provided photographs, the CDC for the case vehicle's combined (i.e., overlapping damage is present) frontal impacts is estimated as: **12-FDEW-1** (**0** degrees). No reconstruction program was used on this crash because the NASS, CDS, WinSMASH protocol requires that actual vehicular crush measurements be obtained; however, this contractor's visually estimated Delta V for the combined frontal impacts is between 6.4 km.p.h. (4 m.p.h.) and 19.3 km.p.h. (12 m.p.h.). Based on the available owner photographs and the data from the EDR, this multiple impact collision fits the reconstruction model, and the results appear to be reasonable. The case vehicle was towed due to damage.

Figure 11: Case vehicle's second seating area showing no apparent contact evidence to the driver's seat back, interior surface of the left rear door, or greenhouse components (case photo #58)

Figure 12: Case vehicle's second seating area showing no apparent occupant contact evidence to the front right passenger's seat back, interior surface of the right rear door, or greenhouse components (case photo #59)

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. Both frontal air bags deployed as a result of the frontal impact with the longitudinal barrier along the east side of the trafficway. Only one stage of the dual-stage air bags was activated. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical, essentially, "I"-configuration cover flaps made of thick vinyl. Both the left and right flaps were trapezoidal in shape with overall dimensions of 7 centimeters (2.8 inches) at the top horizontal seam, 5 centimeters (2.0 inches) at the bottom horizontal seam, and 12 centimeters (4.7 inches) vertically along the seam that separated the two flaps. 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, with each strap approximately 15 centimeters (5.9 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 65 centimeters (25.6 inches). An inspection of the

driver's air bag fabric revealed a makeup smear within the 15 centimeter (5.9 inch) center circular stitching and other possible contacts located toward the left side of the air bag's fabric [i.e., 15 centimeters (5.9 inches) inboard and 5 centimeters (2.0 inches) above the lateral centerline of the air bag **and** 11 centimeters (4.3 inches) inboard and 2 centimeters (0.8 inches) below the lateral centerline–**Figure 13**].

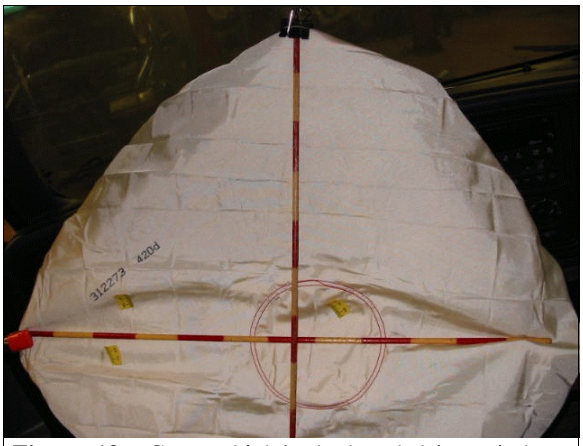


Figure 13: Case vehicle's deployed driver air bag showing makeup smear within center circular stitching and possible contacts toward 9 o'clock position (case photo #29)

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 13.5 centimeters (5.3 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 25 centimeters (9.8 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 with one wide tether that measured approximately 39 centimeters (15.4 inches) in width. The front right air bag had two vent ports, approximately 3 centimeters (1.2 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 60 centimeters (23.6 inches) and a width of approximately 50 centimeters (19.7 inches). An inspection of the front right passenger's air bag fabric revealed that there was some kind of fluid stain evidence apparent on the front surface of the air bag's fabric near the center of the lower right quadrant [i.e., 10 centimeters (3.9 inches) from the bottom and 6 centimeters (2.4 inches) inboard from the right edge]. In addition, there was some irregular scuffing at the lower center of the bag [i.e., 8 centimeters (3.1 inches) from the bottom and 18 centimeters (7.1 inches) inboard from the right edge–**Figure 14**].

Figure 14: Front surface of case vehicle's deployed front right passenger air bag showing a stain and a scuff in the middle of the lower right quadrant and toward the 6 o'clock position, respectively (case photo #39)

The data downloaded from the case vehicle's **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 (2nd event), 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 85 km.p.h. (53 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 12.47 km.p.h. (7.75 m.p.h.) at the 110 millisecond mark of recorded data; see **EVENT DATA RECORDER DATA** (**Figures 33** through **35**) below. This contractor believes that the recorded Delta V seems reasonable considering the amount of deformation pictured to the case vehicle's front.

Likewise for the non-deployment event (1st event), the data downloaded from the case vehicle's **EDR** also 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 case vehicle was traveling at a speed of 87 km.p.h. (54 m.p.h.), the driver's seat belt status showed it was buckled, and the Delta V reached a value of 6.98 km.p.h. (4.34 m.p.h.) at the 150 millisecond mark of recorded data; see **EVENT DATA RECORDER DATA** (**Figures 36** through **38**) below. This contractor believes that the recorded Delta V seems reasonable considering the amount of deformation pictured to the case vehicle's front.

In this contractor's opinion, the non-deployment event occurred prior to the deployment event (i.e., the case vehicle's impacted with the Volvo was the non-deployment event while the impacted with the longitudinal barrier deployed the air bags). The **EDR** showed that there was a 0.9 second interval between the two events.

Figure 15: Overhead view of infant child safety seat's detachable base; arrows indicate where case vehicle's safety belts attach through slots in base (case photo #101)

CHILD SAFETY SEAT

The second seat center passenger was seated in a rear facing infant child safety seat with a separable base (**Figure 15**). The child safety seat was manufactured by Evenflo, on April 18, 2002, and was identified by Model name"Cozy Carry" and Model number **4771273P1**. The infant seat

was designed with a five-point harness. There were three slots in the seat's back for positioning the harness straps; the harness was positioned in the top slots (**Figure 16**). The child seat was in the reclined position.

According to the case vehicle's inspection, the latch plate for this seating position's safety belt was the "sliding" type. The case vehicle's safety belt system had a switchable retractor which, at the time of the crash according to the case vehicle's front right passenger, was in the **Automatic Locking Retractor** (ALR) mode. According to the case vehicle's front right passenger, the belt webbing had been extended completely out of the retractor, buckled, and then slowly released back into the retractor housing.

The infant child safety seat consisted of a plastic one-piece shell and a one piece plastic base. The vehicle's safety belts were positioned through the base and the removable shell locked into the base when in use in the vehicle. A manufacturer's label was affixed to the top of the child seat's base, illustrating the proper way to install the vehicle's safety belts when the seat is in a rear center seat or front passenger seat (**Figure 17**). The warning continues to explain the importance of securing the child restraint with a vehicle's safety belt as specified in the vehicle manufacturer's instructions. This warning label was dated 1/02. There were also two large white, multicolored, warning labels–one on each side of the shell, warning the user parent to not place this child seat in a vehicle's front right seat when the vehicle is equipped with a front right passenger air bag (**Figure 18**). The warning labels were primarily bright white with black writing, advising that serious injury or death could occur if an air bag inflated against this child restraint. The manufacturer's label provided the child seat's height and weight limitations [i.e., approximately 2.3-10 kilograms and 48-65 centimeters (5-22 pounds, 19-26 inches)]. This warning label was dated 10/01. A close inspection of the child safety

Figure 16: Overhead view of infant child safety seat used by case vehicle's back center passenger; Note: harness straps positioned through top of three provided slots (case photo #103)

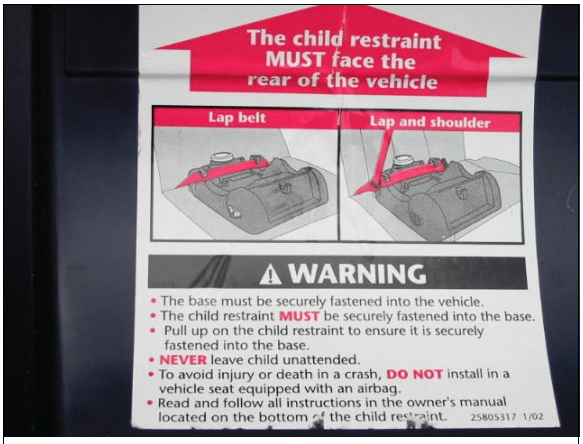


Figure 17: Warning label mounted on top of detachable base of infant child safety seat used in case vehicle (case photo #107)

Figure 18: Overhead view of left side of infant child seat used by case vehicle's back center passenger showing warning label and red and white leveling arrow at bottom of label; Note: child's head is positioned toward arrow (case photo #104)

seat revealed no apparent damage or fractures to the base or the seat's shell (**Figure 19**). The position of the child seat's carrying handle (**Figures 16** and **18** above) at the time of the crash is unknown. This contractor has no indication that the handle was other than in its down position.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [23-year-old, White (Hispanic) female; 163 centimeters and 64 kilograms (54 inches, 140 pounds)] was seated in a slightly reclined posture with her back against the seat back, her left foot on the floor, her right foot on the accelerator, and both hands on the steering wheel. Her seat track was located in its forward-most position, the seat back was slightly reclined, and the tilt steering wheel was located in its middle position.

Figure 19: Overhead view of underneath side of shell of infant child safety seat used by case vehicle's back center passenger; Note: no apparent damage (case photo #105)

Based on this contractor's vehicle inspection and supported by the interview with the case vehicle's front right passenger and the **EDR** data, the driver was restrained by her available, active, three-point, integral lap-and-shoulder, safety belt system; the belt system was not equipped with a pretensioner. There was no mention by the front right passenger of belt pattern bruising and/or abrasions to the driver's torso, and while the inspection of the driver's seat belt webbing, shoulder belt guide, and latch plate found no obvious loading evidence on the integrated safety belt's webbing or latch plate, the webbing was slightly rippled indicating trace loading (**Figure 20**).

Figure 20: Safety belt webbing for case vehicle's driver showing trace evidence (i.e., slight rippling) of loading (case photo #13)

According to the case vehicle's front right passenger, the driver steered to the left to avoid colliding with the alleged noncontact vehicle and then swerved back to the right and left an undetermined number of times, attempting to regain control of the vehicle. As a result and independent of the use of her available safety belts, her pre-impact body position may have shifted from right to left but, most likely, was well within the confines of her seat position. The case vehicle's impact with the Volvo enabled the case vehicle's driver to continue forward and slightly rightward, probably loading her safety belts, as the case vehicle decelerated The driver most likely remained near her original seating position but leaning slightly forward as the case vehicle departed the roadway toward the concrete longitudinal barrier. The case vehicle's impact with the concrete longitudinal barrier enabled the driver to continue forward and slightly rightward as the case vehicle decelerated. As a result, she contacted her deploying driver air bag, depositing a

makeup smear in the bag's center circular area. The driver most likely rebounded rearward toward her seat back as a result of the air bag's deployment. As a result of the barrier impact, the case vehicle rotated clockwise. The driver most likely moved back forward and to her left as the case vehicle slid to final rest. The exact posture of the driver at final rest is unknown, but she was able to exit the vehicle without assistance.

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver was not transported by ambulance to the hospital. Although she was mildly shaken by the crash, she did not sustain any injuries as a result of this crash. According to the case vehicle's front right passenger, she was examined by EMS personnel at the crash scene and did not seek any further medical treatment.

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

The case vehicle's front right passenger [26-year-old, White (Hispanic) male;175 centimeters and 86 kilograms (69 inches, 190 pounds)] was seated in an upright posture with his torso turned to his right, possibly leaning slightly forward, his feet on the floor, his left hand on the armrest, and his right hand on the handle attached to the roof side rail. His seat track was located in its rearmost position, and the seat back was sightly reclined.

Figure 21: Safety belt webbing for case vehicle's front right passenger showing a wavy pattern indicative of occupant loading (case photo #17)

The case vehicle's front right passenger was restrained by his available, active, three-point, integral lap-and-shoulder, safety belt system; the belt system was not equipped with a pretensioner. There was no mention by this occupant of belt pattern bruising and/or abrasions to his torso, but the inspection of the front right passenger's integrated seat belt webbing, shoulder belt guide, and latch plate showed evidence of usage on the webbing during this crash (**Figure 21**).

According to the case vehicle's front right passenger, the driver steered to the left to avoid colliding with the alleged noncontact vehicle and then swerved back to the right and left an undetermined number of times, attempting to regain control of the vehicle. As a result and independent of the use of his available safety belts, the front right passenger's pre-impact body position may have shifted from right to left but, most likely, was well within the confines of his seat position. The case vehicle's impact with the Volvo enabled the case vehicle's front right passenger to continue forward and slightly rightward, probably loading his safety belts, as the case

vehicle decelerated The front right passenger most likely remained near his original seating position but leaning slightly forward as the case vehicle departed the roadway toward the concrete longitudinal barrier. The case vehicle's impact with the concrete longitudinal barrier enabled the front right passenger to continue forward and slightly rightward as the case vehicle decelerated. As a result, he contacted his deploying front right passenger air bag, depositing some scuffing near the lower center of the bag's front surface. The front right passenger most likely rebounded rearward toward his seat back as a result of the air bag's deployment. As a result of the barrier impact, the case vehicle rotated clockwise. The front right passenger most likely moved back forward and to his left as the case vehicle slid to final rest. The exact posture of the front right passenger at final rest is unknown, but he was able to exit the vehicle without assistance.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The right front passenger was not transported to a medical facility and did not sustain any injuries as a result of this crash. According to his interview, he was examined by EMS personnel at the crash scene and did not seek any further medical treatment.

CASE VEHICLE SECOND SEAT LEFT PASSENGER KINEMATICS

The case vehicle's second seat left passenger [61-year-old, White (Hispanic) female; 173 centimeters and 59 kilograms (68 inches and 130 pounds)] was seated in an upright posture but turned to the right feeding the infant occupant in the second seat center seat. Her feet were on the floor but her hands were holding a baby bottle. There was no seat track, and the seat back was not adjustable.

This passenger was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. There was no mention by the front right passenger of belt pattern bruising and/or abrasions to the second seat left passenger's torso, but the inspection of the second seat left passenger's seat belt webbing and latch plate showed evidence of usage (i.e., rippling) during this crash (**Figure 22**).

Figure 22: Seat belt webbing for case vehicle's back left passenger showing a wavy pattern indicative of occupant loading (case photo #51)

According to the case vehicle's front right passenger, the driver steered to the left to avoid colliding with the alleged noncontact vehicle and then swerved back to the right and left an undetermined number of times, attempting to regain control of the vehicle. As a result and independent of the use of her available safety belts, the second seat left passenger's pre-impact body position most likely shifted from right to left but, most likely, was well within the confines of her seat position. The case vehicle's impact with the Volvo enabled the case vehicle's second seat left passenger to continue forward and slightly rightward, probably loading her safety belts, as the case vehicle decelerated The second seat left passenger most likely remained near her

original seating position but leaning slightly forward as the case vehicle departed the roadway toward the concrete longitudinal barrier. The case vehicle's impact with the concrete longitudinal barrier enabled the second seat left passenger to continue forward and slightly rightward as the case vehicle decelerated. As a result, she reloaded her safety belts as the case vehicle decelerated. The second seat left passenger most likely rebounded rearward toward her seat back as a result of loading her safety belts as the case vehicle rebounded from the longitudinal barrier. As a result of the barrier impact, the case vehicle rotated clockwise. The second seat left passenger most likely moved back forward and to her left as the case vehicle slid to final rest. The exact posture of the second seat left passenger at final rest is unknown, but she was able to exit the vehicle with some assistance.

CASE VEHICLE SECOND SEAT LEFT PASSENGER INJURIES

The second seat left passenger was not transported to a medical facility and, according to the case vehicle's front right passenger, did not sustain any injuries as a result of this crash. She was examined by EMS personnel at the crash scene and did not seek any further medical treatment.

CASE VEHICLE SECOND SEAT CENTER PASSENGER KINEMATICS

The case vehicle's second seat center passenger [5-month-old, White (Hispanic) male; 71 centimeters and 9 kilograms (28 inches and 20 pounds)] was seated facing rearward in a child (infant) safety seat. The child's feet and hands were within the child seat. There was no seat track, and the seat back was not adjustable.

This passenger was restrained by a five-point harness built into the child safety seat and the seat was secured by the available, active, three-point, lap-and-shoulder, safety belt system that was used in conjunction with the child safety seat. There was no mention by the front right passenger of belt pattern bruising and/or abrasions to the second seat center passenger's torso, but the inspection of the second seat center passenger's seat belt webbing and latch plate showed evidence of usage on the webbing during this crash (**Figure 23**).

Figure 23: Seat belt webbing for case vehicle's back center passenger showing stress marks indicative of restraint usage (case photo #54)

According to the case vehicle's front right passenger, the driver steered to the left to avoid colliding with the alleged noncontact vehicle and then swerved back to the right and left an undetermined number of times, attempting to

regain control of the vehicle. As a result and independent of the use of his available safety belts, the second seat center passenger's pre-impact body position most likely shifted from right to left but remained well within the confines of his child safety seat. The case vehicle's impact with the Volvo enabled the back of the case vehicle's second seat center passenger to continue forward, loading the back of his child safety seat, and slightly rightward as the case vehicle decelerated. The second seat center passenger most likely remained against the back of his child safety seat as the case vehicle departed the roadway toward the concrete longitudinal barrier. The case vehicle's impact with the concrete longitudinal barrier enabled the second seat center passenger to reload the back of his child safety seat and his safety belts as the case vehicle decelerated. The second seat center passenger most likely rebounded rearward loading the child seat's five-point harness as the case vehicle rebounded from the longitudinal barrier. As a result of the barrier impact, the case vehicle rotated clockwise. The second seat center passenger most likely moved back forward and to his right (i.e., left side of the rear facing child safety seat) as the case vehicle slid to final rest. The exact posture of the second seat center passenger at final rest is unknown, but he was able to exit the vehicle with parental assistance.

CASE VEHICLE SECOND SEAT CENTER PASSENGER INJURIES

The second seat center infant passenger was not transported to a medical facility and, according to the case vehicle's front right passenger, did not sustain any injuries as a result of this crash. He was examined by EMS personnel at the crash scene and did not seek any further medical treatment.

CASE VEHICLE SECOND SEAT RIGHT PASSENGER KINEMATICS

The case vehicle's second seat right passenger [7-year-old, White (Hispanic) female; 114 centimeters and 31 kilograms (45 inches and 69 pounds)] was seated in an upright posture with her feet dangling over the front edge of the seat's cushion, angled downward. In addition, the exact position of her hands is unknown. There was no seat track, and the seat back was not adjustable.

The second seat right passenger was restrained by her available, active, three-point, lap-and-shoulder, safety belt system; however, given this child's stature, it is unknown if but unlikely that the torso portion of the safety belt engaged this child's shoulder as designed. There was no mention by the front right passenger of belt pattern bruising and/or abrasions to the second seat right passenger's torso, but the inspection of the second seat right passenger's seat belt webbing and latch plate showed only trace evidence of usage during this crash (**Figure 24**).

Figure 24: Seat belt webbing for case vehicle's back right passenger showing stress marks indicative of occupant loading (case photo #48)

According to the case vehicle's front right passenger, the driver steered to the left to avoid colliding with the alleged noncontact vehicle and then swerved back to the right and left an undetermined number of times, attempting to regain control of the vehicle. As a result and independent of the use of her available safety belts, the second seat right passenger's pre-impact body position most likely shifted from right to left but, most likely, was well within the confines of her seat position. The case vehicle's impact with the Volvo enabled the case vehicle's second seat right passenger to continue forward and slightly rightward, probably loading her safety belts, as the case vehicle decelerated The second seat right passenger most likely remained near her original seating position but leaning slightly forward as the case vehicle departed the roadway toward the concrete longitudinal barrier. The case vehicle's impact with the concrete longitudinal barrier enabled the second seat right passenger to continue forward and slightly rightward as the case vehicle decelerated. As a result, she reloaded–at least the torso portion of, her safety belts as the case vehicle decelerated. The second seat right passenger most likely rebounded rearward toward her seat back as a result of loading her safety belts as the case vehicle rebounded from the longitudinal barrier. As a result of the barrier impact, the case vehicle rotated clockwise. The second seat right passenger most likely moved back forward and to her left as the case vehicle slid to final rest. The exact posture of the second seat right passenger at final rest is unknown, but she was able to exit the vehicle with some assistance.

CASE VEHICLE SECOND SEAT RIGHT PASSENGER INJURIES

Once again, the second seat right passenger was not transported to a medical facility and, according to the case vehicle's front right passenger, did not sustain any injuries as a result of this crash. She was examined by EMS personnel at the crash scene and also did not seek any further medical treatment.

OTHER VEHICLE

The 2002 Volvo S40 was a front wheel drive, five-passenger, four-door sedan (VIN: YV1VS29532F------) equipped with a 1.9L, I-4 engine and a five-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 256 centimeters (100.9 inches), and the odometer reading at inspection was 15,308 kilometers (9,512 miles).

Figure 25: Volvo's front seating area showing non-deployed driver and front right passenger air bags; Note: steering wheel, instrument panel, and greenhouse area show no apparent evidence of occupant contact (case photo #70a)

The Volvo was equipped with advanced occupant protection system features including dual stage driver and front right passenger air bag inflators, pretensioners, seat belt height adjustors, and a LATCH system. In addition, the vehicle was equipped with front, seat back-mounted, side impact air bags and side-inflatable curtain air bags which extend from each of the roof side rails. Furthermore, the Volvo was equipped with knee bolsters for both the driver and front right

passenger and manual, three-point, lap-and-shoulder, safety belt systems for all five occupant seating positions. The interior was equipped with bucket seats for the driver and front right passenger, and the back split bench seat was non-adjustable.

Neither frontal air bag deployed (**Figure 25** above) as a result of the Volvo's left side impact (**Figure 4** above) with the case vehicle nor was either driver or front right passenger knee bolsters damaged or deformed.

Figure 26: Outboard surface of Volvo's driver seat back-mounted side impact air bag showing no evidence of intrusion or contact (case photo #82)

Figure 27: Inboard surface of Volvo's driver seat back-mounted side impact air bag showing no apparent occupant contact evidence (case photo #77)

Figure 28: Outboard surface of Volvo's left side inflatable curtain protecting driver's seating area (case photo #78)

Figure 29: Outboard surface of Volvo's left side inflatable curtain protecting back left seating area (case photo #91)

On the other hand, the driver's seat back-mounted side air bag (**Figures 26** and **27** above) and the left side inflatable curtain (**Figures 28** and **29** above and **Figures 30** and **31**) did deploy as a result of the Volvo's left side impact with the case vehicle.

Figure 30: Inboard surface of Volvo's left side inflatable curtain protecting driver's seating area; Note: a hair and a possible lip print were found on the curtain's fabric (case photo #84)

Figure 31: Inboard surface of Volvo's left side inflatable curtain protecting back left seating area; Note: no apparent evidence of occupant contact (case photo #89)

Exterior Damage: Based on the vehicle inspection, the CDCs for the Volvo were estimated as: **08-LZEW-2** (**250** degrees) and **04-BDEW-1** (**130** degrees). No crush profile or maximum crush were taken on the Volvo's left side impact because the door surface was cut by pneumatic shears. No crush profile was taken on the impact to the Volvo's back (**Figure 32**) because this impact occurred with a longitudinal barrier and the case vehicle was not involved. The Volvo manufacturer's recommended tire size was: P195/60R15, and the Volvo's tires were the recommended size. The Volvo's tire data are shown in the table below. At the time of inspection, none of the Volvo's tires were damaged, deflated, or physically restricted. The Volvo was towed due to damage.

Figure 32: Damage to Volvo's left and back surfaces viewed from left of back; Note: greatest damage to Volvo's back occurred to back right bumper (case photo #64)

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	207	30	221	32	7	9	None	No	No
RF	214	31	221	32	7	9	None	No	No

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LR	207	30	200	29	7	9	None	No	No
RR	207	30	200	29	5	6	None	No	No

Volvo's Occupants: According to the Police Crash Report, the Volvo's driver [53-year-old, (unknown race and/or ethnic origin) 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.

1GNEK13ZX3J	System Status At Deployment
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	378
Ignition Cycles At Investigation	402
Maximum SDM Recorded Velocity Change (MPH)	-8.09
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	120
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	12.5
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	12.5
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	N/A
Time Between Non-Deployment And Deployment Events (sec)	.9
Frontal Deployment Level Event Counter	1
Event Recording Complete	Yes
Multiple Events Associated With This Record	Yes
One Or More Associated Events Not Recorded	No

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.62	-2.48	-4.03	-4.96	-5.58	-6.20	-6.51	-6.82	-7.13	-7.44	-7.75	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	53	1536	0	OFF
-4	52	1472	0	ON
-3	39	1024	0	OFF
-2	39	1024	0	OFF
-1	22	448	0	ON

Figure 33: 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 110 milliseconds post deployment

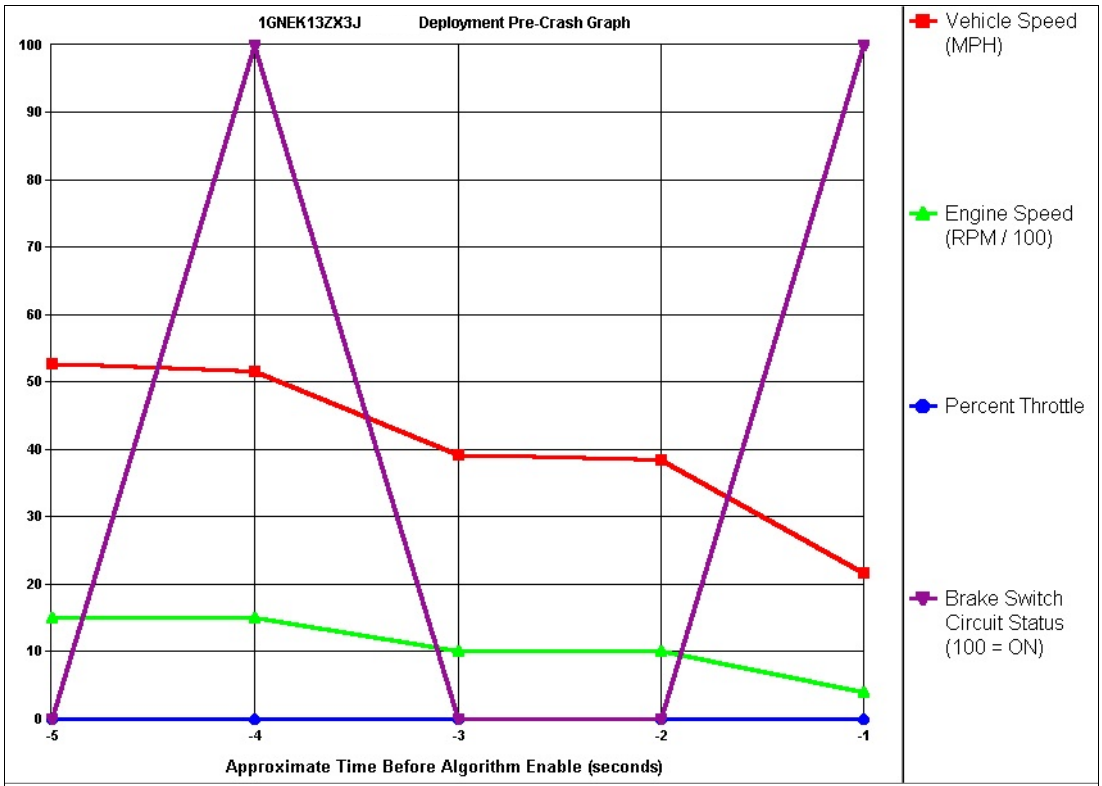


Figure 34: Case vehicle's pre-crash speed and brake switch circuit status showing that the vehicle's speed was recorded at 85 km.p.h. (53 m.p.h.), with the brake not activated, at approximately 5 seconds prior to algorithm enable and that the brake switch had been activated twice, once during the 4th and again during the 1st recorded sample periods prior to algorithm enable.

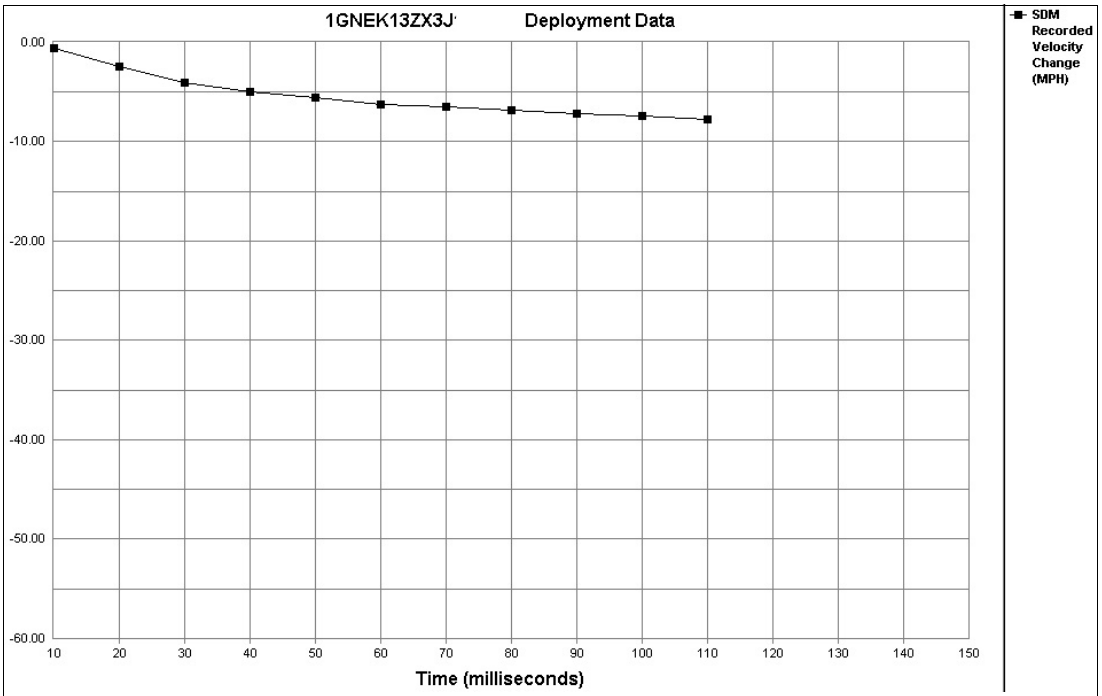


Figure 35: The case vehicle sustained a velocity change of approximately 12.5 km.p.h. (7.8 m.p.h.) during the first 110 milliseconds after the algorithm was enabled; maximum velocity change was recorded as 13.0 km.p.h. (8.1 m.p.h.) at 120 milliseconds

1GNEK13ZX3J	System Status At Non-Deployment
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Non-Deployment	378
Ignition Cycles At Investigation	402
Maximum SDM Recorded Velocity Change (MPH)	-4.44
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	75
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.31	-1.24	-2.17	-2.79	-3.41	-4.03	-4.03	-4.34	-4.34	-4.34	-4.34	-4.34	-4.34	-4.34	-4.34

PRE-CRASH DATA				
Seconds Before AE	**Vehicle Speed (MPH)**	**Engine Speed (RPM)**	**Percent Throttle**	**Brake Switch Circuit Status**
-5	54	1536	0	OFF
-4	53	1536	0	OFF
-3	52	1472	0	ON
-2	39	1024	0	OFF
-1	39	1024	0	OFF

Figure 36: 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 150 milliseconds post algorithm enablement

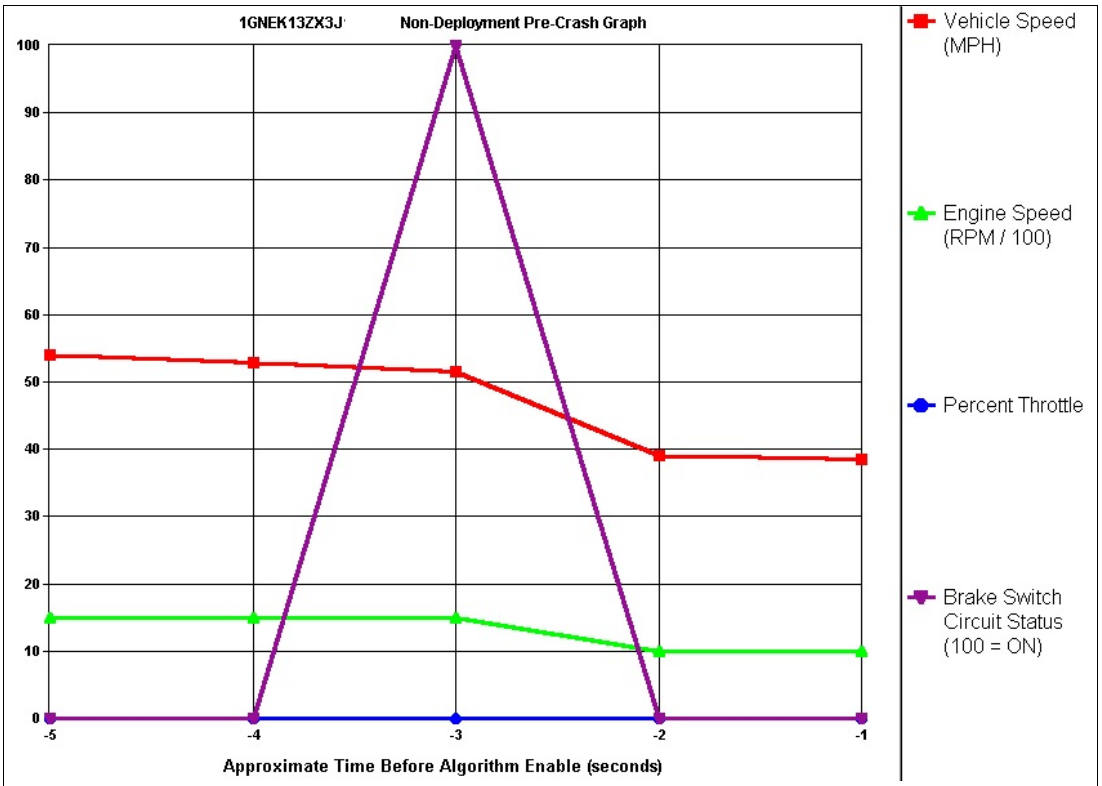


Figure 37: Case vehicle's pre-crash speed and brake switch circuit status showing that the vehicle's speed was recorded at 87 km.p.h. (54 m.p.h.), with the brake not activated, at approximately 5 seconds prior to algorithm enable and that the brake switch had been activated between the 4th and 2nd recorded sample periods prior to algorithm enable.

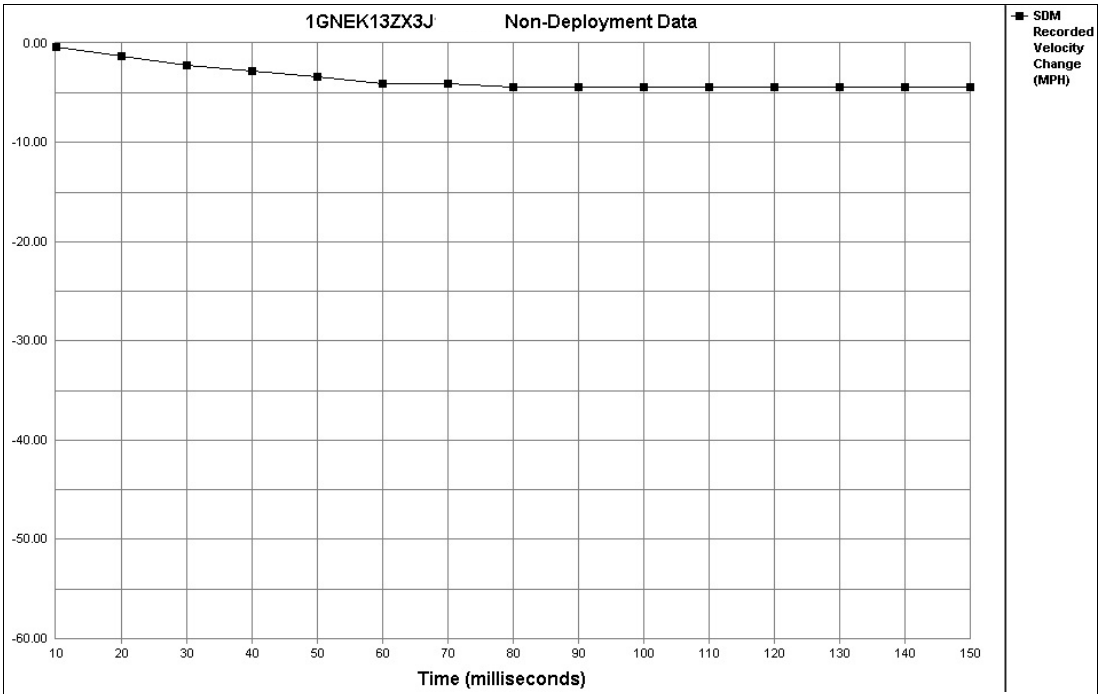
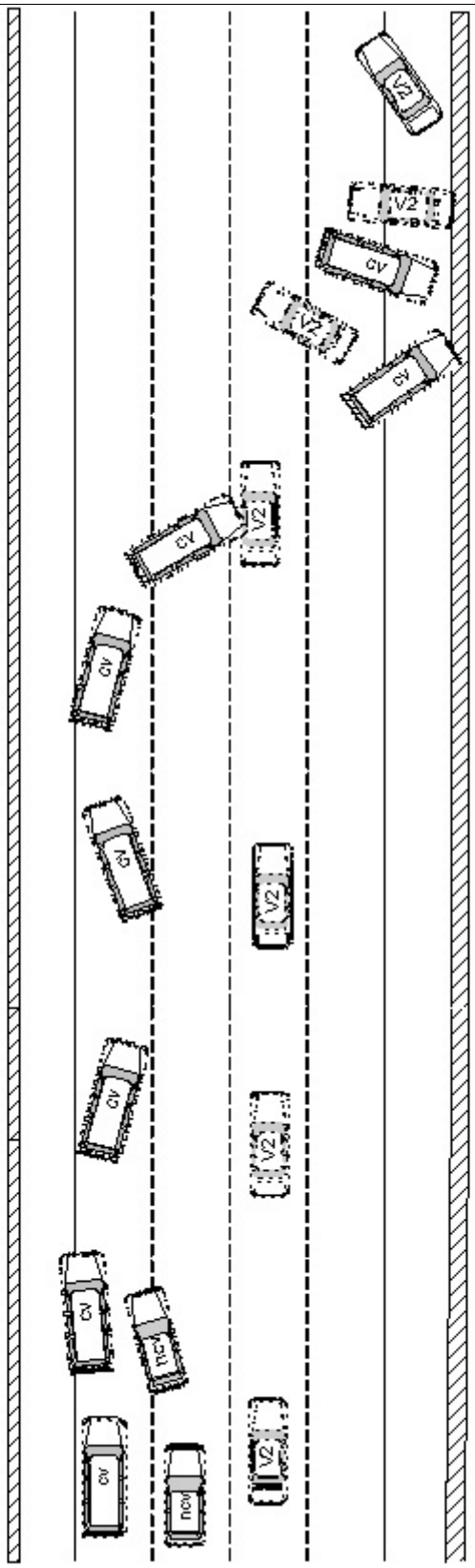
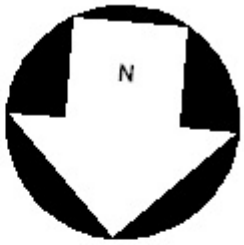


Figure 38: The case vehicle sustained a velocity change of approximately 7.0 km.p.h. (4.3 m.p.h.) during the first 150 milliseconds after the algorithm was enabled; maximum velocity change was recorded as 7.1 km.p.h. (4.4 m.p.h.) at 75 milliseconds

Impact and final rest positions of both vehicles are estimated based on police schematic and interview with case vehicle's owner/occupant





IN-03-005

1 cm = 2.5 m
Straight, Level (i.e., very slight slope, negative to south--downgrade)
Dark but lighted, Snowing, Snowy/slushy concrete roadway; Coefficient of friction = .40

*CV = 2003 Chevrolet 1500, 4x4, Tahoe
*V2 = 2002 Volvo S40