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VERIDIAN ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

CASE NO. CA03-011

VEHICLE – 2002 GMC ENVOY

LOCATION - STATE OF TENNESSEE

CRASH DATE – JANUARY 2003

Contract No. DTNH22-01-C-17002

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 are 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 STANDARD TITLE PAGE

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16. Abstract This single-vehicle crash focused on the side impact inflatable occupant protection system in a 2002 GMC Envoy. The Envoy was involved in a left side impact with a concrete light pole that resulted in the deployment of the dual-stage frontal air bags and the driver's side impact air bag. The Envoy was occupied by a restrained 54-year-old male driver and a restrained 17-year-old male front right passenger. The driver relinquished control of the Envoy, although it was not known if he fell asleep or experienced a medical episode. The Envoy traveled onto a concrete sidewalk after striking the curb edge and initiated a shallow clockwise (CW) yaw. The left aspect of the Envoy struck a concrete light pole at the left A-pillar and the front aspect struck a wood fence that was adjacent to the pole. The impact resulted in moderate damage to the Envoy, a dual-stage deployment of the frontal air bag system, and the deployment of the driver's side impact air bag. The driver's right arm was displaced as a result of the driver's frontal air bag deployment, which resulted in a right ulna fracture. The pole fractured in multiple locations as the Envoy was redirected in a counterclockwise (CCW) motion around the pole. Warning signs present on the pole and concrete fragments intruded into the driver's space, which resulted in a severe open forehead laceration with penetrating head trauma, right side neck and scalp lacerations, and abrasions and contusions on the right aspect of head and neck. The driver was pronounced dead at the scene and did not receive medical treatment. The 17-year-old front right passenger sustained a possible injury and was transported by ambulance to a local hospital. His admission status was not reported.			
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TABLE OF CONTENTS

VERIDIAN ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION SYSTEM CRASH INVESTIGATION
SCI TECHNICAL SUMMARY REPORT
CASE NO. – CA03-011
SUBJECT VEHICLE – 2002 GMC ENVOY
LOCATION - STATE OF TENNESSEE
CRASH DATE – JANUARY 2003

BACKGROUND

This single-vehicle crash focused on the side impact inflatable occupant protection system in a 2002 GMC Envoy. The Envoy was involved in a left side impact with a concrete light pole that resulted in the deployment of the dual-stage frontal air bags and the driver's side impact air bag. The Envoy was occupied by a restrained 54-year-old male driver and a restrained 17-year-old male front right passenger. The driver relinquished control of the Envoy, although it was not known if he fell asleep or experienced a medical episode. The Envoy traveled onto a concrete sidewalk after striking the curb edge and initiated a shallow clockwise (CW) yaw. The left aspect of the Envoy struck a concrete light pole at the left A-pillar and the front aspect struck a wood fence that was adjacent to the pole. The impact resulted in moderate damage to the Envoy **(Figure 1)**, a dual-stage deployment of the frontal air bag system, and the deployment of the driver's side impact air bag. The driver's right arm was displaced as a result of the driver's frontal air bag deployment, which resulted in a right ulna fracture. The pole fractured in multiple locations as the Envoy was redirected in a counterclockwise (CCW) motion around the pole. Warning signs present on the pole and concrete fragments intruded into the driver's space, which resulted in a severe open forehead laceration with penetrating head trauma, right side neck and scalp lacerations, and abrasions and contusions on the right aspect of head and neck. The driver was pronounced dead at the scene and did not receive medical treatment. The 17-year-old front right passenger sustained a possible injury and was transported by ambulance to a local hospital. His admission status was not reported.

Figure 1. On-scene photograph of damaged 2002 GMC Envoy

This crash was identified by the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) due to the frontal air bag deployment, side air bag deployment, and driver fatality. An on-site investigation was initiated on February 19, 2002.

SUMMARY

Crash Site

This single-vehicle crash occurred in the state of Tennessee during the nighttime hours of January 2003. At the time of the crash, there were no adverse weather conditions and the asphalt roadway surface was dry. The roadway was illuminated by overhead lights on concrete poles. The east/west roadway **(Figure 2)** was configured with two travel lanes in each direction that were separated by a center left-turn lane. The travel lanes were bordered by 15.2 cm (6.0")

concrete curbs and concrete sidewalks that measured 1.8 m (5.9') in width. The roadway was level at the crash site and had a slight eastbound right curve. The concrete pole that was struck was located at the inboard edge of the east sidewalk and measured 22.2 cm (8.8") square at the base, with a slight vertical taper. Two metal signs were fixed to the pole. A "No Parking" sign was present 167.4 cm (66.0") above the base of the pole and a diamond-shaped crosswalk warning sign was present above the "No Parking" sign. The 90-degree corner of a wood fence was located adjacent to the east side of the concrete pole. The fence extended south along the border of a municipal park area and one section of the fence extended east along the roadside to a paved walkway that led into the park. The fence consisted of 10.2 cm (4.0") square posts spaced 1.5 m (5.0') apart connected by three horizontal planks. A second wood fence extended along the concrete sidewalk east of the paved walkway. A residential roadway intersected the east/west roadway in a T-configuration 46 m (151') west of the concrete light pole. There was no traffic control present at the crash site. The posted speed limit for the east/west roadway was 64 km/h (40 mph). The scene schematic is included as **Figure 24** of this report.

Figure 2. Eastbound view of crash site

CRASH SEQUENCE

Pre-Crash

The 54-year-old male driver of the 2002 GMC Envoy was operating the vehicle eastbound on the four-lane roadway during nighttime hours **(Figure 3)**. The driver may have fallen asleep or experienced a medical episode, although neither could be confirmed. He relinquished control of the vehicle as the roadway curved to the right. The vehicle drifted to the right and crossed the intersecting roadway in the T-intersection located west of the crash site. The EDR summary indicated the vehicle's speed five seconds prior to a recorded near event was 89 km/h (55 mph) and 90 km/h (56 mph) five seconds prior to a recorded deployment event. Given an EDR-stated 0.5-second interval between the near-event and deployment event, a total of 6 seconds of pre-impact data was collected prior to the deployment event (impact with the pole). Per the EDR output, the vehicle exhibited an increased throttle percentage over the entire six-second pre-impact interval from 25 percent to 53 percent. There was no scene evidence to suggest pre-crash braking and the EDR output shows the brake switch as "off" for the entire pre-crash duration.

Figure 3. Eastbound approach for the 2002 GMC Envoy

Crash

The Envoy struck the southeast curb edge at the intersection corner with the front right wheel and traveled onto the concrete sidewalk **(Figure 4)**. Based on EDR-recorded vehicle pre-crash speed and distance traveled, the curb impact occurred approximately 1.5 seconds prior to impact with the pole and the Envoy was traveling approximately 97 km/h (60 mph). The curb impact was located 40.1 m (131.6') west of the pole. Given the stated EDR speed of the Envoy was 92 km/h (57 mph) one second prior to algorithm enable and the stated time of 0.5 seconds between the event and near event, the near event would have been located approximately 13m (42') west of the pole impact where the left rear wheel ramped up the curb. At 92 km/h (57 mph), the vehicle was traveling at 25.5 m (83.8') per second (57 mph x 1.47 = 83.8' per second). There was no damage to the left rear tire or wheel suggestive of an impact. However, based solely on vehicle damage, it would appear that the near event was the initial curb impact with the right front wheel, evidenced by moderate deformation to the alloy wheel and sidewall tears. Given the Envoy's EDR-stated pre-impact speed, the initial curb impact occurred approximately 1.5 seconds prior to the pole impact, which was not consistent with the EDR output.

Figure 4. On-scene police photograph showing southeast curb impact

The right front tire had a rapid air-out as a result of the curb impact. The impact may have been sufficient to rotate the Envoy slightly CW enough to prevent the left rear wheel from ramping up the curb edge. It was not known if the driver woke up or regained consciousness as a result of the curb impact and steered right in an attempted avoidance maneuver when he detected the approaching pole, or if the CW rotation was a result of the right front tire air out. Tire/wheel marks present at the scene provided the basis for the Envoy's path of travel along the sidewalk. The left front wheel ramped up the curb face at the east aspect of the intersection corner and the left rear wheel straddled the curb edge along the roadway, which increased the CW yaw. The left rear wheel ramped up the curb approximately 14 m (45') prior to the pole impact. The EDR timing data suggests that the near-event occurred at this point.

The Envoy continued in a CW yaw and struck the concrete light pole with the left front aspect forward of the left A-pillar **(Figure 5)**. Simultaneously, the front aspect of the Envoy impacted the wood fence and 10.2 cm (4.0") square fence post **(Figure 6)**. The fence post fractured and the fence shattered at impact, which provided little resistance relative to the pole impact and resulted in minor damage to the frontal plane of the Envoy. The approximate sideslip angle at the point of impact was 30 degrees and the direction of force was in the 11 o'clock sector. The pole impact resulted in the deployment of the driver's side impact air bag, and also resulted in sufficient longitudinal deceleration to deploy both stages of the frontal air bag system 20 milliseconds into the crash. The EDR reported delta-V for the impact was 18.04 km/h (11.21 mph). The concrete pole fractured in multiple locations, however, provided sufficient resistance to redirect the Envoy in a counterclockwise (CCW) direction as it engaged the pole. The square nature of the pole allowed sustained left side engagement against the Envoy, which caused significant rearward displacement of the left front door skin as the vehicle continued around the pole.

Figure 5. View of pre-impact tire marks

Figure 6. Close-up of replaced concrete pole and fractured fence post

The top aspect of the left front door frame and left roof side rail also sustained contact with the "No Parking" sign which intruded into the driver's window as the pole fractured **(Figure 7)**. The Envoy traveled east 23 m (75') in a tracking mode to final rest on the roadside, parallel to the roadway. The total rotation from impact to final rest was 30 degrees in a CCW direction. The EDR summary is included as **Appendix A** of this report.

Post-Crash

The driver of the Envoy was pronounced dead at the scene. His body was removed from the vehicle after the crash and transported to the morgue. The 17-year-old male front right passenger attempted to call for help on a cellular phone after the crash. Police reported that as the front right passenger was calling for help, the Envoy's OnStar system activated and alerted local public safety personnel of the crash. It was not known how the 17-year-old exited the vehicle. Police reported that he sustained a possible injury and was transported by ambulance to a local hospital. His admission status was not reported.

Figure 7. Post-impact view of fractured pole showing position of metal signs

VEHICLE DATA – 2002 GMC Envoy

The 2002 GMC Envoy was identified by the Vehicle Identification Number (VIN): 1GKDS13S522 (production sequence omitted). At the time of the vehicle inspection the Envoy's odometer read 30,260 km (18,803 miles). The Envoy was a 4x2, four-door sport-utility vehicle, equipped with a 4.2 liter, V-6 cylinder engine, a four-speed automatic transmission, power four-wheel anti-lock disc brakes, alloy wheels, power steering, a tilt steering wheel, power door locks, power windows, and the OnStar system. The Envoy was equipped with Michelin Cross Terrain P235/65R17 tires. Each tire was de-beaded at the time of the vehicle inspection. Although the left rear wheel struck the curb with the inboard aspect, there was no visible deformation to the inboard aspect of the wheel. The specific tire data is as follows:

Tire	Measured Pressure	Recommended Pressure	Tread Depth	Restricted	Damage
LF	Flat	221 kpa (32 psi)	7 mm (9/32")	No	None
LR	Flat	221 kpa (32 psi)	7 mm (9/32")	No	None
RF	Flat	221 kpa (32 psi)	8 mm (10/32")	No	Lacerations in outboard sidewall from curb impact
RR	Flat	221 kpa (32 psi)	7 mm (9/32")	No	Scuffing and laceration on outboard sidewall

The front seating positions in the 2002 GMC Envoy were configured with bucket seats with adjustable head restraints. Both head restraints were in the full down position at the time of the vehicle inspection. Both front bucket seats were equipped with power seat adjustments. The driver's seat was adjusted to 8.9 cm (3.5") forward of the full rear position and 12.7 cm (5.0") rear of the full forward position. The front right seat was adjusted to 17.8 cm (7.0") rear of full forward and 3.8 cm (1.5") forward of full-rear. The rear seating positions were configured with a 60/40-split bench with folding backs. The bench seat backs were configured with head restraints on the outboard positions that folded rearward when the seat backs were folded forward.

VEHICLE DAMAGE

Exterior Damage – *2002 GMC Envoy*

The 2002 GMC Envoy sustained minor right front wheel damage as a result of the first curb impact. The right front wheel exhibited a 12.7 cm (5.0") area of outward deformation that was located on the outboard aspect of the alloy wheel **(Figure 8)**. Two tears in the outboard sidewall were present adjacent to the wheel damage. The Collision Deformation Classification (CDC) for the right front wheel impact with the curb was 12-FRWN-3.

Figure 8. Damaged right front wheel and tire

The Envoy sustained minor frontal damage **(Figure 9)** as a result of the simultaneous fence and fence post impact while the left aspect struck the pole. The direct damage on the bumper fascia included contact abrasions that began 69.9 cm (27.5”) right of the centerline and extended 141.6 cm (55.8”) across the fascia to the front left corner. The combined direct and induced damage involved the entire frontal width and measured 143.5 cm (56.5”). Direct contact damage on the hood included rearward buckling, and abrasions on the leading edge that began 38.7 cm (15.3”) right of center and extended laterally to the front left corner. The front bumper fascia was partially separated and fractured in multiple places along the entire width. The front left corner of the bumper beam was deformed rearward, outboard of the frame rail. The maximum crush that resulted from the fence post was located on the bumper beam 16.5 cm (6.5”) right of the centerline and measured 8.9 cm (3.5”). The grille and left headlamp were separated. The CDC for the frontal impact with the wood fence was 11-FDEW-1. Six crush measurements were documented along the front bumper beam and were as follows: C1 = 7.0 cm (2.3”), C2 = 0.6 cm (0.3), C3 = 2.7 cm (1.1”), C4 = 7.3 cm (2.9”), C5 = 1.9 cm (0.8”), C6 = 0.0 cm.

Figure 9. Overall view of frontal damage

The Envoy sustained moderate left side damage as a result of the concrete pole impact **(Figure 10)**. The direct contact from the pole began on the left front fender 26.7 cm (10.5”) aft of the left front axle. The direct contact continued along the left side plane to the left rear bumper corner. The direct contact aft of the left front door consisted only of abrasions along the lower rear door and left rear quarter panel. The maximum crush on the left front fender was located 52.1 cm (20.5”) aft of the left front axle and measured 20.3 cm (8.0”). The direct contact longitudinal abrasions from the pole extended the entire vertical height of the left front fender. The lateral displacement at the rear aspect caused the forward aspect of the fender to be displaced 22.9 cm (9.0”) outward. A 3.8 cm (1.5”) longitudinal tear in the sheet metal of the fender was located 20.3 cm (8.0”) forward of the rear edge. The left A-pillar exterior trim was separated and the left aspect of the windshield was fractured. Bond separation was noted along the top left corner and measured 17.8 cm (7.0”) across the top aspect and 40.6 cm (16.0”) downward from the top along the left A-pillar.

Figure 10. View of left side damage

The left roof side rail sustained heavy abrasions and lateral deformation located 34.3 cm (13.5”) forward of the center of the left B-pillar as a result of the impact **(Figure 11)**. Red paint transfers were also present from direct contact with the “No Parking” sign that was present on the pole. The lateral crush on the left roof side rail measured 8.8 cm (3.5”). Abrasions were also present on the top aspect of the left front door.

Figure 11. Damage on the left roof side rail, left A-pillar, and left front door

Due to the lateral crush on the left front fender and sustained engagement with the concrete pole, the leading edge of the left front door snagged on the pole **(Figure 12)**. The leading edge of the left front door was deformed and displaced rearward. The forward aspect of the door was crushed laterally and the rear aspect was deformed and buckled outward. The outer door skin was separated 21.6 cm (8.5”) outward at the rear aspect of the door.

Figure 12. Left front door damage

The lower trim along the left sill was fractured and separated. The maximum crush on the left sill was located 92.0 cm (36.2”) rear of the left front axle and measured 14.0 cm (5.5”). Six crush measurements were documented along the left side of the Envoy at the mid-door aspect and were as follows: C1 = 0.0 cm, C2 = 0.0 cm, C3 = 0.0 cm, C4 = 21.6 cm (8.5”), C5 = 17.1 cm (6.8”), C6 = 0.0 cm.

The CDC for the impact with the concrete pole was 11-LDAW-3.

Interior Damage - *2002 GMC Envoy*

Interior damage to the 2002 GMC Envoy was moderate and attributed to passenger compartment intrusion **(Figure 13)**. The left front door was jammed shut as a result of the damage. However, the door was removed at the hinge to facilitate extrication of the driver. The windshield was fractured and the bond was partially separated on the upper left corner. The left front window disintegrated as a result of impact forces. The remaining glazing was undamaged. The tilt steering wheel was jammed in the mid position. Inspection of the shear capsules confirmed no steering column compression. The knee bolster was fractured to the left of the steering column from impact forces and separated from the vehicle. There was no occupant contact evidence on the knee bolster. The metal backing plate remained in place, but was

Figure 13. Interior view through left front door

deformed laterally and bowed outward at the center aspect as a result of intrusion. The outboard aspect of the left instrument panel was fractured and partially separated. Due to the instrument panel damage, the instrument cluster was not functional even though power was applied to the vehicle during the inspection. The rear view mirror was separated at the time of the vehicle inspection, although it was in place in the on-scene police photographs. The driver's sun visor was displaced and the left A-pillar trim was partially separated **(Figure 14)**. The plastic interior panel of the left front door was separated at the time of the vehicle inspection. The plastic door trim exhibited numerous stress marks from occupant loading and intrusion and was fractured at the armrest. The bottom aspect exhibited numerous abrasions and blue paint transfers from engagement against the sill. Concrete fragments were present throughout the floor pan and left sill areas of the interior.

Figure 14. Overall view of instrument panel and displaced components

Multiple intrusions that resulted from the impact were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
FL	Left front door	10.2 cm (4.0")	Lateral
FL	Left A-pillar	7.6 cm (3.0")	Lateral
FL	Left roof side rail	6.4 cm (2.5")	Lateral
FL	Left roof side rail	3.8 cm (1.5")	Vertical
FL	Left sill	8.9 cm (3.5")	Lateral
FL	Concrete pole	Unknown	Lateral

MANUAL RESTRAINT SYSTEMS – 2002 GMC Envoy

The 2002 GMC Envoy was configured with integrated manual 3-point lap and shoulder belts with sliding latch plates for the front seat positions. The driver's safety belt was configured with a belt-sensitive Emergency Locking Retractor (ELR) and the front right passenger's safety belt was configured with a belt-sensitive switchable/Automatic Locking Retractor (ALR). At the time of the vehicle inspection, the driver's safety belt was wrapped around the left front door frame and steering wheel to anchor the left front door in place, which masked signs of driver loading. Body fluid was also noted on the webbing. The driver's safety belt had been cut 174.0 cm (68.5") above the lower anchor **(Figure 15)**. The latch plate

Figure 15. View of driver's safety belt

Figure 16. Frontal view of displaced plastic cover

Figure 17. Rear view of displaced plastic cover and steel bracket

was still present on the webbing and exhibited a small amount of abrasion on the left aspect from loading against the safety belt webbing. The latch plate also had abrasions consistent with regular usage. There was no visible webbing left in the retractor located on the top outboard aspect of the seat back. The plastic cover and steel bracket were deformed vertically and laterally toward the left as a result of the driver loading the safety belt **(Figures 16 and 17)**. The vertical displacement measured 3.2 cm (1.3") on the inboard aspect of the cover and the outboard aspect contacted the left B-pillar.

The front right safety belt exhibited minor stretching over an area that measured 22.2 cm (8.8") in length and began 67.3 cm (26.5") above the lower anchor **(Figure 18)**. Small amounts of body fluid were present on the webbing, most likely from the driver.

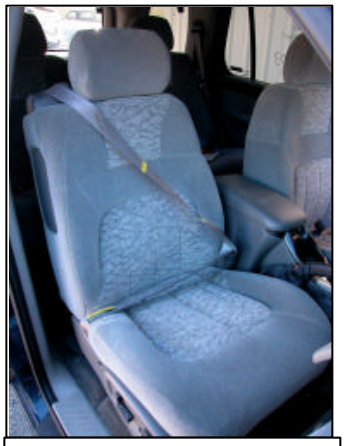


Figure 18. Front right passenger's safety belt

The rear seating positions were configured with manual 3-point lap and shoulder belts with sliding latch plates and belt-sensitive, switchable/ALR retractors. The rear outboard restraints were configured with fixed D-rings and the center position was integrated into the seat back. The rear outboard seats were equipped with Lower Anchors and Tethers For Children (LATCH) anchors.

FRONTAL AIR BAG SYSTEM – 2002 GMC Envoy

The 2002 GMC Envoy was equipped with dual-stage frontal air bags for the driver and front right passenger that deployed as a result of the impact with the concrete pole. The EDR summary indicated that both the first and second stages deployed in this crash.

The driver's air bag was housed in the center of the steering wheel with symmetrical I-configuration cover flaps. The cover flaps measured 11.7 cm (4.6") in height and 7.6 cm (3.0") in width. The air bag was circular in shape and measured 66.0 cm (26.0") in diameter. The air bag was tethered by two internal straps located at the 3 and 9 o'clock positions that measured 15.2 cm (6.0") in width. The air bag was also vented by two circular ports located at the 11 and 1 o'clock positions on the rear aspect of the air bag. The ports measured 2.5 cm (1.0") in diameter and were located 8.3 cm (3.3") from the circumferential seam.

Heavy body fluid transfers were present on the face of the driver's air bag **(Figure 19)**. There was no additional contact evidence on the air bag; however, the bottom rear aspect of the air bag exhibited numerous linear abrasion-like body fluid transfers **(Figure 20)**.

Figure 19. Body fluid transfers on the face of the driver's air bag

Figure 20. Abrasion-like transfers on the bottom rear aspect of the driver's air bag

The front right passenger's air bag **(Figure 21)** deployed from a mid-mount module with a rectangular cover flap hinged at the forward aspect. The vinyl cover flap measured 33.0 cm (13.0") in width and 14.0 cm (5.5") in height. The front right passenger's air bag measured 49.5 cm (19.5") in width and 55.9 cm (22.0") in height. The air bag was tethered by a wide-band tether located at the center of the air bag that measured 30.5 cm (12.0") in width. The air bag was vented by two circular ports located at the 2 and 10 o'clock positions on the side panels of the air bag. The vent ports measured 3.8 cm (1.5") in diameter and were located 11.4 cm (4.5") rear of the face of the air bag. Trace amounts of body fluid spatter were present on the face of the air bag, most likely from the driver.

Figure 21. View of front right passenger's air bag

SIDE IMPACT AIR BAG SYSTEM – 2002 GMC Envoy

The 2002 GMC Envoy was equipped with seat back-mounted side impact air bags for the driver and front right passenger positions. The driver's side impact air bag deployed as a result of the impact with the concrete pole. The air bag deployed from the outboard aspect of the driver's seat back **(Figures 22 and 23)**. The module was configured with a rectangular module cover flap that measured 7.6 cm (3.0") in width and 19.1 cm (7.5") in height. The air bag measured 40.6 cm (16.0") in length and 22.9 cm (9.0") in height. The side impact air bag provided abdominal/torso protection only, and did not offer protection for the occupant's head. The air bag was vented by a single circular port located on the top rear corner of the outboard aspect. The vent port measured 3.8 cm (1.5") in diameter and was located 7.6 cm (3.0") forward of the rear aspect of the air bag and 1.3 cm (0.5") below the top aspect. The side impact air bag deployed 30.5 cm (12.0") forward of the front aspect of the driver's seat back and 15.2 cm (6.0") above the seat cushion. There was no contact evidence, damage, or evidence of an impeded deployment on either side of the side impact air bag.

Figure 22. Inboard aspect of driver's side impact air bag

Figure 23. Outboard aspect of driver's side impact air bag

OCCUPANT DEMOGRAPHICS – 2002 GMC Envoy

Driver

Age/Sex:	54-year-old male
Height:	178 cm (70")
Weight:	96 kg (212 lb)
Seat Track Position:	8.9 cm (3.5") forward of full-rear
Manual Restraint Use:	Integrated manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Expired at scene and transported to morgue

Driver Injuries

Injury	Injury Severity AIS 90(Update 98)	Probable Injury Mechanism
Forehead laceration with penetrating head trauma*	Moderate (290604.2,7)	"No Parking" sign (probable)
Multiple right neck contusions	Minor (390402.1,1)	Concrete pole (probable)
Multiple right facial abrasions	Minor (290202.1,1)	Concrete pole (probable)
Multiple right facial lacerations	Minor (290600.1,1)	Concrete pole (probable)
Right neck lacerations	Minor (390600.1,1)	Signs on concrete pole (possible)
Closed right ulna fracture	Moderate (753202.2,1)	Center instrument panel (possible)
Small bilateral upper chest puncture wounds	Minor (490600.1,3)	Unknown
Right hand abrasion	Minor (790202.1,1)	Center instrument panel (possible)
Left hand abrasion	Minor (790202.1,2)	Interior surface of left front door, left instrument panel, left A-pillar, or flying glass (possible)

Injury source: Medical Examiner's investigation report (non-invasive)

*The penetrating head trauma was not explained by the Medical Examiner but probably involved a brain injury

Driver Kinematics

The 54-year-old male driver was operating the 2002 GMC Envoy in an eastbound direction on the four-lane roadway. He was restrained by the integrated manual 3-point lap and shoulder belt. It was not known if the driver fell asleep or experienced a medical episode. He relinquished control of the Envoy and the vehicle struck the curb and traveled onto the roadside. It was not known if the driver woke up or regained consciousness prior to impact with the pole, and his pre-crash posture was not known.

At impact with the pole, the frontal air bag system deployed and the driver's side impact air bag deployed. The driver's left hand may have been projected into the left interior door surface, left instrument panel, or left A-pillar, which resulted in a left hand abrasion. His right hand may have been deflected against the center instrument panel, which resulted in a fractured right ulna and right hand abrasions. The driver initiated a forward and lateral trajectory to the left, and loaded the safety belt and deployed driver's side impact air bag with his lower left torso. Due to the size of the side impact air bag, it offered no protection to the head or shoulder region from intruding components. The Envoy engaged the pole and the "No Parking" sign at the left A-pillar. The bottom aspect of the sign was vertically oriented below the top aspect of the roof side rail. As the Envoy contacted the pole and the sign, the pole fractured in multiple locations along the shaft and the sign and pole intruded into the driver's space. The driver was struck in the forehead by the bottom corner of the "No Parking" sign that resulted in a forehead laceration with penetrating head trauma. There were no soft tissue injuries to the face or left side of the head to suggest contact with the face of the pole. As the vehicle continued through the pole, the driver's head

snagged on the sign and rotated in a rapid CCW direction, which may have resulted in a neck fracture (the investigating officer stated that the driver sustained a fractured neck, although it was not confirmed in the Medical Examiner's external report). The snagging resulted in additional loading on the safety belt webbing, which pulled the cover of the integrated shoulder belt retractor away from the top of the seat back. The CCW rotation of the driver's head exposed the right side of his head to the concrete pole and signs. It is possible that the segment of the pole with the signs rotated in a CW direction as a result of torsional forces during the crash exposing the edge of one of the signs toward the driver's head. As the vehicle continued around the pole, the driver contacted the pole with the right side of his head, which resulted in multiple right neck contusions, multiple right facial abrasions, and multiple right facial lacerations. He also sustained two large lacerations on the right neck under the right ear from possible contact with one of the signs. The driver also sustained two small bilateral puncture wounds on the upper chest, but the mechanism was unknown.

It was not known how the driver came to rest in the vehicle. He was pronounced dead at the scene and did not receive medical treatment.

Right Front Passenger

Age/Sex:	17-year-old male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	3.8 cm (1.5") forward of full-rear
Manual Restraint Use:	Integrated manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a local hospital and treated and released

Right Front Passenger Kinematics

The 17-year-old male front right passenger was restrained by the available integrated manual 3-point lap and shoulder belt. Police reported that he was sleeping prior to the pole impact, and his pre-crash posture was not known. Police stated that he did not wake up until the frontal air bag deployment.

As the Envoy impacted the curb, the front right passenger remained in position and may have been slightly displaced within the seat and manual restraint system. At impact with the concrete pole, the frontal air bag system deployed and the 17-year-old front right passenger initiated a forward and slightly lateral trajectory to the left. He loaded the safety belt, evidenced by minor stretch marks on the webbing. He also loaded the deployed front right passenger's air bag, which provided additional protection against the frontal crash forces. He rebounded rearward into the seat back and was redirected to the right as the Envoy rotated CCW through the pole. He came to rest in the front right seat after the crash.

The front right passenger attempted to arouse the driver after the Envoy came to rest but was unsuccessful. He used a cellular telephone to call for help and as he did so, the Envoy's OnStar system activated and dispatched emergency personnel. It was not known how the front right

passenger exited the vehicle. He sustained a police-reported “possible injury” and was transported by ambulance to a local hospital. His admission status was not reported.

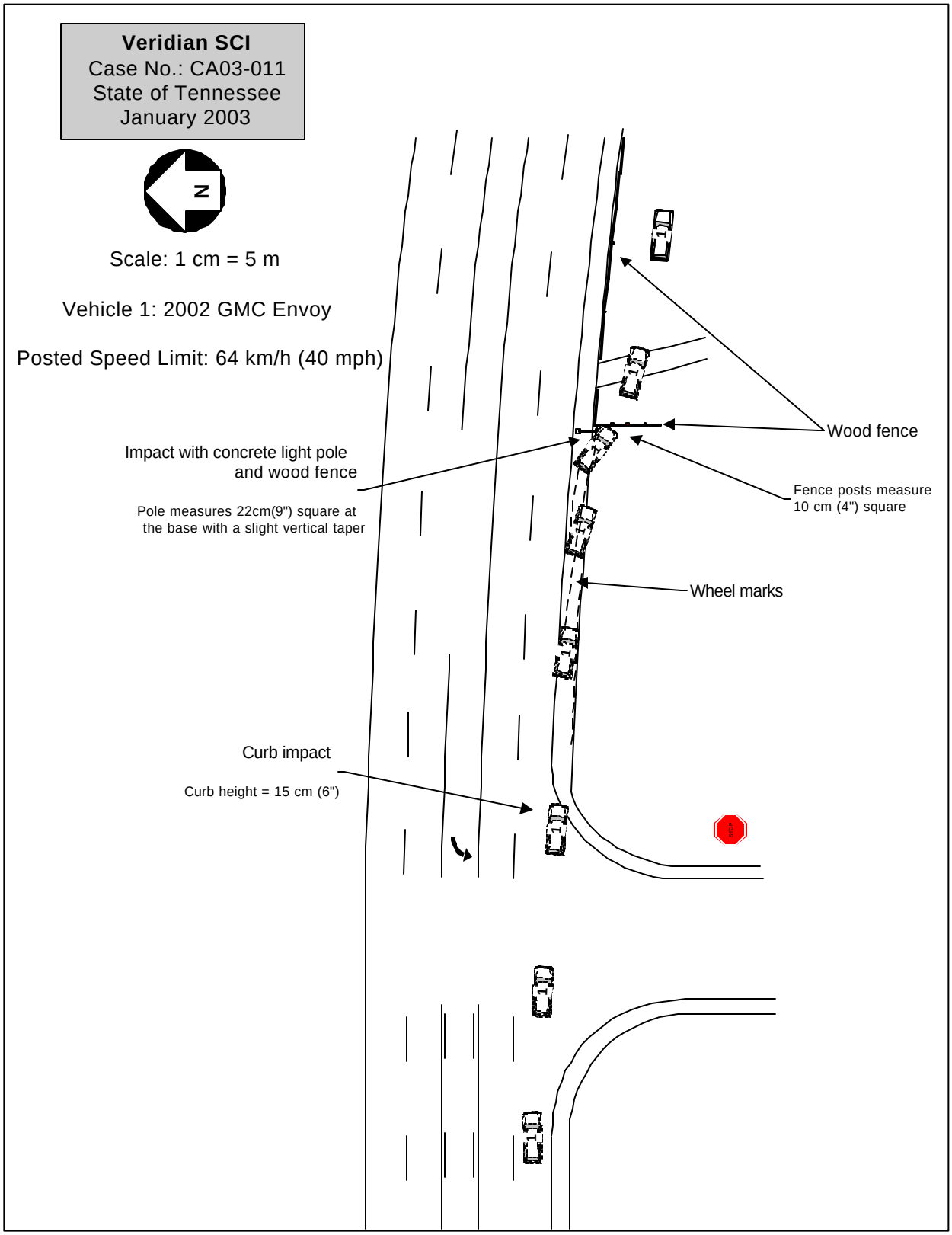


Figure 24. Scene Schematic

APPENDIX A – EDR SUMMARY, 2002 GMC Envoy

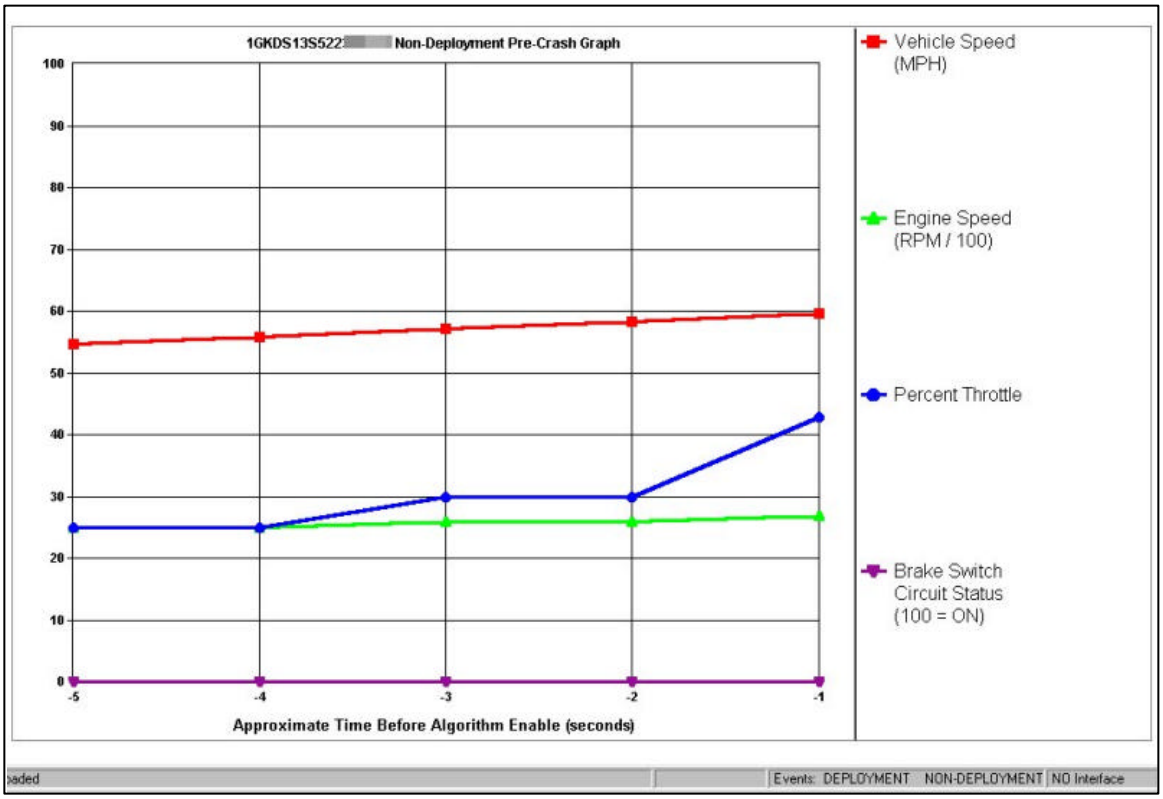
1GKDS13S522[redacted] System Status At Non-Deployment	
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Non-Deployment	2925
Ignition Cycles At Investigation	2926
Maximum SDM Recorded Velocity Change (MPH)	0.00
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	0
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No

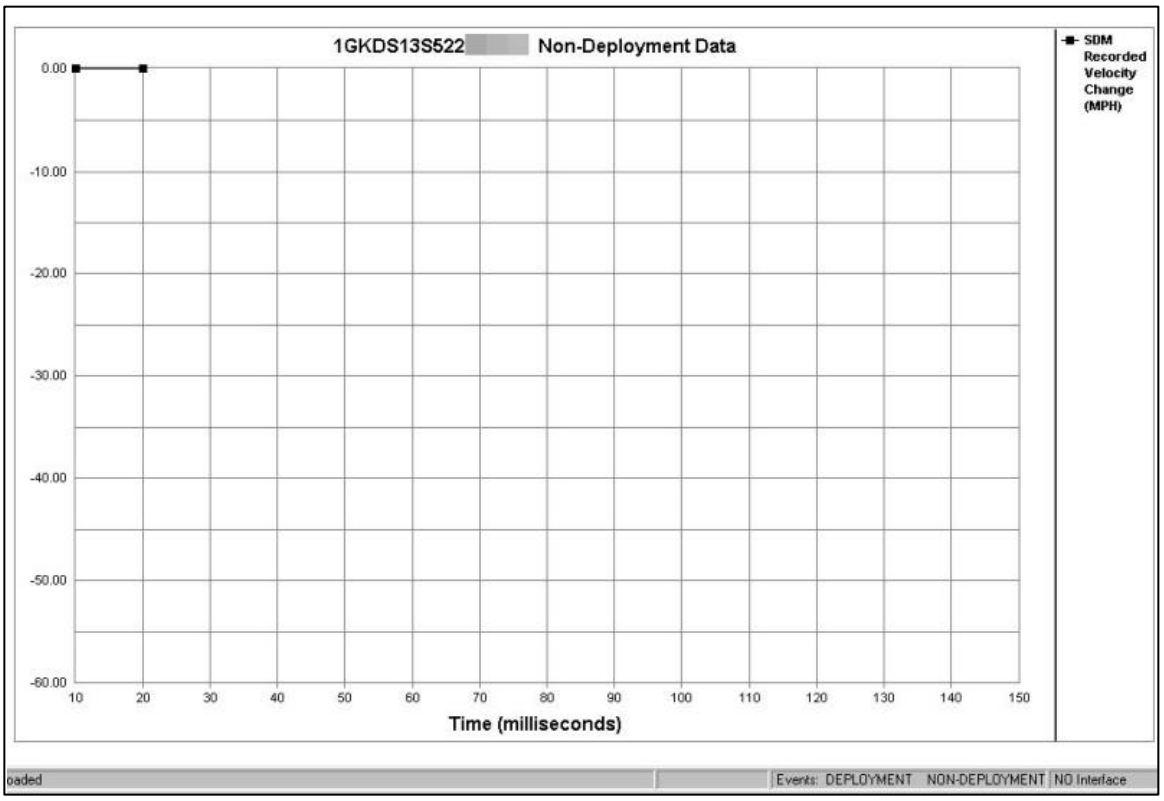
Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	0.00	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

PRE-CRASH DATA

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	55	2496	25	OFF
-4	56	2496	25	OFF
-3	57	2560	30	OFF
-2	58	2624	30	OFF
-1	60	2688	43	OFF

e loaded | Events: DEPLOYMENT NON-DEPLOYMENT | NO Interface





1GKDS13S522 System Status At Deployment

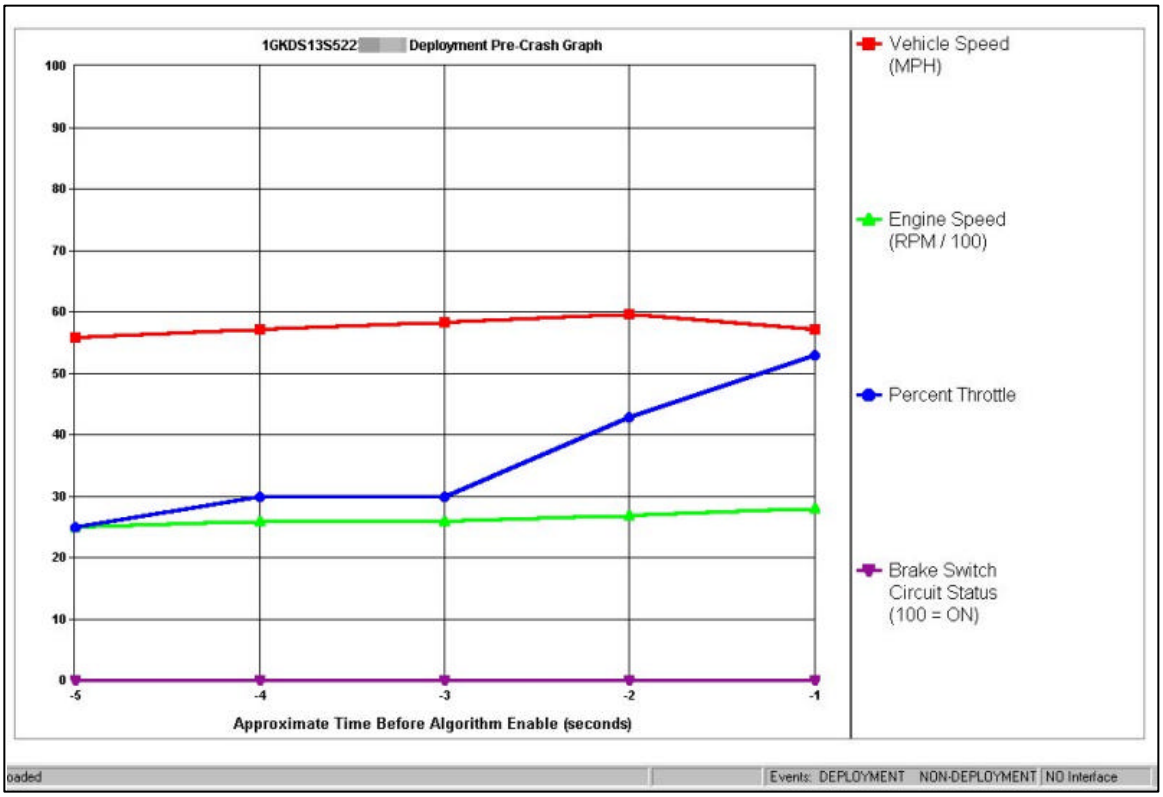
SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	2925
Ignition Cycles At Investigation	2926
Maximum SDM Recorded Velocity Change (MPH)	-11.21
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	117.5
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	20
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	20
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	20
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	20
Time Between Non-Deployment And Deployment Events (sec)	.5
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

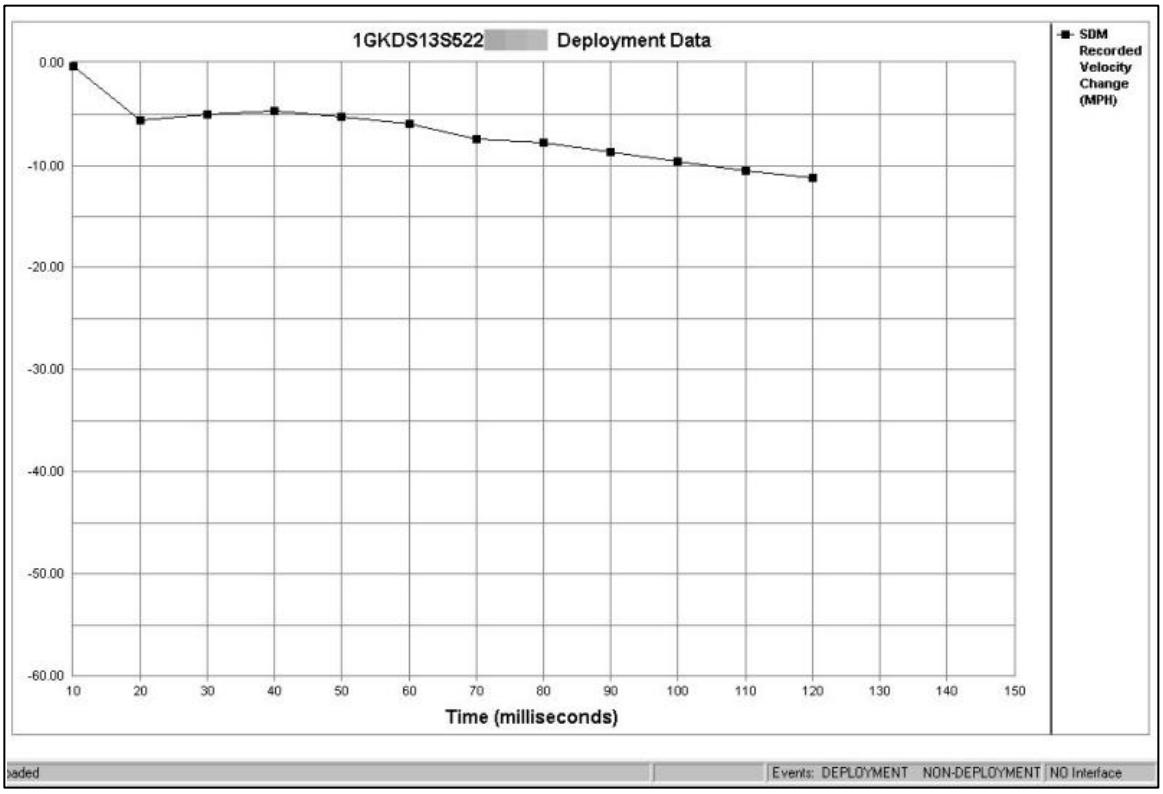
Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.31	-5.58	-4.96	-4.65	-5.27	-5.89	-7.44	-7.75	-8.68	-9.61	-10.54	-11.16	N/A	N/A	N/A

PRE-CRASH DATA

Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	56	2496	25	OFF
-4	57	2560	30	OFF
-3	58	2624	30	OFF
-2	60	2688	43	OFF
-1	57	2816	53	OFF

e loaded Events: DEPLOYMENT NON-DEPLOYMENT NO Interface


1GKDS13S522 Deployment Pre-Crash Graph
100
90
80
70
60
50
40
30
20
10
0
-5
-4
-3
-2
-1
Approximate Time Before Algorithm Enable (seconds)
Vehicle Speed (MPH)
Engine Speed (RPM / 100)
Percent Throttle
Brake Switch Circuit Status (100 = ON)
oaded
Events: DEPLOYMENT NON-DEPLOYMENT NO Interface


1GKDS13S522 Deployment Data
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Time (milliseconds)
SDM Recorded Velocity Change (MPH)
oaded
Events: DEPLOYMENT NON-DEPLOYMENT NO Interface