TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

Advanced Information Engineering Services
A General Dynamics Company
Buffalo, NY 14225

GENERAL DYNAMICS ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION

SCI CASE NO. – CA04-041

SUBJECT VEHICLE – 2005 GMC YUKON DENALI

LOCATION - STATE OF NEW YORK

CRASH DATE – SEPTEMBER 2004

Contract No. DTNH22-01-C-17002

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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

1. Report No. CA04-041	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle General Dynamics On-Site Certified Advanced 208-Compliant Vehicle Crash Investigation Vehicle: 2005 GMC Yukon Location: State of New York		*5. Report Date*: January 2005 *6. Performing Organization Code*	
7. Author(s) Crash Data Research Center		*8. Performing Organization Report No.*	
9. Performing Organization Name and Address Transportation Sciences Crash Data Research Center Advanced Information Engineering Services A General Dynamics Company P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* C00410.0000.0238 *11. Contract or Grant No.* DTNH22-01-C-17002	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		*13. Type of Report and Period Covered* Technical Report Crash Date: March 2004 *14. Sponsoring Agency Code*	
15. Supplementary Note On-site investigation focused on the performance of the Certified Advanced 208-Compliant safety system in a 2005 GMC Yukon.			
16. Abstract This on-site investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in a 2005 GMC Yukon Denali. The manufacturer of this vehicle has certified that this 2005 GMC Yukon Denali meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS 208) No. 208. The safety system included dual stage frontal air bags, seat track position sensors for the front seats, safety belt buckle switch sensors, and an occupant detection sensor for the front right seat. In addition, the GMC was equipped with seatback-mounted side impact air bags for the front seating positions. The side impact air bags did not deploy in the subject crash. The GMC also contained an Event Data Recorder (EDR) that was downloaded during this on-site investigative effort. The EDR output is included in this report as **Attachment A**. The GMC was occupied by a restrained 18-year-old male driver. The GMC was involved in an offset head-on collision with a 1991 Eagle Talon. The Eagle was occupied by a restrained 19-year-old male driver. The front right aspect of the Eagle impacted the front left area of the GMC, which induced a counterclockwise rotation of the GMC. The GMC subsequently struck a curb and departed the road. The GMC rolled over and struck a utility box and a utility pole with the left side roof area. The initial impact with the Eagle resulted in the driver's frontal air bag deployment in the GMC. The driver of the GMC sustained left ankle fractures and soft tissue injuries and was transported by ambulance to a regional trauma center where he was hospitalized for two days. As a result of the crash, the Eagle's left side structure was torn open resulting in the ejection of the driver. The driver of the Eagle sustained incapacitating injuries and was transported to a regional trauma center where he was admitted in critical condition.			
17. Key Words Certified Advanced 208-Compliant (CAC) Frontal Air Bag Deployment		*18. Distribution Statement* General Public	
19. Security Classif. (of this report) Unclassified	*20. Security Classif. (of this page)* Unclassified	*21. No. of Pages* 22	*22. Price*

TABLE OF CONTENTS

GENERAL DYNAMICS ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION
SCI CASE NO. – CA04-041
SUBJECT VEHICLE – 2005 GMC YUKON DENALI
LOCATION - STATE OF NEW YORK
CRASH DATE – SEPTEMBER 2004

BACKGROUND

This on-site investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in a 2005 GMC Yukon Denali **(Figure 1)**. The manufacturer of this vehicle has certified that this 2005 GMC Yukon Denali meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS 208) No. 208. The safety system included dual stage frontal air bags, seat track position sensors for the front seats, safety belt buckle switch sensors, and an occupant detection sensor for the front right seat. In addition, the GMC was equipped with seatback-mounted side impact air bags for the front seating positions. The side impact air bags did not deploy in the subject crash. The GMC also contained an Event Data Recorder (EDR) that was downloaded during this on-site investigative effort. The EDR output is included in this report as **Attachment A**. The GMC was occupied by a restrained 18-year-old male driver. The GMC was involved in an offset head-on collision with a 1991 Eagle Talon. The Eagle was occupied by a restrained 19-year-old male driver. The front right aspect of the Eagle impacted the front left area of the GMC, which induced a counterclockwise rotation of the GMC. The GMC subsequently struck a curb and departed the road. The GMC rolled over and struck a utility box and a utility pole with the left side roof area. The initial impact with the Eagle resulted in the driver's frontal air bag deployment in the GMC. The driver of the GMC sustained left ankle fractures and soft tissue injuries and was transported by ambulance to a regional trauma center where he was hospitalized for two days. As a result of the crash, the Eagle's left side structure was torn open resulting in the ejection of the driver. The driver of the Eagle sustained incapacitating injuries and was transported to a regional trauma center where he was admitted in critical condition.

Figure 1. Subject 2005 GMC Yukon.

The Special Crash Investigations (SCI) team was notified of the crash by the investigating police officer. The notification was forwarded to the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA). Due to the presence of the CAC system in the GMC, NHTSA assigned an on-site investigative effort to the General Dynamics SCI on September 27, 2004. The inspections of the involved vehicles, crash site, and EDR download were initiated on September 28, 2004.

SUMMARY

Crash Site

This multiple event crash occurred during the evening hours of September 2004. At the time of the crash, it was daylight and the weather was clear with no adverse conditions. The crash occurred in the southbound lanes and the west roadside of a four-lane north/southbound roadway. The north/southbound roadway was configured with two travel lanes in each direction and was delineated by a painted center left turn lane/median. The roadway was constructed of worn asphalt and was bordered by concrete barrier curbs. The west roadside consisted of a curb, earth embankment, utility box, and a utility pole. The utility box and the utility pole were located 4.5 m (14.8 ft) west of the curb. The posted speed limit for the north/southbound traffic was 72 km/h (45 mph). The scene schematic is included as **(Figure 19)** of this report.

Vehicle Data – 2005 GMC Yukon Denali

The 2005 GMC Yukon Denali was identified by the Vehicle Identification Number (VIN): 1GKEK63U75 (production sequence omitted). The odometer reading at the time of the inspection was unknown. The vehicle was a large four-door sport utility vehicle that was equipped with a 6.0-liter, eight-cylinder engine, 4-speed automatic transmission, all-wheel drive, power-front and rear disc brakes with anti-lock, OEM alloy wheels, direct tire pressure monitoring system, On Star, Stabilitrak, power adjustable pedals, daytime running lights, navigation system, power-steering, and a tilt steering wheel. The GMC was equipped with Goodyear Wrangler HP tires, size P265/70R17. The maximum pressure for these tires was 303.4 kpa (44.0 psi). The vehicle manufacturer recommended tire pressure for this vehicle was unknown. The placard was not accessible due to the restricted (jammed) left front door. The specific tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0.0 kPa	10 mm (12/32)	No	Cut to sidewall and tread
LR	251.7 kPa (36.5 PSI)	10 mm (12/32)	No	None
RF	230.9 kPa (33.5 PSI)	10 mm (12/32)	No	None
RR	0.0 kPa	10 mm (12/32)	No	De-beaded

The seating positions in the GMC were configured with heated leather trimmed front buckets seats with height adjustable head restraints. The front seat head restraints were both adjusted to the full-down position at the time of the vehicle inspection. The second row was configured with heated leather trimmed captain seats and height adjustable head restraints. The head restraints were adjusted to the full-down position. The third row was configured with a leather upholstered three-passenger split/folding (50/50) bench seat with height adjustable head restraints for the outboard seating positions. The head restraints were adjusted to the full-down position. The third seat was folded forward at the time of the crash.

1991 Eagle Talon

The 1991 Eagle Talon was identified by the VIN: 4E3CS44R6M (production sequence omitted). The odometer reading at the time of the inspection was unknown. The vehicle was a two-door hatch back that was equipped with a 2.0-liter, four-cylinder engine, 5-speed manual transmission, front-wheel drive, power front and rear disc brakes. The front tires on the Eagle were Goodyear Eagle HP, size P205/55R16. The maximum pressure for these tires was 303.4 kpa (44.0 psi). The rear tires on the Eagle were Dayton Quadra LTE tires, size P205/55R16. The vehicle manufacturer recommended tire pressure was unknown. The maximum pressure for these tires was 241.2 kpa (35.0 psi). The specific tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0.0 kPa	6 mm (8/32)	No	Cut to inner sidewall
LR	189.6 kPa (27.5 PSI)	6 mm (8/32)	No	None
RF	0.0 kPa	4 mm (5/32)	Yes	Cut to outer sidewall
RR	258.5 kPa (37.5 PSI)	6 mm (8/32)	No	None

Crash Sequence

Pre-Crash

The restrained 18-year-old male driver of the 2005 GMC Yukon was operating the vehicle southbound on the inboard lane of the four-lane roadway **(Figure 2)**. The driver of the GMC stated to the SCI investigator that he traveling in the left through lane with the cruise control on and set at 72 km/h (45 mph). The restrained 19-year-old male driver of the Eagle was operating the vehicle northbound on the inboard lane of the same roadway **(Figure 3)**. It was police reported that the driver of the Eagle was operating the vehicle with excessive speed in order to catch up to a friend that was ahead of him. As the driver of the Eagle continued northbound, the driver lost directional control of the vehicle and began to rotate counterclockwise (CCW). The Eagle entered the center left turn median lane and then entered the inboard southbound lane. The driver of the GMC stated to the SCI investigator that he observed the Eagle as it entered the center left turn median lane. As the Eagle entered the left through lane, the driver of the GMC steered right just prior to the impact.

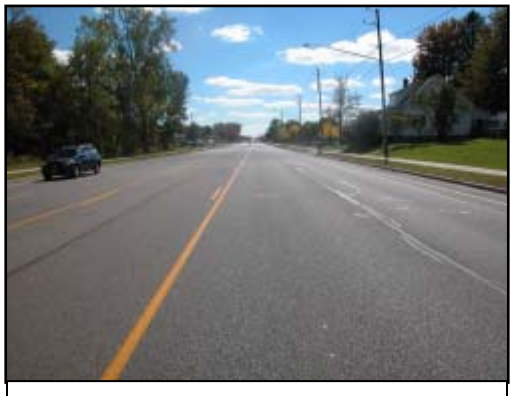


Figure 2. Southbound approach for the GMC.

Figure 3. Northbound approach for the Eagle.

Crash

The front of the Eagle impacted the front left aspect of the GMC on the inboard southbound lane **(Figure 4)**. The resulting directions of force were within the 11 o'clock sector for the GMC and the 1 o'clock sector for the Eagle. The Eagle penetrated and engaged the undercarriage and left side structure of the GMC. At maximum engagement, the undercarriage of the GMC snagged the Eagle's frontal structure. As the Eagle began to rotate counterclockwise (CCW), the lateral forces exerted on the left side structure resulted in the separation of the unibody chassis. The left sill and the floor/toe pan separated forward of the driver's seat. The engine separated from the transmission bell housing and was thrown from the vehicle. As a result of the gross deformation, a crush profile could not be obtained from the Eagle. Due to the lack of crush measurements, the WINSMASH missing vehicle algorithm was used to calculate a delta V for this impact. The total delta V for the GMC was 16.0 km/h (9.9 mph). The longitudinal and lateral components were -15.0 km/h (-9.3 mph) and 5.5 km/h (3.4 mph), respectively. The total delta V for the Eagle was 29.0 km/h (18.0 mph). The longitudinal and lateral components were -27.3 km/h (-16.9 mph) and -9.9 km/h (-6.2 mph), respectively. The EDR recorded a maximum delta V of -16.9 km/h (-10.5 mph). As a result of this impact the frontal air bag deployed in the GMC. It should be noted that the delta V's were calculated using the frontal crush of the GMC, therefore the computed delta V's were not representative of the total crush damage to the GMC.

Figure 4. Northbound view of the area of impact between the GMC and the Eagle.

Figure 5. West roadside curb impact.

As a result of the frontal impact, the GMC was redirected in a southwest direction and began a CCW rotation. The GMC departed the west roadside and impacted the concrete barrier curb with its right side tires **(Figure 5)**. The curb was located approximately 5.0 m (16.4 ft) west of the initial area of impact. This impact resulted in the de-beading and deflation of the right rear tire and minor damage to the concrete barrier curb. A delta V for this impact could not be calculated.

Figure 6. Area of rollover and impact to the utility box and utility pole.

The GMC continued off-road rotating CCW and began to climb an earthen embankment. As a result of the de-beaded right rear tire, the right rear wheel rim furrowed into the embankment, which resulted in a tripping mechanism. The GMC began to rollover with its right side leading.

The GMC rolled onto its right side and traveled 4.5 m (14.8 ft) west of the curb and impacted a utility box with the roof area. The utility box was square and measured 21.0 cm (8.3”). This impact was non-horizontal and was overlapped by a second roof impact, which was outside the scope of the WINSMASH program.

The GMC rolled beyond its right side; however, prior to the second quarter turn the left roof side rail impacted a 29.6 cm (11.7”) diameter wooden utility pole **(Figure 6)** that was located adjacent to the utility box. Therefore, the GMC only completed one-quarter turn during the off-road crash sequence. Although a crush profile was obtained, this impact was non-horizontal and outside the scope of the WINSMASH program.

The utility pole impact redirected the rollover momentum of the GMC and the GMC rolled back onto its right side where it came to final rest.

Post-Crash

A passing motorist who witnessed the crash assisted the driver of the GMC out of the vehicle. The driver of the GMC sustained left ankle fractures and soft tissue injuries and was transported by ambulance to a regional trauma center where he was hospitalized for two days. As a result of the impact, the Eagle’s left side structure was torn open resulting in the ejection of the driver. The driver of the Eagle sustained incapacitating injuries and was transported to a trauma center where he was admitted in critical condition. The GMC and the Eagle sustained severe damage and were towed from the crash site.

Vehicle Damage

Exterior Damage – 2005 GMC Yukon Denali

The 2005 GMC Yukon Denali sustained severe damage as a result of the frontal impact with the Eagle **(Figure 7)**. The Eagle penetrated through the front left corner and engaged the left front suspension, and the left side frame of the vehicle. The direct damage measured 30.5 cm (12.0”) which began 58.4 cm (23.0”) left of the centerline and extended left. The maximum crush was located at the front left end of the bumper reinforcement beam and measured 32.5 cm (12.8”). The front left corner of the fiberglass bumper beam was fractured at impact, therefore the crush profile began approximately 14.0 cm (5.5”) inboard of the bumper beam corner. The damage involved longitudinal displacement of the front

Figure 7. Damage from the impact with the Eagle.

bumper, left front fender, left front door, lateral displacement of the left side frame rail, and fractured left front axle. Six equidistant measurements were used to document the crush at the bumper support using a combined direct and induced damage width of 127.0 cm (50.0”) and were as follows: C1 = 32.5 cm (12.8”), C2 = 20.4 cm (8.0), C3 = 13.2 cm (5.2”), 4.6 cm (1.8”), C5 = 0.0 cm, C6 = 0.0 cm. The Collision Deformation Classification (CDC) for this impact was 11-FLEE-9.

The Eagle penetrated into the left side of the GMC, deforming the sheet metal and engaging the frame of the Denali. The lateral crush to the left frame rail was measured at two locations. The first location was 201.9 cm (79.5”) forward of the left rear axle **(Figure 8)** which measured 42.0 cm (16.5”) of lateral crush. The second location was 17.3 cm (44.0”) forward of the left rear axle **(Figure 9)** and measured 20.0 cm (7.9”) of lateral displacement.

Figure 8. Forward aspect of the left frame rail crush.

Figure 9. Rear aspect of the left frame rail crush.

The GMC sustained minor damage as result of the impact with the concrete barrier curb. The damage consisted of an abraded right front tire **(Figure 10)** and de-beaded right rear tire **(Figure 11)**. A crush profile was not obtained for this impact. The CDC’s for this impact was 03-RFWW-1 and 03-RBWW-1.

Figure 10. Right front tire damage. Note damage consisted of abrasions to the sidewall.

Figure 11. Right rear tire damage.

The GMC sustained moderate damage as a result of the rollover event **(Figure 12)**. Although the GMC rolled onto its roof, the maximum area of damage was to the right side plane. The direct damage consisted of longitudinal and lateral abrasions and lateral deformation to the right side. Also noted was dirt and grass that was embedded in the upper right front door edge and the right side luggage rack. The direct damage on the right front fender measured 82.0 cm (32.3") in width and began at the forward edge extending rearward. No direct contact damage was noted to the right front door; however, the right side mirror (glass) was fractured. Lateral deformation was noted to the right rear door which measured 91.0 cm (35.8") in width and began at the rear door edge terminating 5.0 cm (2.0") rear of the forward edge. The deformation to the right rear door was approximately 3.0 cm (1.0") in depth. The right rear quarter panel sustained lateral deformation that began rear of the right rear door edge and measured 55.0 cm (21.7") in width and was approximately 3.0 cm (1.0") in depth. The height of the damage to the right side was 67.0 cm (26.4"). The CDC for this impact was 00-RDAO-2.

Figure 12. Right side rollover damage.

The GMC sustained unknown damage as a result of the impact with the utility box. The impact area was to the roof and was overlapped by the pole impact with no distinct contact evidence. The CDC for this impact was 00-TPL9-9 (9 = unknown).

The GMC sustained moderate damage as a result of the roof impact with the utility pole **(Figure 13)**. The direct contact damage measured 30.0 cm (11.8") on the left roof side rail and was contained within the B- and C-pillars. The direct contact damage also extended vertically onto the left rear door. The direct contact damage measured 40.0 cm (15.7") on the top of the left rear doorframe. Although the damage was non-horizontal a crush profile was documented along the roof side rail. The crush was documented using six equidistant points on the top aspect of the left roof side rail using a combined direct and induced damage width of 54.0 cm (21.3") and were as follows: C1 = 15.0 cm (5.9"), C2 = 20.0 (7.9"), C3 = 26.0 cm (10.2"), C4 = 25.5 cm (10.0"), C5 = 22.0 cm (8.7"), C6 = 16.5 cm (6.5"). The CDC for this impact was 00-TPLN-4.

Figure 13. Left roof and roof side rail damage.

Exterior – 1991 Eagle Talon

The 1991 Eagle Talon sustained severe damage as a result of the frontal impact with the GMC **(Figure 14)**. The Talon's engine was separated from the vehicle. The bell housing of the transmission fractured allowing the engine to rotate counterclockwise, separating from its mounts and from the vehicle. Due to the gross deformation to the vehicle a crush profile could not be obtained. The direct damage on the bumper fascia measured 168.0 cm (66.1") and 82.5 cm (32.5") on the hood. The force of the impact tore the left side structure beginning at the left A-pillar and extending to the left B-pillar, exposing the passenger compartment **(Figure 15)**. The front of the Talon remained attached at the right A-pillar. A pivot point that was located 30.5 cm (12.0") forward of the right B-pillar was where the front of the vehicle shifted right approximately 90-degrees in relation to the passenger compartment of the Talon. The CDC for this impact was 61-FDEW-9 (9 = unknown), with an incremented shift value of 60.

Figure 14. Frontal damage from the impact with the GMC.

Figure 15. Left side structure torn from at impact.

Interior Damage – 2005 GMC Yukon Denali

The 2005 GMC Yukon Denali sustained moderate interior damage as result of occupant contacts. At impact with the Eagle, the driver initiated a forward and left trajectory. The driver loaded the lap belt portion of the safety belt which was evidenced by a transfer. The driver's left knee contacted the knee bolster as it intruded which was evidenced by a scuffmark. The GMC began a counterclockwise rotation as it traveled to the west roadside. The driver's left shoulder contacted the left B-pillar resulting in a scuffmark to the B-pillar plastic trim panel. The GMC departed the road and began to rollover right side leading. As a result of the rollover, possible occupant contacts were noted to the sun visor and the roof area rear of the sun visor which were evidenced by black smudges. The driver's head contacted the roof area above the head

Figure 16. Overall view of the first row.

restraint. Hair was noted to this area of occupant contact. Also documented were two scuffmarks which appeared to be possible body fluid on the roof right of the left head restraint from possible contact from the driver's head. A black scuffmark from possible contact from the driver was noted to the overhead console that was mounted on the center roof area between the front seats. **Figure 16** is an overall view of the first row. The GMC sustained severe interior damage as a result of passenger compartment intrusion. The passenger compartment intrusions are listed in the table below:

Seat Position	Intruded Component	Magnitude	Direction
Front Left	Side panel forward of the A-pillar	16.5 cm (6.5")	Lateral
Front Left	Toe pan	2.5 cm (1.0") [This intrusion was more vertical which is represented in the floor measurement]	Longitudinal
Front Left	Floor	15.0 cm (6.0")	Vertical
Front Left	Door	30.5 cm (12.0")	Lateral
Front Left	Sill	30.5 cm (12.0")	Lateral
Front Left	B-pillar	7.0 cm (2.8")	Vertical
Front Left	Roof	25.5 cm (10.0")	Vertical
Front Left	Instrument panel	Approximately 10.0 cm (4.0")	Vertical
Front Left	Knee bolster	Approximately 5.0 cm (2.0")	Longitudinal
Front Center	Roof	20.5 cm (8.1")	Vertical
Rear Left	Roof side rail	25.1 cm (9.9")	Vertical
Rear Left	Roof	38.1 cm (15.0")	Vertical
Rear Left	Door	42.4 cm (16.7")	Vertical
Rear Left	C-pillar	20.0 cm (7.9")	Vertical
Rear Center	Roof	18.3 cm (7.2")	Vertical

Certified Advanced 208-Compliant Safety System – 2005 GMC Yukon Denali

The 2005 GMC Yukon Denali was equipped with a Certified Advanced 208-Compliant (CAC) safety system. The manufacturer of this vehicle has certified that this 2005 GMC Yukon Denali meets the advanced air bag requirements of the Federal Motor Vehicle Safety Standard (FMVSS 208) No. 208. The system consisted of dual stage frontal air bags, seat track positioning sensors for the front seats, and an occupant presence sensor for the front right seat. The system was monitored and controlled by a Sensing and Diagnostic control Module (SDM) that was located on the floor under the driver's seat. The SDM deploys the appropriate safety component(s) dependant on occupant presence, occupant size, belt usage, seat track position and crash severity. In the subject crash, the SDM commanded a stage two deployment of the driver's air bag. The driver's air bag module was located in the center of the steering wheel hub **(Figure 17)**. Two symmetrical I-configuration cover flaps concealed the air bag and measured 12.2 cm (4.8") in height and 8.4 cm (3.3") in width at the top and 6.4 cm (2.5") in width at the bottom. The air bag measured 59.7 cm (23.5") in diameter in its deflated state and contained two tethers. Two vent ports at the 11 and 1 o'clock positions on the rear aspect vented the air bag.

Figure 17. Deployed driver's frontal air bag.

The front right seat was not occupied during the crash; therefore the suppressed the front right air bag deployment.

Event Data Recorder – 2005 GMC Yukon Denali

The 2005 GMC Yukon Denali was equipped with an Event Data Recorder (EDR). The SCI investigator downloaded the EDR data through the Diagnostic Link Connector that was located under the knee bolster. The vehicle battery was damaged during the crash; therefore the SCI investigator applied power to the EDR through the fuse box that was located in the engine compartment. The EDR recorded two files; a Deployment and a Non-Deployment event. The deployment file of the EDR indicated that the driver's safety belt was buckled at the time of the crash and the first stage of the driver's air bag deployed at 7.6 ms after Algorithm Enable (AE) followed by the second stage at 15.0 ms after AE. The maximum-recorded delta V was -16.9 km/h (-10.5 mph), which is under representative of the damage due to the engagement to the undercarriage and left side structure by the Eagle.

The EDR also recorded a Non-Deployment event that was initiated by the curb strike. It appeared that the Non-Deployment event encompassed the curb impact and a portion of the rollover event. This seems to be supported by the long crash pulse. The maximum-recorded delta V was -14.3 km/h (-8.9 mph) which occurred at 317.5 ms after AE. The EDR printout is included as **Attachment A** of this report.

Side Impact Air Bags – 2005 GMC Yukon Denali

The 2005 GMC Yukon Denali was equipped with seatback-mounted side impact air bags for the front seat positions. The side impact air bags did not deploy in the subject crash.

Manual Restraint Systems – 2005 GMC Yukon Denali

The 2005 GMC Yukon Denali was equipped with integrated manual 3-point lap and shoulder safety belts for the front seating positions. The driver safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). The driver utilized his safety belt in the crash which was evidenced by a transfer on the lap portion of the safety belt from the driver loading the belt system. Also noted was a laceration to the belt buckle sleeve from the sleeve loading against the edge of the seatback bracket **(Figure 18)**. Furthermore, the EDR data indicated that the driver's safety belt was buckled at the time of the crash. The front right safety belt was configured with a sliding latch plate, and a switchable ELR/Automatic Locking Retractor (ALR). The second row was with equipped manual 3-point lap and shoulder safety belts that were configured with sliding latch plates and switchable ELR/ALR. The third row outboard safety belts were equipped with integrated manual 3-point lap and shoulder belts that were configured with sliding latch plates, and switchable ELR/ ALR. The third row center was equipped with a 2-point lap belt that was configured with a locking latch plate and no retractor.

Figure 18. Laceration to safety belt sleeve from loading against seatback

Occupant Demographics – 2005 GMC Yukon Denali

Driver

Age/Sex:	18-year-old/Male
Height:	170.2 cm (67.0")
Weight:	70.3 kgs (155.0 lbs)
Seat Track Position:	Full rear
Manual Restraint Use:	Integrated manual 3-point lap and shoulder safety belt
Usage Source:	Vehicle inspection
Eyewear:	None
Type of Medical Treatment:	Hospitalized

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Left talus fracture	Moderate (853200.2,2)	Intruding floor
Left calcaneus fracture	Moderate (851400.2,2)	Intruding floor
Left subtalar dislocation	Minor (851203.1,2)	Intruding floor
Left ankle laceration	Minor (890602.1,2)	Intruding floor
Bilateral knee abrasions	Minor (890202.1,3)	Intruding knee bolster
Superficial forehead lacerations	Minor (290602.1,7)	Flying glass
Right hand abrasions (scrapes)	Minor (790202.1,1)	Flying glass
Upper left chest contusion	Minor (490402.1,4)	Shoulder belt

Injury source: Emergency room records, discharge records, and driver interview.

Driver Kinematics

The 18-year-old male driver of the 2005 GMC Yukon was seated in an upright posture and was restrained by the manual 3-point lap and shoulder safety belt. The driver's seat was adjusted to the full-rear position. At impact with the Eagle, the frontal air bag (Stage 2 deployment) deployed. The driver initiated a forward and slight left trajectory in response to the 11 o'clock direction of force. His chest loaded the shoulder belt portion which resulted in the chest contusion. The driver's abdomen loaded the lap belt portion of the safety belt which resulted in the transfer on the lap belt. As a result of the severe impact, the left toe pan intruded longitudinally and vertically virtually eliminating the front left floor area. This intrusion resulted in the left talus fracture, left calcaneus fracture, left subtalar dislocation, and the left ankle laceration. The driver's knees contacted the knee bolster which resulted in the bilateral knee abrasions. The initial impact disintegrated the left side glass. The driver sustained superficial forehead lacerations from the flying glass. Additionally, the driver sustained right hand abrasions that were probably attributed to the flying glass.

As a result of the frontal impact, the GMC initiated a CCW rotation and the driver contacted the left B-pillar that was evidenced by transfer on the plastic B-pillar trim panel. The GMC subsequently the departed the west roadside and impacted a concrete barrier curb with its right side tires. This impact was minor and probably did not displace the driver. The GMC subsequently rolled over off-road. The belted status of the driver retained him in the seat during the rollover sequence.

The GMC impacted a utility box and utility pole with its roof which resulted in the roof intrusion. The driver contacted the roof with his head that was evidenced by the hair on the headliner. Possible contacts from the driver were noted to the sun visor and the roof area rear of the sun visor, two scuffmarks which appeared to be possible body fluid on the roof right of the left head restraint from possible contact from the driver's head. A

black scuffmark from possible contact from the driver was noted to the overhead console that was mounted on the center roof area, between the front seats. These contact points did not result in further injury to the driver. The combination of safety belt use and frontal air bag deployment prevented the driver from additional injury and prevented him from possible ejection.

Medical Treatment

The driver was transported by ambulance to a trauma center where he was admitted. The driver underwent surgery for the open talus fracture/dislocation that consisted of irrigation and debridgement, open reduction and internal fixation. The driver was released from the trauma center two days post-crash.

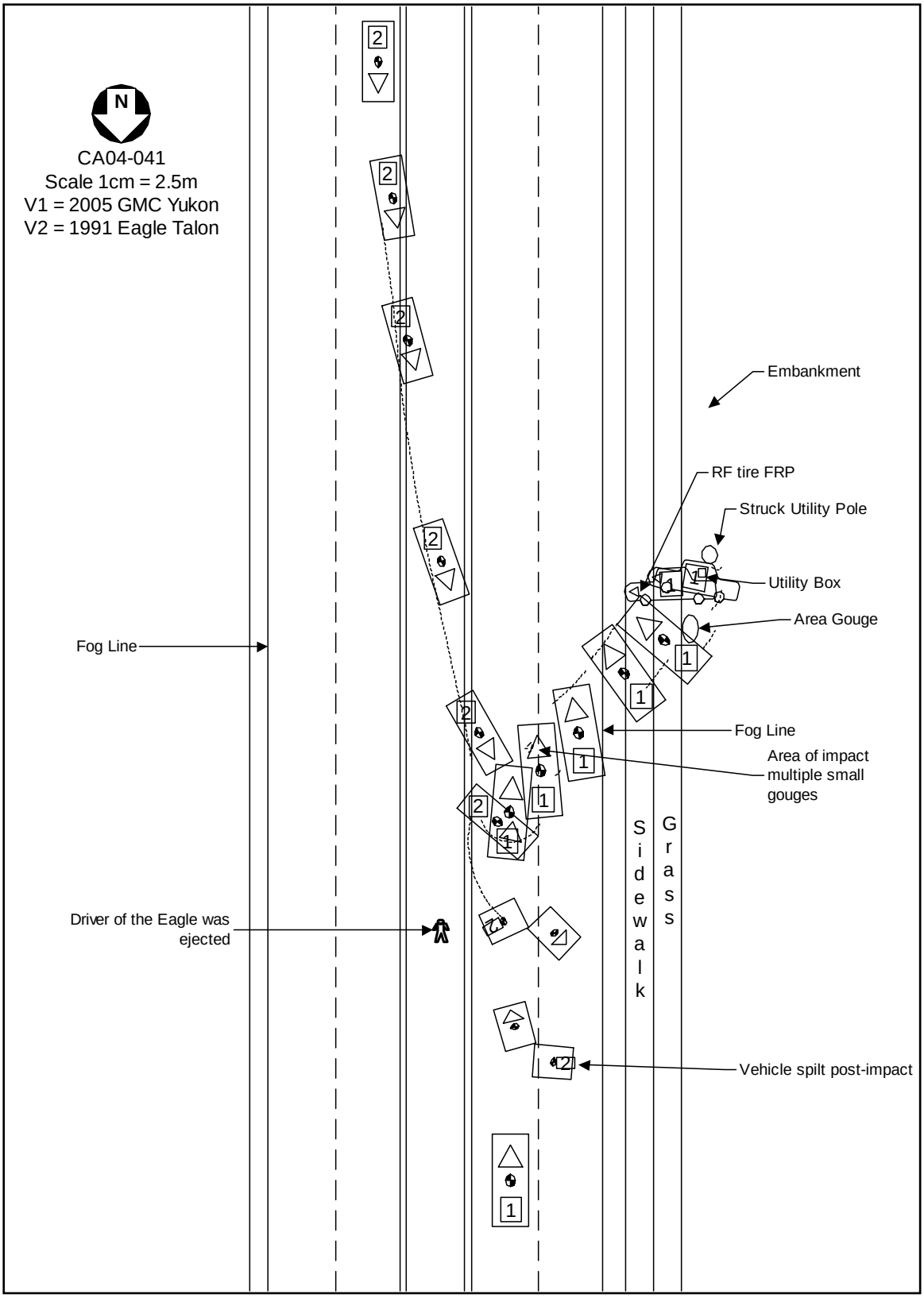


Figure 19. Scene schematic

Attachment A: GMC Yukon EDR Printout

CDR File Information

Vehicle Identification Number	1GKEK63U75Jxxxxxx
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	
Saved on	
Data check information	595D2053
Collected with CDR version	Crash Data Retrieval Tool 2.55
Collecting program verification number	968FEF4F
Reported with CDR version	Crash Data Retrieval Tool 2.40
Reporting program verification number	32B7A917
Interface used to collected data	Block number: 00 Interface version: 3F Date: 08-06-04 Checksum: 6700
Event(s) recovered	Deployment Non-Deployment

SDM Data Limitations

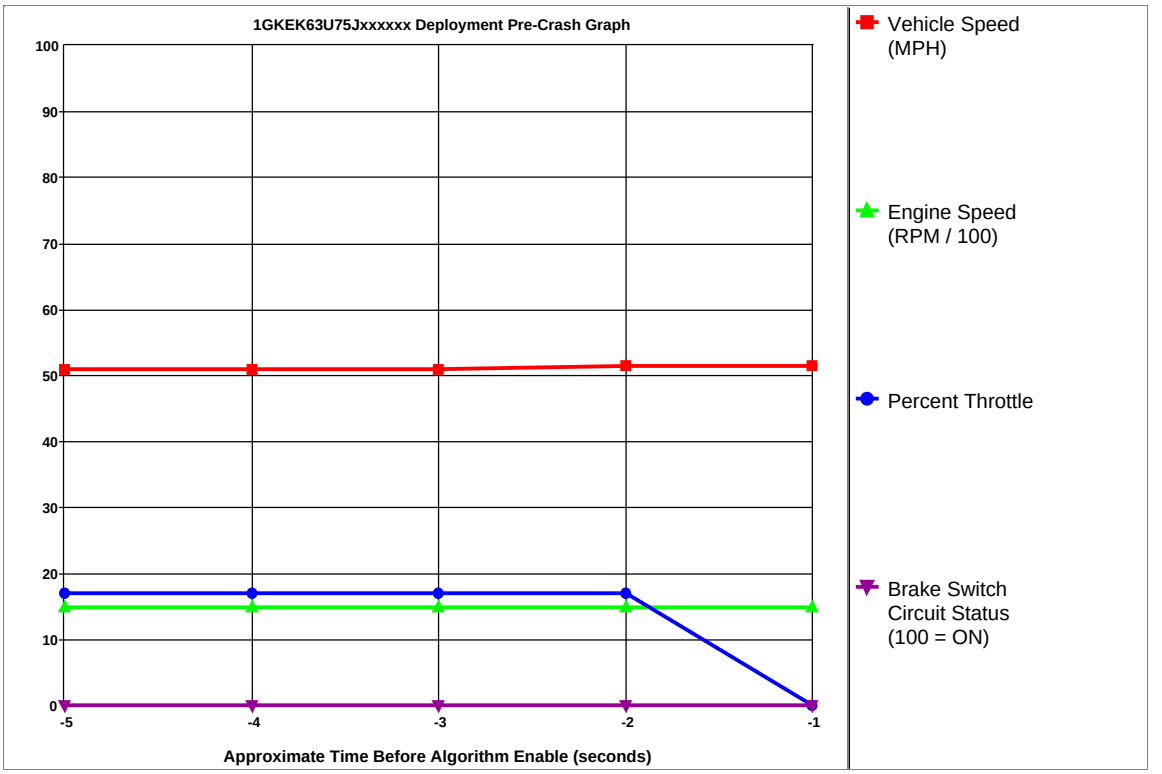
SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded vehicle forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 250 times.
The second type of SDM recorded crash event is the Deployment Event. It also contains Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within five seconds of one another. Deployment events can not be overwritten or cleared from the SDM. Once the SDM has deployed the air bag, the SDM must be replaced.
The data in the non-deployment file will be locked after a deployment, if the non-deployment occurred within 5 seconds before the deployment or a deployment level event occurs within 5 seconds after the deployment.

SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change is one of the measures used to make air bag deployment decisions. SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Forward Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. For deployments and deployment level events, the SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. For non-deployments, the SDM will record the first 150 milliseconds of data after algorithm enable.
-Event Recording Complete will indicate if data from the recorded event has been fully written to the SDM memory or if it has been interrupted and not fully written.
-SDM Recorded Vehicle Speed accuracy can be affected if the vehicle has had the tire size or the final drive axle ratio changed from the factory build specifications.
-Brake Switch Circuit Status indicates the status of the brake switch circuit.
-Pre-Crash Electronic Data Validity Check Status indicates "Data Invalid" if the SDM does not receive a valid message.
-Driver's Belt Switch Circuit Status indicates the status of the driver's seat belt switch circuit
-The Time Between Non-Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than 25.4 seconds, "N/A" is displayed in place of the time.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.

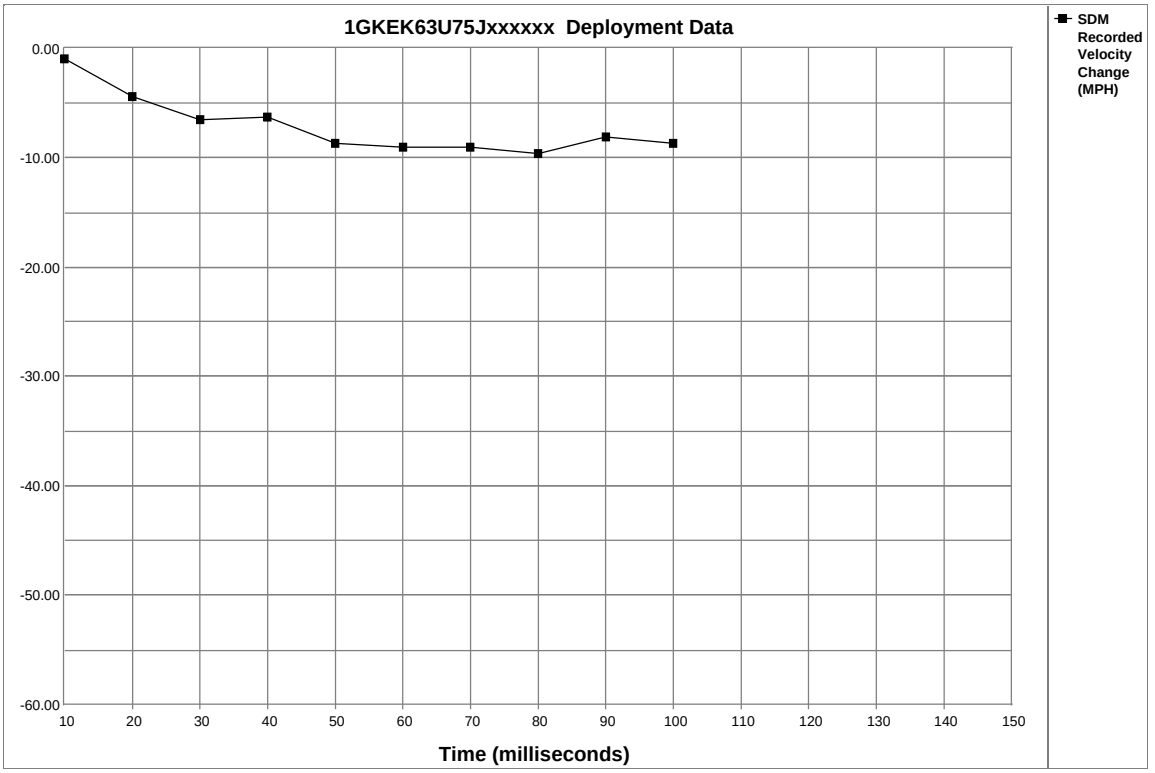
SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the Class 2 data link, to the SDM.
-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the Class 2 data link, to the SDM.
-In most vehicles, the Driver's Belt Switch Circuit is wired directly to the SDM. In some vehicles, the Driver's Belt Switch Circuit Status data is transmitted from the Body Control Module (BCM), via the Class 2 data link, to the SDM.

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Deployment	222
Ignition Cycles At Investigation	229
Maximum SDM Recorded Velocity Change (MPH)	-10.53
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	72.5
Driver First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	7.5
Driver Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	15
Passenger First Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	Suppressed
Passenger Second Stage Time Algorithm Enabled to Deployment Command Criteria Met (msec)	Suppressed
Time Between Non-Deployment And Deployment Events (sec)	N/A
Frontal Deployment Level Event Counter	1
Automatic Passenger SIR Suppression System Status	Air Bag Suppressed
Event Recording Complete	Yes
Multiple Events Associated With This Record	No
One Or More Associated Events Not Recorded	No



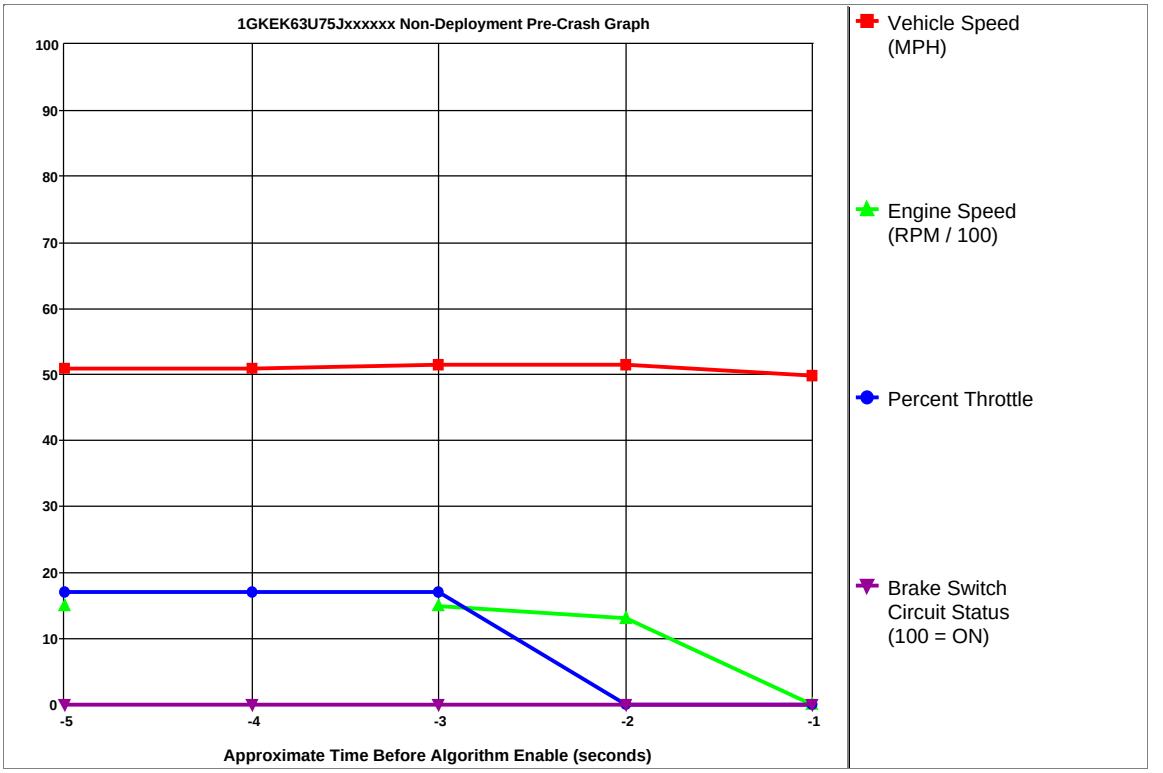
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	51	1472	17	OFF
-4	51	1472	17	OFF
-3	51	1472	17	OFF
-2	52	1472	17	OFF
-1	52	1472	0	OFF



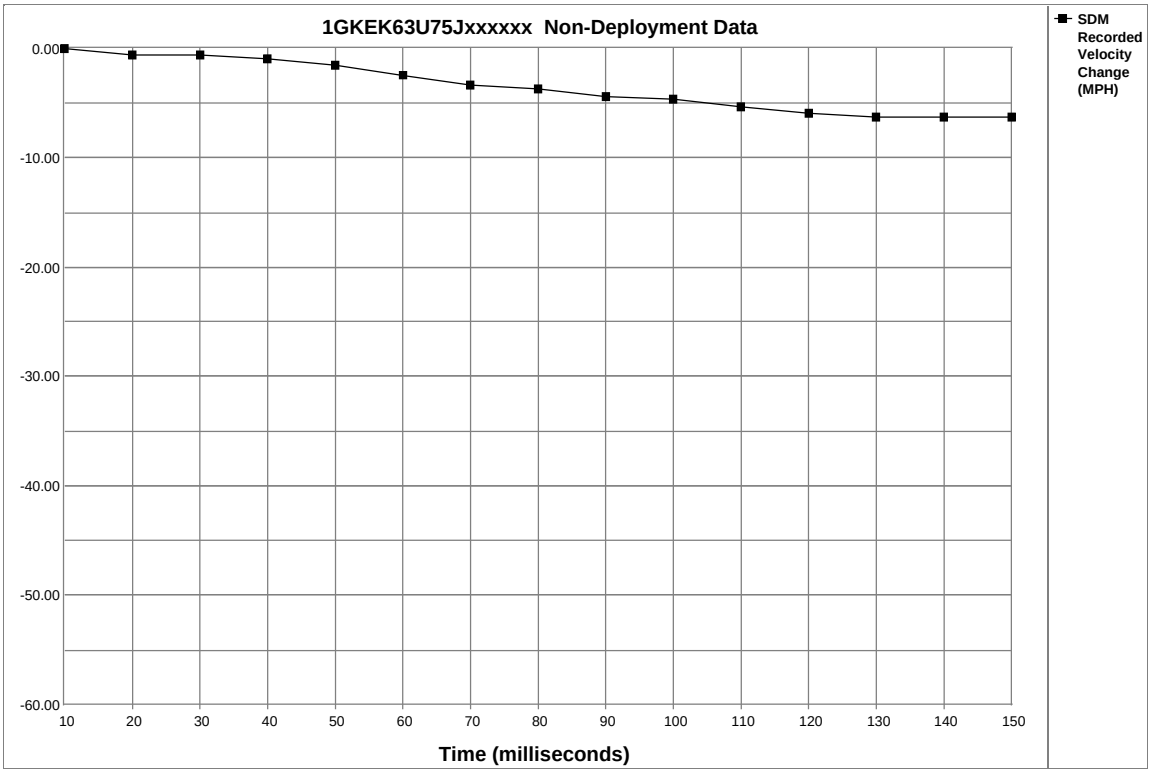
Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-0.93	-4.34	-6.51	-6.20	-8.68	-8.99	-8.99	-9.61	-8.06	-8.68	N/A	N/A	N/A	N/A	N/A

System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger's Belt Switch Circuit Status	UNBUCKLED
Ignition Cycles At Non-Deployment	222
Ignition Cycles At Investigation	229
Maximum SDM Recorded Velocity Change (MPH)	-8.96
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	317.5
Event Recording Complete	Yes
Multiple Events Associated With This Record	Yes
One Or More Associated Events Not Recorded	Yes



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	51	1472	17	OFF
-4	51	Invalid	17	OFF
-3	52	1472	17	OFF
-2	52	1344	0	OFF
-1	50	0	0	OFF



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	0.00	-0.62	-0.62	-0.93	-1.55	-2.48	-3.41	-3.72	-4.34	-4.65	-5.27	-5.89	-6.20	-6.20	-6.20

Hexadecimal Data

This page displays all the data retrieved from the air bag module.
It contains data that is not converted by this program.

```
$01  F0 3C E3 42 B1 3C
$02  F1 F1 3C 3C A8 00
$03  41 53 34 32 32 34
$04  4B 47 5A 33 38 32
$05  30 4E 52 38 36 31
$06  21 99 26 22 00 00
$07  32 04 31 56 00 00
$08  41 44 35 22 58 42
$09  18 4A 35 4A 42 47
$0A  41 44 35 22 58 42
$0B  18 4A 35 4A 41 56
$0C  41 55 35 21 58 42
$0D  18 41 30 52 57 30
$0E  41 55 35 21 58 42
$0F  18 41 30 54 37 58
$10  FF E3 E0 00 00 00
$11  83 83 84 7B 7B 7B
$12  A0 01 00 39 3C 00
$13  FF 02 00 00 00 00
$14  1D 1D 05 05 64 40
$15  FA FA FA FA FA FA
$16  FA FA FA FA FA FA
$17  FA FA 00 00 00 00
$18  00 3F 55 EC F5 00
$19  09 00 0A 00 00 64
$1A  00 00 00 00 00 00
$1B  00 00 00 00 00 00
$1C  00 0C 00 00 00 00
$1D  00 00 00 00 00 00
$1F  FE 00 00 00 00 00
$20  5E FB 00 00 FF FF
$21  FF F7 FF FF FF FF
$22  FF FF FF FF FF FF
$23  FF FF FF FF FF F7
$24  23 01 CE 00 7F 24
$25  20 00 00 23 FF FF
$26  00 02 02 03 05 08
$27  0B 0C 0E 0F 11 13
$28  14 14 14 00 FF E4
$29  C0 A5 FF FF FF FF
$2A  FF FF FF FF FF FF
$2B  FF FF FF FF FF FF
$2C  FF FF FF FF FF FF
$2D  FF FF 00 00 00 00
$30  B2 FE 00 00 FF FF
$31  FF FF FF FF FF FF
$32  FF FF FF FF FF FF
$33  FF FF FF FF FF FF
$34  23 00 30 07 03 03
$35  00 00 00 00 00 00
$36  35 0D 06 03 00 00
$37  00 00 00 02 1F 29
$38  1D 03 2B 1E 00 00
$39  05 00 00 23 FF FF
$3A  03 0E 15 14 1C 1D
$3B  1D 1F 1A 1C 00 00
$3C  00 00 00 0A FF E4
$3D  C0 A5 00 00 00 00
$40  53 53 52 52 52 00
$41  00 00 00 2C 2C 2C
$42  2C 00 17 17 17 17
$43  17 00 1B F0 00 00
```

```
$44  53 53 52 52 52 00
$45  00 00 00 2C 2C 2C
$46  2C 00 17 17 17 17
$47  17 00 80 FE 00 00
$48  50 53 53 52 52 00
$49  00 00 00 00 2C 2C
$4A  2C 00 15 17 17 17
$4B  17 00 80 FE 00 00
$4C  FF FF FF FF FF FF
$4D  FF FF FF FF FF FF
$4E  FF FF FF FF FF FF
$4F  FF FF FF FF 00 00
$50  FF FF FF FF FF FF
$51  FF FF FF FF FF FF
$52  FF FF FF FF FF FF
$53  FF FF FF FF FF FF
$54  FF FF FF FF FF FF
```