Office of Defect Investigations Potential Fail-to-Deploy Investigation / Vehicle to Object
Dynamic Science, Inc. / Case Number: DS02011
2001 GMC Yukon XL 2WD Four Door Sport Utility Vehicle
California
June, 2002

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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.

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16. Abstract

This case was selected as an Office of Defect Investigations Potential Fail-to-Deploy investigation. The crash occurred in northern California in June, 2002 at 0017 hours on an eastbound interstate.

The case vehicle was a 2001 GMC Yukon XL 4-door 4x2 driven by a restrained 40-year-old male. The other vehicle involved in the crash was a 2002 Acura 3.2 TL driven by a 22-year-old female. There were two additional occupants in the other vehicle. A 24-year-old male seated in the front right seat position and a 22-year-old seated in the rear right seat position.

The case vehicle was traveling northbound in the third lane from the left on the interstate at an estimated 97-105 km/h (60-65 mph). The driver of the case vehicle stated to the police that a vehicle in the lane to his right and just ahead of his location swerved into the lane the case vehicle was traveling on. The driver of the case vehicle steered to the right in an effort to avoid a collision. The driver of the case vehicle lost control of the vehicle, swerved to the right leaving the roadway on the south roadway edge. The front of the case vehicle struck and slightly overrode a wood/metal guardrail with its front end (11FDEW1).The maximum SDM recorded velocity change was -6.53 km/h (-4.06 mph). Neither the driver's nor the front right air bags in the case vehicle deployed on impact. After striking the metal/wood guardrail the driver of the case vehicle steered back to the left. The case vehicle entered back into eastbound traffic lanes, crossed three of the eastbound traffic lanes and was struck on the left side (08LPEW1) by the front right of the other vehicle.

The case vehicle came to final rest facing northeast straddling the third and fourth lanes from the left. The driver of the case vehicle was able to exit the vehicle under his own power. The police administered a alcohol breath test to the driver of the case vehicle, with a result of .08 %. He was subsequently arrested for driving under the influence (DUI). At the scene he not did report any injuries, but two days later sought treatment from a private physician for a sore back. He subsequently received treatment for unknown injuries for an unknown length of time.

Both vehicles were towed from the scene due to damage. The case vehicle sustained moderate, was towed from the scene due to damage from the scene and subsequently declared a total loss by the insurance company.

This crash involved a relatively long duration impact with a guardrail (impact 1). This enabled the algorithm and generated a non-deployment event. It appears that the system worked properly and the non-deployment decision was correct.

17. Key Words	18. Distribution Statement
Air bag, non-deployment, injury, Vetronix, Sensing Diagnostic Module (SDM)	

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Dynamic Science, Inc.
Crash Investigation
Case Number: DS02-011

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BACKGROUND:

Description:	This case was selected as an Office of Defect Investigations Potential Fail-to-Deploy investigation. The collision was reported to the National Highway Traffic Safety Administration by driver of the case vehicle. DSI was assigned the case on June 19, 2002. The case was conducted as an on-scene investigation. The case vehicle is equipped with a Sensing and Diagnostic Module (SDM) and the data contained within the module was downloaded via the J1962 connector found to the left of the steering wheel column. All field work was completed on June 26, 2002.
Investigation Type:	Office of Defect Investigations Potential Fail-to-Deploy
Crash Location:	California
Crash Date:	June, 2002
Notification Date:	June 19, 2002
Field Work Completed:	June 26, 2002

SUMMARY

Crash Site

The crash occurred in northern California in June, 2002 at 0017 hours on an eastbound interstate. The roadway consists of four asphalt traffic lanes; a high occupancy vehicle lane and three traffic lanes. The asphalt surface was dry, level and free of defects. It was dark but the roadway was lit by overhead street lamps. The speed limit is 105 km/h (65 mph).

Figure 1. Area of impact 1 (eastbound)

Pre-Crash

The case vehicle was a 2001 GMC Yukon XL 4-door 4x2 driven by a restrained 40-year-old male (185 cm-73 in/104 kg-230 lbs). The other vehicle involved in the crash was a 2002 Acura 3.2 TL driven by a 22-year-old female. There were two additional occupants in the other vehicle. A 24-year-old male seated in the front right seat position and a 22-year-old seated in the rear right seat position.

The case vehicle was traveling northbound in the third lane from the left on the interstate at an estimated 97-105 km/h (60-65 mph). The driver of the case vehicle stated to the police that a vehicle in the lane to his right and just ahead of his location swerved into his travel lane. The driver of the case vehicle steered to the right in an effort to avoid a collision.

Crash

Figure 2. Impact 1, frontal damage vs guardrail.

The driver of the case vehicle lost control of the vehicle, swerved to the right leaving the roadway on the south roadway edge. The front of the case vehicle struck and slightly overrode a wood/metal guardrail with its front end (11FDEW1). The total velocity change calculated by the Barrier algorithm of the WINSMASH[1] collision model was 18.0 km/h (11.2 mph). The longitudinal and lateral delta V components were -16.9 km/h (-10.5 mph) and 6.2 km/h (3.8 mph) respectively for the case vehicle. This is a borderline reconstruction given that the collision with the metal guardrail is a yielding object type collision that is beyond the scope of WINSMASH. The Sensing Diagnostic Module (SDM)[2] recorded a near deployment event. The maximum SDM recorded velocity change was -6.53 km/h (-4.06 mph); algorithm enable (AE) to maximum SDM recorded velocity change was 77.5 msec. Neither the driver's nor the front right air bags in the case vehicle deployed on impact. This non-deployment event was a relatively long duration impact with a guardrail. This enabled the algorithm and generated a non-deployment event. It appears that the system worked properly and the non-deployment decision was correct.

After striking the metal/wood guardrail the driver of the case vehicle steered back to the left. The case vehicle entered back into eastbound traffic lanes, crossed three of the eastbound traffic lanes and was struck on the left side (08LPEW1) by the front right of the other vehicle. The total velocity change calculated by the Missing Vehicle algorithm of the WINSMASH[3] collision model was 6.0 km/h (3.7 mph). The longitudinal and lateral delta V components were 3.0 km/h (1.9 mph) and 5.2 km/h (3.2 mph) respectively for the case vehicle. The driver's seat mounted side air bag did not deploy.

Post-Crash

The case vehicle came to final rest facing northeast straddling the third and fourth lanes from the left.

The driver of the case vehicle was able to exit the vehicle under his own power. The police administered a alcohol breath test to the driver of the case vehicle, with a result of .08 %. He was

[1] Calculated using WINSMASH version 2.41, barrier option using size and stiffness coefficients derived from NCAP test 3553. WINSMASH run violates beyond scope criteria but is provided here for informational purposes.

[2] See Attachment 2

[3] Calculated using WINSMASH version 2.41, Missing Vehicle option using default size and stiffness coefficients in NASS Coding manual.

subsequently arrested for driving under the influence (DUI). At the scene he did not report any injuries, but two days later sought treatment from a private physician for a sore back. He subsequently received treatment for unknown injuries for an unknown length of time.

The occupants of the other vehicle exited their vehicle under their own power. None of the occupants reported injuries to the police at the scene of the crash.

Both vehicles were towed from the scene due to damage. The case vehicle sustained moderate damage to the front bumper, hood, grille area, front right and left fenders, left side doors, cracked windshield, and possible steering/axle damage. The case vehicle was towed from the scene and subsequently declared a total loss by the insurance company.

VEHICLE DATA - 2001 GMC Yukon XL 2WD

The case vehicle is a 2001 GMC Yukon XL 4-door 4x2 sport utility vehicle. The vehicle was equipped with a 5.3 liter, V-8 engine, power steering and an automatic transmission.

VIN:	3GKEC16T81GXXXXXX
Odometer:	42,382 kilometers (26,336 miles)
Engine:	5.3L, V8
Reported Defects:	None reported
Cargo:	None

The 2001 GMC Yukon XL 2WD was equipped with Firestone Wilderness LE P265/70R16 tires. The specific tire data is as follows:

Tire	Tread	Pressure	Recommended pressure
LF	5 mm (6/32 in)	Unknown	303 kPa (44 psi)
LR	5 mm (6/32 in)	Unknown	303 kPa (44 psi)
RF	5 mm (6/32 in)	Unknown	303 kPa (44 psi)
RR	5 mm (6/32 in)	Unknown	303 kPa (44 psi)

The front seating positions in the case vehicle was configured with fabric covered 40/20/40 split bench seat with seat integrated lap and shoulder safety seat belts and integral head restraints for both outboard seat positions. The middle seat position was equipped with a lap only safety seat belt. The front left and front right seats were adjusted between middle and rear most track positions. The case vehicle was equipped with a second row split bench (folding backs), and a bench (folding backs) for the third row seating positions.

VEHICLE DAMAGE

Exterior Damage - 2001 GMC Yukon XL 2WD

Damage Description (Impact 1 - Guardrail):	Moderate to severe damage to front bumper, hood, grille area, both front fenders, cracked windshield and possible front axle damage.	
CDC: Impact 1 - Guardrail(Highest delta v):	11FDEW1	
Delta V (Impact 1):	Total	Estimated to be >= 10.0 km/h (6.2 mph) but < 25.0 km/h (15.5 mph)
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

The case vehicle sustained moderate to severe damage to the front bumper as a result of striking the metal/wood guardrail (Impact 1). Direct and induced damage began at the front right bumper corner and extended laterally to the front left bumper corner. The damage was assigned a Collision Deformation Classification (CDC) of 11FDEW1, and a Principle Direction of Force (PDOF) of 340 degrees. The combined direct and induced damage width was 173.3 cm (68.2 in) [SMASH L = 176 cm (69.3 in)]. Six crush measurements were documented at the level of the bumper: C1= 12.0 cm (4.7 in), C2= 17.0 cm (6.7 in), C3= 18.0 cm (7.1 in), C4= 14.0 cm (5.5 in), C5= 7.0 cm (2.8 in), C6= 12.0 (4.7 in). The maximum crush depth was 18.0 cm (7.1 in.) and was located at C3.

Figure 3. Impact 1, with crush stands.

Exterior Damage - 2001 GMC Yukon XL 2WD (Cont...)

Damage Description (Impact 2 - 2002 Acura 3.2 TL):	Moderate damage to the left side.	
CDC: Impact 2 - 2002 Acura 3.2 TL	08LPEW1	
Delta V[4] (Impact 2):	Total	6.0 km/h (3.7 mph)
	Longitudinal	3.0 km/h (1.9 mph)
	Latitudinal	5.2 km/h (3.2 mph)
	Energy	5,958 Joules 4,394 ft/lbs

The case vehicle sustained moderate damage to the left side as a result of the front of the Acura striking the left side of the case vehicle (Impact 2). Direct and induced damage began 98 cm (38.5 in) forward of the rear left axle, and extended forward. The damage was assigned a CDC of 08LPEW1, and a PDOF of 240 degrees. The combined direct and induced damage width was 138.0 cm (54.3 in) [SMASH L = 138.0 cm (54.3 in)]. Six crush measurements were documented at the sill and above levels: C1= 0.0 cm (0.0 in), C2= 4.0 cm (1.6 in), C3= 13.0 cm (5.1 in), C4= 6.0 cm (2.4 in), C5= 9.0 cm (3.5 in), C6= 0.0 (0.0 in). The maximum crush depth was 13.0 cm (5.1 in.) and was located at C3.

Figure 4. Impact 2, left side damage vs other vehicle.

[4] Delta Vs were calculated using WINSMASH version 2.41, Missing Vehicle option using default size and stiffness coefficients in the NASS Coding manual. The results are borderline.

Interior Damage - 2001 GMC Yukon XL 2WD

There was no interior damage related to the exterior forces of the crash. The driver's seat was adjusted to between the middle and rear most track position. The driver's adjustable head restraint was in the full down position. There was no damage to the four-spoke steering wheel. The tilt steering column was adjusted to the center position. There were no knee bolster contacts.

MANUAL RESTRAINT SYSTEMS - 2001 GMC Yukon XL 2WD

The interior of the case vehicle consisted of a nine passenger seating configuration. The front row consisted of a 40/20/40 split bench (with folding backs) that seats three. The second row consisted of a 60/40 split bench (with folding backs) that seats three. The third row consisted of a bench seat (with folding back) that seats three. The third row split bench seat could be removed from the vehicle to accommodate cargo.

The driver's 3-point manual lap and shoulder safety belt system was integrated into the seat back and consisted of a continuous loop belt webbing with a sliding latchplate and a dual mode retractor (inertial lock/belt sensitive). The middle seat's (fold away jump seat) manual lap safety belt system consisted of a locking latchplate and no retractor. The front right 3-point manual lap and shoulder safety belt system was also integrated into the seat back and consisted of a continuous loop belt webbing with a sliding latchplate and a retractor equipped with an inertial and switchable lock mechanism. The driver's lap and shoulder belt was completely spooled out and the retractor was locked indicating that the lap and shoulder safety belt was in use at the time of the crash. The data downloaded from the SDM also indicated that the driver's seat belt was "BUCKLED". The middle lap belt had no evidence of historical usage and was found buckled. The front right latchplate was scratched indicating historical usage. No pretensioners were identified.

Figure 5. Driver's safety seat belt.

The second row outboard seating positions were equipped with 3-point manual lap and shoulder safety seat belt systems which consisted of a continuous loop belt webbing with a sliding latchplate that retracted into an inertial sensitive and switchable retractor. The second row center seat position was equipped with a 2-point manual lap safety belt with a locking latchplate. All three safety seat belts exhibited scratching of the latchplates indicative of historical usage.

The third row outboard positions were equipped with 3-point manual lap and shoulder safety seat belt systems integrated into the seat backs and consisted of continuous loop belt webbing with a sliding latchplate that retracted into an inertial sensitive and switchable retractor. The third row center seat position was equipped with a 2-point manual lap safety belt with a locking latchplate. All three safety seat belts were absent of any evidence of historical usage.

FRONTAL AIR BAG SYSTEM - 2001 GMC Yukon XL 2WD

The case vehicle was equipped with redesigned frontal air bags for the driver and front right passenger positions that did not deploy as a result of the crash. The driver air bag was housed in the center of the steering wheel hub. The front right passenger air bag was housed in the mid-instrument panel area. The SDM was located on the floor under the driver' seat.

Figure 6. Non-deployed frontal air bags.

The case vehicle was also equipped with side air bags for the outboard seat positions which did not deploy. The air bag modules were housed in the outboard side aspect of the front seat backs.

The air bag system is controlled by the SDM. The primary function of the SDM is to control the deployment of the occupant protection systems. The system records the vehicle's forward velocity change. For non-deployments and deployment level events, the SDM will record the first 150 milliseconds of data after algorithm enable (AE).

Figure 7. Non-deployed driver's side air bag.

A single event was recorded by the SDM in this crash, a Non-Deployment event at 2405 ignition cycles. The data in the SDM was downloaded using the Vetronix Crash Data Retrieval System via the J1962 connector found to the left of the steering column. The Vetronix system status at Non-Deployment report indicates that:

1. SIR warning lamp status was OFF.
2. The driver's belt switch status was BUCKLED.
3. Passenger front air bag suppression switch circuit status: Air bag not suppressed.
4. Ignition cycles at non-deployment 2405.
5. Ignition cycles at investigation 2419.
6. Maximum SDM recorded velocity change -6.53 km/h (-4.06 mph).
7. Algorithm enable (AE) to maximum SDM recorded velocity change was 77.5 milliseconds.
8. The Vehicle Speed was 124 km/h (77 mph) 5 through 4 seconds before AE, decelerated to 89 km/h (55 mph) 3 through 2 seconds before AE, and to 58 km/h (36 mph) 1 second before AE.
9. The Engine Speed (RPM) was 2432 rpm 5 through 4 seconds before AE, 1856 rpm at 3 seconds before AE, 1728 rpm at 2 seconds before AE, and 1088 rpm at 1 second before AE.

10. The Percent Throttle was 0 at 5 through 1 seconds before AE.
11. The Brake Switch Circuit Status was ON from 5 through 4 seconds before AE, and OFF 3 through 2 seconds before AE, and ON at 1 second before AE.

This crash involved a relatively long duration impact with a guardrail (impact 1). This enabled the algorithm and generated a non-deployment event. It appears that the system worked properly and the non-deployment decisions was correct.

VEHICLE DATA - Other Vehicle 2002 Acura 3.2 TL

Description:	2002 Acura 3.2 TL	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	None	
Cargo:	Unknown	
Damage Description:	Moderate damage to the right front end, per PAR. No prior damage or mechanical defects were noted or claimed.	
CDC:	Unknown (Missing Vehicle Algorithm)	
Delta V:	Total	8.0 km/h (5.0 mph)
	Longitudinal	-7.9 km/h (-4.9 mph)
	Latitudinal	-1.4 km/h (-0.9 mph)
	Energy	2,197 Joules 1,620 ft/lbs

The Acura was not inspected. Delta Vs was calculated using WINSMASH version 2.41, Missing Vehicle option using default size and stiffness coefficients in the NASS Coding manual. The results are borderline.

OCCUPANT DEMOGRAPHICS - 2001 GMC Yukon XL 2WD

	Occupant 1
Age/Sex:	40/Male
Seated Position:	Front left
Seat Type:	Fabric covered split bench seat with seat integrated lap and shoulder safety seat belt. Seat track adjusted to between middle and rear most track position. Seat back reclined 35 degrees from vertical.
Height:	185 cm (73 in)
Weight:	104 kg (230 lb)
Occupation:	Unknown
Pre-existing Medical Condition:	None reported
Alcohol/Drug Involvement:	Alcohol breath test indicated .08%. Subsequently arrested for DUI
Driving Experience:	Presumed greater than 20 years
Body Posture:	Normal, upright.
Hand Position:	Both hands on steering wheel
Foot Position:	Right foot on acceleration pedal and left on floorboard
Restraint Usage:	Integrated lap and shoulder belts used
Air bag:	Available steering wheel mounted front air bag and seat back mounted side air bag available, but did NOT deploy

OCCUPANT DEMOGRAPHICS - Other Vehicle 2002 Acura 3.2 TL

Age/Sex:	22/Female	24/Male
Seated Position:	Front left	Front right
Seat Type:	Unknown	Unknown
Height:	165 cm (65 in)	Unknown
Weight:	51 cm (112 lb)	Unknown
Occupation:	Unknown	Unknown
Pre-existing Medical Condition:	None reported	None reported
Alcohol/Drug Involvement:	None reported	N/A
Driving Experience:	Unknown	Unknown
Body Posture:	Assumed normal, upright	Unknown
Hand Position:	Assumed both on steering wheel	Unknown
Foot Position:	Assumed right on accelerator pedal, left on floor	Unknown
Restraint Usage:	Lap and shoulder, used per police report	Lap and shoulder, used per police report

OCCUPANT DEMOGRAPHICS - Other Vehicle (Cont...)

Age/Sex:	22/Male
Seated Position:	Rear right
Seat Type:	Unknown
Height:	Unknown
Weight:	Unknown
Occupation:	Unknown
Pre-existing Medical Condition:	None reported
Alcohol/Drug Involvement:	N/A
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder, used per police report

OCCUPANT INJURIES -2001 GMC Yukon XL 2WD

	Injury	OIC Code	Injury Mechanism	Confidence Level
Driver:	Reported un-injured on police report. Complained of sore back and sought medical treatment from private physician two days later. Received treatment for unknown length of time. No codeable injuries.			

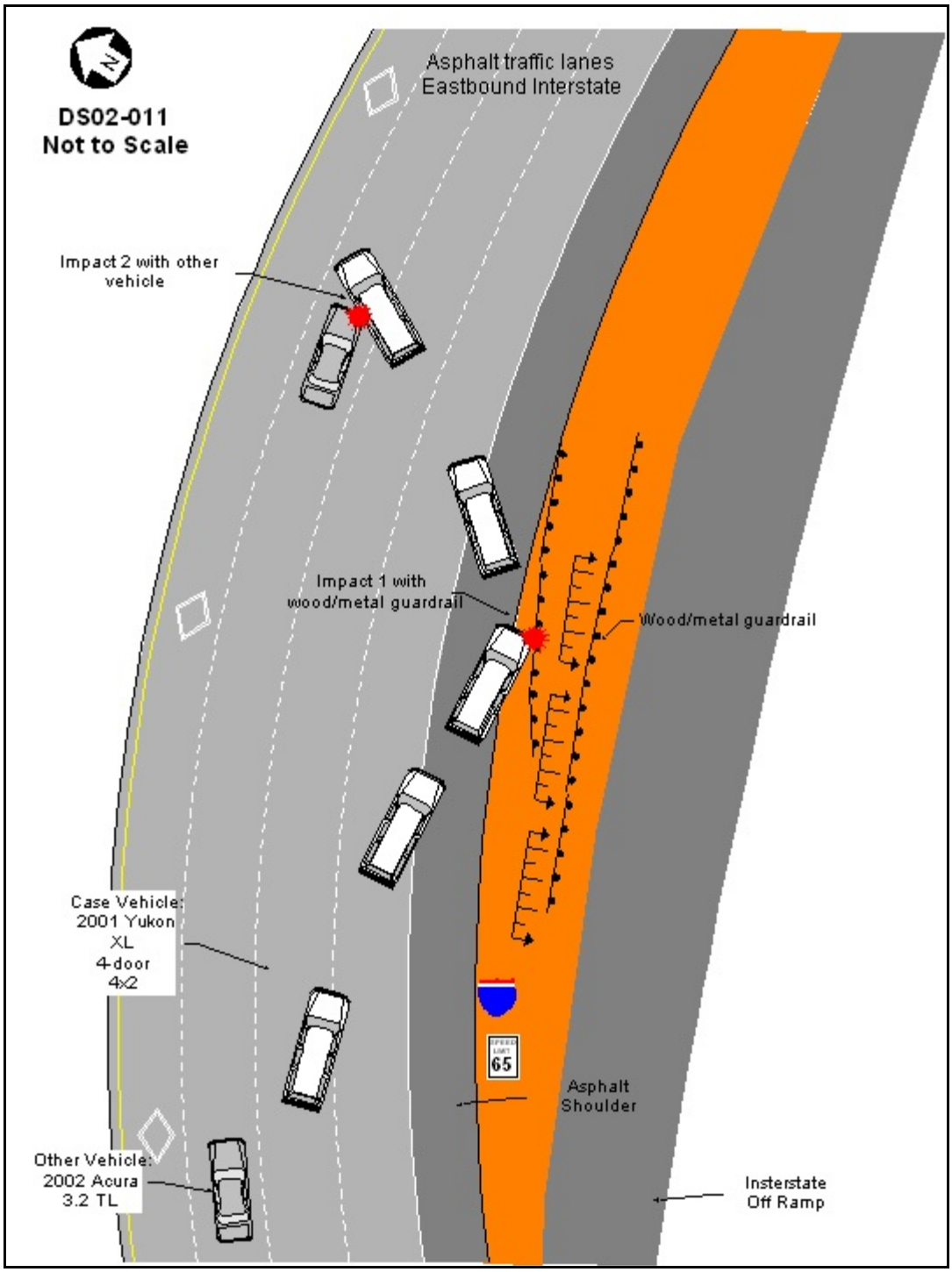
OCCUPANT INJURIES - Other Vehicle 2002 Acura 3.2 TL

	Injury	OIC Code	Injury Mechanism	Confidence Level
Driver:	Reported un-injured on police report			
FR Occupant:	Reported un-injured on police report			
RR Occupant:	Reported un-injured on police report			

OCCUPANT KINEMATICS - 2001 GMC Yukon XL 2WD

The driver of the case vehicle was seated in a normal, upright position with both of his hands on the steering wheel. His right foot was pressing the brake pedal. He was wearing the available seat integrated manual three point lap and shoulder belt. The seat track of the fabric covered split bench seat was adjusted to between the middle and rear most position. The seat back was slightly reclined to 35 degrees from vertical. At impact, the driver responded to the 340 degree direction of force by moving forward and slightly to the left. The manual three point lap and shoulder belt restricted his forward motion. On impact with the other vehicle, the driver responded by moving laterally to the left. The driver of the case vehicle was able to exit the vehicle under his own power. The police administered a breath alcohol test to the driver with a results of .08 %. He was subsequently arrested for driving under the influence. At the scene he did not report any injuries, but two days later sought treatment from a private physician for a sore back. He subsequently received treatment for unknown injuries for an unknown length of time.

ATTACHMENT 1 - SCENE DIAGRAM



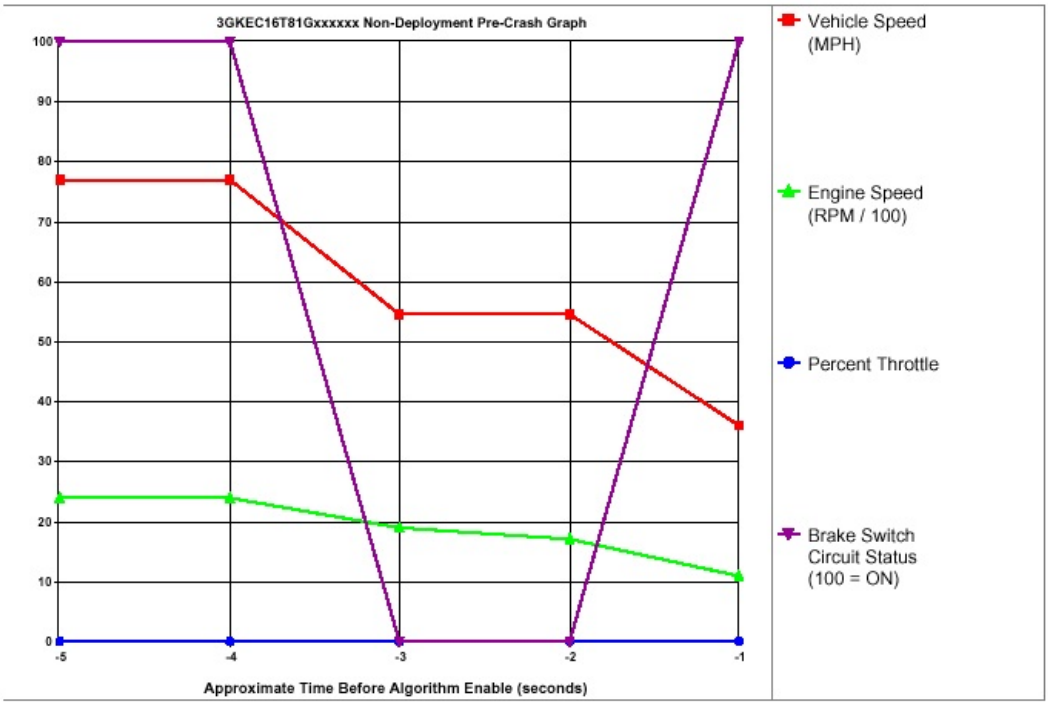
ATTACHMENT 2 - Vetronix Output Report

Vetronix

CDR CRASH DATA RETRIEVAL SYSTEM

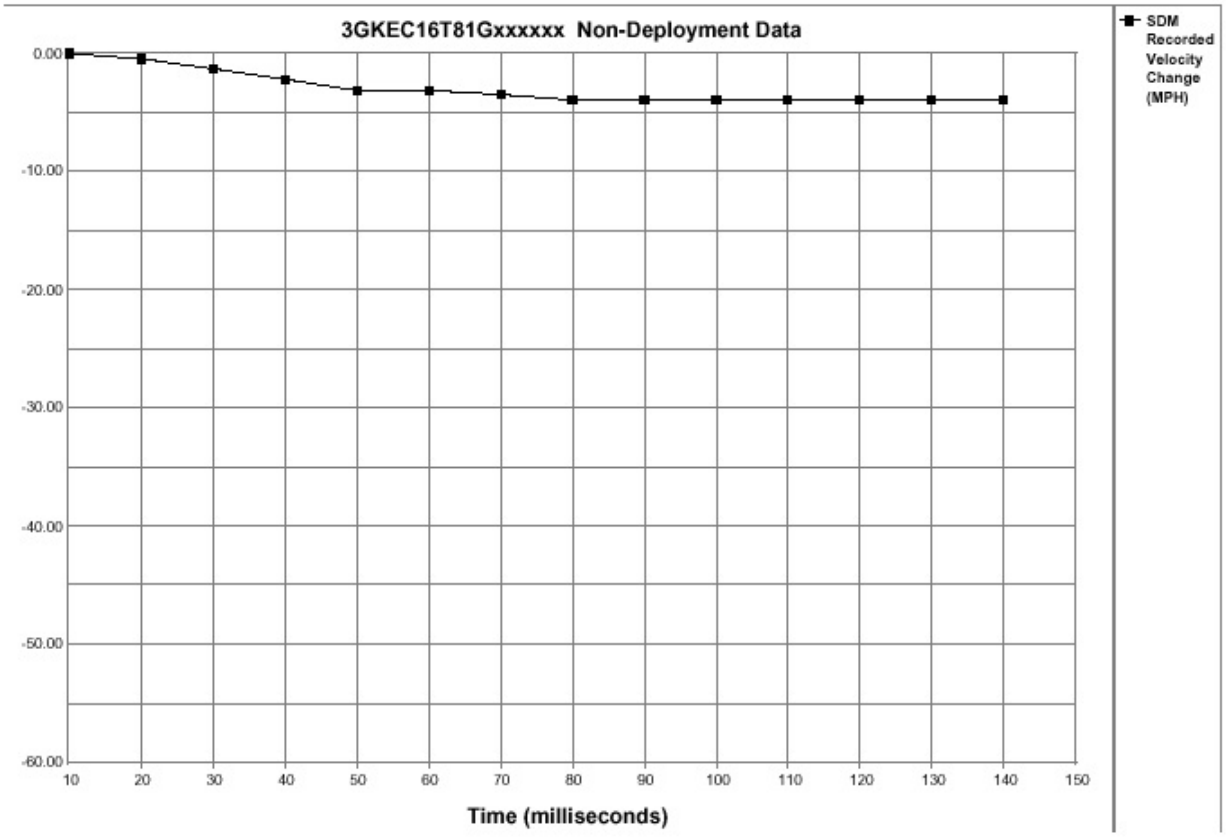
System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Non-Deployment	2405
Ignition Cycles At Investigation	2419
Maximum SDM Recorded Velocity Change (MPH)	-4.06
Algorithm Enable to Maximum SDM Recorded Velocity Change (msec)	77.5



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	77	2432	0	ON
-4	77	2432	0	ON
-3	55	1856	0	OFF
-2	55	1728	0	OFF
-1	36	1088	0	ON

ATTACHMENT 2 - Vetronix Output Report (Cont...)



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
SDM Recorded Velocity Change	0.00	-0.44	-1.32	-2.19	-3.07	-3.07	-3.51	-3.95	-3.95	-3.95	-3.95	-3.95	-3.95	-3.95	N/A