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

ON-SITE ADVANCED OCCUPANT PROTECTION SYSTEM INVESTIGATION

CASE NUMBER - IN-03-004
LOCATION - TEXAS
VEHICLE - 2003 NISSAN ALTIMA S
CRASH DATE - December 2002

Submitted:

December 20, 2006

Contract Number: DTNH22-01-C-07002

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

DISCLAIMERS

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 be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

1. *Report No.* IN-03-004	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* On-Site Advanced Occupant Protection System Investigation Vehicle - 2003 Nissan Altima S Location - Texas		5. *Report Date:* December 20, 2006 6. *Performing Organization Code*	
7. *Author(s)* Special Crash Investigations Team #2		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Research Center Indiana University 222 West Second Street Bloomington, Indiana 47403-1501		10. *Work Unit No. (TRAIS)* 11. *Contract or Grant No.* DTNH22-01-C-07002	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation (NPO-122) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. *Type of Report and Period Covered* Technical Report Crash Date: December 2002 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site advanced air bag deployment investigation involving a 2003 Nissan Altima S, four-door sedan, with manual safety belts and dual front air bags, a 1996 Ford Explorer XL, and a 1991 GMC pickup			

16. *Abstract*

This report covers an on-site investigation of an air bag deployment crash that involved a 2003 Nissan Altima S (case vehicle), a 1996 Ford Explorer XL (1st other vehicle), and a 1991 GMC C1500 Sierra pick-up truck (2nd other vehicle). This crash is of special interest because the case vehicle was equipped with multiple **A**dvance **O**ccupant **P**rotection **S**ystem (AOPS) features, including dual stage front air bags with seat belt sensors and front seat belt pretensioners with load limiters, and the case vehicle's driver (26-year-old female) sustained moderate injuries in the crash. The trafficway on which all three vehicles were traveling was a nine-lane, divided, county trafficway, traversing in a north-south direction, and the case vehicle was approaching a four-leg intersection. Both the north and south roadways had four through lanes and one left-hand turn lane. The north-south trafficway was curved. The case vehicle was traveling north in the outside through lane. The Ford was traveling in a south-southeasterly direction, moving west-to-east across the southbound roadway. The Ford's driver may have been unconscious due to a diabetic condition. The GMC had been traveling southward and was entering the left-hand turn lane. The crash originated in the left-hand turn lane of the southbound roadway. The crash began (1st event) when the front of the Ford impacted the back of the GMC. This contractor believes that the Ford's impact with the GMC pickup (1st event) involved sustained contact, and the Ford pushed the GMC diagonally across the median and roadways and into the northbound roadway's outside through lane. It is this contractor's opinion that the front of the GMC pickup (2nd event) impacted the case vehicle's front and left sides and that the GMC was in sustained contact with and being pushed south-southeasterly by the Ford. The GMC was redirected along the case vehicle's left fender, eventually separating from the case vehicle as it continued southward. Next, the front left of the case vehicle was impacted (3rd event) by the front of the Ford. The case vehicle's driver and front right supplemental restraints (air bags) deployed, most likely as a result of the impact with the GMC. The case vehicle's driver was most likely was seated with her seat track located in its middle position. The case vehicle was equipped with both a tilt and a telescoping steering column, but their pre-crash positions could not be determined because the steering wheel was jammed against the left instrument panel. She was restrained by her available, active, three-point, lap-and-shoulder, safety belt system and sustained, according to her medical records, moderate injuries that included: a fracture of her left C_6 transverse process, a moderate nonanatomic brain injury, contusion of her posterior left scalp, safety belt contusions and abrasions, and abrasions to her left lateral forearm and knees.

17. *Key Words* Advanced Air Bag Deployment Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
19 *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 21	22. *Price* $8,000

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS IN-03-004

Page No.

SELECTED PHOTOGRAPHS (Continued)

Page No.

SELECTED PHOTOGRAPHS (Continued)

BACKGROUND

IN-03-004

This on-site investigation was brought to NHTSA's attention on January 23, 2003 by NASS CDS sampling activities. This crash involved a 2003 Nissan Altima S (case vehicle), a 1996 Ford Explorer XL (1st other vehicle), and a 1991 GMC C1500 Sierra pick-up truck (2nd other vehicle). The crash occurred in December 2002, at 12:46 p.m., in Texas and was investigated by the applicable city police department. This crash is of special interest because the case vehicle was equipped with multiple **A**dvance **O**ccupant **P**rotection **S**ystem (AOPS) features, including dual stage front air bags with seat belt sensors and front seat belt pretensioners with load limiters, and the case vehicle's driver [26-year-old, White (Hispanic) female] sustained moderate injuries as a result of the crash. It is unknown whether her injuries were a result of contact with her deploying driver air bag. This contractor inspected the scene and case vehicle on January 30, 2003. This contractor was unable to interview the driver for the case vehicle. This summary is based on the Police Crash Report, scene and case vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

SUMMARY

Crash Environment: The trafficway on which all three vehicles were traveling was a nine-lane, divided, county trafficway, traversing in a north-south direction, and the case vehicle was approaching a four-leg intersection–the eastern leg of the intersection was a commercial driveway. Both the north and south roadways had four through lanes and one left-hand turn lane. The northbound roadway began to curve gently to the left on the south side of the intersection. The northern leg of the southbound roadway was curved gently to the right. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry. Traffic density was not determined, and the site of the crash was urban commercial. In addition, the intersecting roadways did not play a role in this crash; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle was traveling north in the outside through lane of the northbound roadway and intended to continue straight ahead. The Ford was traveling in a south-southeasterly direction, moving west-to-east across the southbound roadway (i.e., an unknown number of lanes were crossed). According to the Police Crash Report, the Ford's driver may have been unconscious due to a diabetic condition. The GMC had been traveling southward in the southbound roadway and was entering the southbound roadway's left-hand turn lane. Based on the Police Crash Report, the Ford's driver made no avoidance maneuvers prior to the crash. The crash originated in the left-hand turn lane of the southbound roadway, just north of a four-leg intersection.

Crash: The crash began (1st event) when the front of the Ford impacted the back of the GMC. According to the police schematic, the Ford continued south-southeastward through the median that separated the north-south roadways, diagonally across the junction of the intersecting trafficway, and into the outside through lane of the northbound roadway. The GMC also continued across the median of the trafficway, through the intersection, and across all northbound lanes, but its trajectory was slightly to the right of the Ford's. According to the police schematic, the Ford passed the GMC pickup as it traveled south-southeastward and the GMC did not impact

the case vehicle; see **POLICE SCHEMATIC** near end. Based on the Police Crash Report and the converging trajectories of the Ford and the case vehicle, it is unlikely that the case vehicle's driver made any avoidance maneuvers prior to becoming involved in the crash. According to the police schematic, the front left of the case vehicle was impacted by the front of the Ford, causing the case vehicle's driver and front right supplemental restraints (air bags) to deploy. It is unknown whether more than one stage of the case vehicle's multi-stage air bags were activated.

Based on the police photographs and this contractor's inspection of the case vehicle, this contractor believes that the extensive damage sustained by the case vehicle could not have been caused solely by an impact from the Ford. As a result, this contractor believes that the Ford's impact with the back of GMC pickup (1st event) involved sustained contact, and the Ford pushed the GMC diagonally across the median and roadways and into the northbound roadway's outside through lane. It is this contractor's opinion that the front of the GMC pickup (2nd event) impacted the case vehicle's front and left sides and that the GMC was in sustained contact with and being pushed south-southeasterly by the Ford. It is unclear whether the Ford and GMC had exactly the same heading angle or whether the GMC's heading angle was slightly clockwise relative to the Ford's. In this contractor's opinion, the GMC was redirected along the case vehicle's left fender, eventually separating from the case vehicle as it continued southward. Next, the front left of the case vehicle was impacted (3rd event) by the front of the Ford. The case vehicle's driver and front right supplemental restraints (air bags) deployed, most likely as a result of the impact with the GMC.

Post-Crash: Based on the on-scene police photographs, the case vehicle was redirected to its right and came to rest against the curb near its initial point of impact. As a result of impacting the case vehicle, the Ford rotated approximately 140 degrees counterclockwise. Subsequently, the Ford's right quarter panel side slapped (4th event) the case vehicle's left quarter panel. The two vehicles separated, and the Ford came to rest heading north, straddling the right center and outside through lanes of the northbound roadway.

The GMC pickup continued in a south-southeasterly direction after impacting the case vehicle. The GMC traveled a considerable distance (not measured) from its impact with the case vehicle to its final rest position, approximately a city block away. In this contractor's opinion, the GMC's driver must have accelerated for unknown reasons, either intentionally or unintentionally, because the GMC departed the right (eastern) side of the northbound roadway and obliquely traversed the grassy roadside, most likely traveling along a sidewalk bordering the roadway before finally re-entering the northbound roadway where it came to rest heading southwest in the junction of a commercial driveway and the northbound roadway straddling the outside northbound lane.

Case Vehicle: The 2003 Nissan Altima S was a front wheel drive, four-door sedan (VIN: 1N4AL11D32C------). Four-wheel, anti-lock brakes, front seat back-mounted side impact air bags, and front and rear head curtain air bags were all options for this model and were available as part of the ABS & Air Bag Package, but the case vehicle was not so equipped.

Vehicle Exterior: Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **11-FYEW-3** (**340** degrees) for the frontal impact and **09-LBEW-1** (**270** degrees) for the

left side slap impact. The frontal CDC is based on the totality of the damage the case vehicle sustained from its impacts with the GMC pickup and the Ford SUV. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity frontal impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 33.0 km.p.h. (20.5 m.p.h.), -31.0 km.p.h. (-19.3 m.p.h.), and +11.3 km.p.h. (+7.0 m.p.h.). The case vehicle was towed due to damage.

Exterior Damage: The case vehicle's initial contact with the GMC and the Ford involved primarily the front left half. The exact location of the direct damage cannot be determined because the case vehicle's bumper fascia was not present at the time of our inspection. Direct and induced damage occurred to the entire front bumper which measured 103 centimeters (40.6 inches) in length. Maximum crush was measured as 64 centimeters (25.2 inches) at C_1. The case vehicle's side slap contact–most likely with the Ford, involved primarily the left quarter panel. Direct damage began 32 centimeters (12.6 inches) forward of the left rear axle and extended, a measured distance of 119 centimeters (46.9 inches), along the left quarter panel toward the left rear bumper corner. Residual maximum crush was measured as 14 centimeters (5.5 inches) at C_2. The wheelbase on the case vehicle's left side was shortened 27 centimeters (10.6 inches) while the right side was extended 6 centimeters (2.4 inches). The case vehicle's front bumper fascia, bumper, grille, hood, radiator, right and left headlight and turn signal assemblies, left fender, left front wheel assembly, and left "A"-pillar were directly damaged and crushed rearward. The left fender and left front door were directly damaged and crushed inward. Both the right and left fenders sustained induced damage as well as the case vehicle's windshield and left "A"-pillar. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

The recommended tire size was: P205/65R16, and the case vehicle tires were the recommended size. The case vehicle's left front tire was physically restricted, and the top of the tire was rotated inward from the crash. None of the case vehicle's other tires were damaged, deflated, or physically restricted.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	97	14	200	29	7	9	Rotated inward from crash	Yes	No
RF	165	24	200	29	7	9	None	No	No
LR	172	25	200	29	7	9	None	No	No
RR	172	25	200	29	8	10	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior revealed significant intrusion into the driver's seating area. Specifically, the left "A"-pillar was intruded approximately 30 centimeters (11.8 inches) rearward while the left and center instrument panels were intruded both rearward (longitudinally) and rightward (laterally) from the collisions with the GMC and Ford. The left

instrument panel moved approximately 6 centimeters (2.4 inches) laterally and the center instrument panel moved approximately 3 centimeters (1.2 inches) laterally. In addition, the left side panel, forward of the left "A"-pillar, was pushed inward (i.e., laterally) approximately 12 centimeters (4.7 inches). There was obvious contact evidence to the left side of the driver's knee bolster, most likely from the driver's left knee area. On the other hand, there was no evidence of occupant contact to the front right passenger area. In addition, the steering wheel was jammed forward against the intruding left instrument panel. Finally, the steering column compression could not be determined because of the severity of longitudinal and lateral intrusions.

Supplemental Restraints: The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each approximately 8 centimeters (3.1 inches) in width. The driver's air bag had two vent ports, approximately 4.5 centimeters (1.8 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag was round with a diameter of 64 centimeters (25.2 inches). An inspection of the driver's air bag fabric revealed obvious occupant contact evidence (i.e., scuffs) on the air bag's fabric.

The front right passenger's air bag was located in the top of the instrument panel. An inspection of the front right air bag module's cover flap and the air bag's fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 9 and 3 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 51 centimeters (20.1 inches) and a width of approximately 38 centimeters (15.0 inches). An inspection of the front right passenger's air bag fabric revealed two small holes on the top surface of the air bag near the beginning of the front surface. Specifically, there was a small hole located 5 centimeters (2.0 inches) from the left surface and 0.8 centimeters (0.3 inches) from the front surface. A second small hole was located 8 centimeters (3.1 inches) from the right surface and 10 centimeters (3.9 inches) from the front surface. It is believed that these holes resulted from contact by shards of flying glass. The air bag's front surface showed no obvious contact evidence on the front right air bag's fabric.

1st Other Vehicle: The 1996 Ford Explorer XL was a rear wheel drive, four-door sport utility vehicle (VIN: 1FMDU32X5TUC------). This vehicle was equipped with four-wheel, anti-lock brakes and driver and front right passenger air bags that deployed as a result of one of this vehicle's frontal impacts.

Exterior Damage: Based on the available police photographs, one CDC for the three events that the Ford was most likely involved in is estimated as: **12-FDEW-2** (**0** degrees) for the impacts with the back of the GMC and the front of the case vehicle. Damage to the Ford's front is a result of two overlapping impacts. With no clear vehicle photographs of the Ford's right side slap damage, the CDC for this impact (4th event) is most likely estimable as: **03-R{B,Y}{M,E}W-1** (**90** degrees). However, the WinSMASH reconstruction program, missing vehicle algorithm, was used

on the Ford's right side slap impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 6.0 km.p.h. (3.7 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and -6.0 km.p.h. (-3.7 m.p.h.). According to the Police Crash Report, the Ford was towed due to damage.

2nd Other Vehicle: The 1996 GMC Sierra was a rear wheel drive, two-door, regular cab, normal bed, pick up truck (VIN: 1GTDC14Z0MZ------) This vehicle was equipped with a rear only anti-lock brake system, but there were no front occupant supplemental restraints (air bags).

Exterior Damage: Based on the available police photographs, the CDCs for the two events (1st and 2nd) that the GMC was most likely involved in are estimable as: **26-BDEW-2** (**180** degrees) for its back (1st event) impact and **12-FDEW-1** (**0** degrees) for its frontal impact (2nd event) with the case vehicle. According to the Police Crash Report, the GMC was towed due to damage.

Case Vehicle's Driver: The exact posture of the case vehicle's driver [26-year-old, White (Hispanic) female; 163 centimeters and 77 kilograms (64 inches, 170 pounds)] immediately prior to the crash is unknown. The driver was most likely was seated in a reclined posture with her back against the seat back, her left foot on the floor, her right foot on the accelerator, and at least one hand on the steering wheel. Based on the vehicle inspection, her seat track was located in its rearmost position and the seat back was slightly reclined. Based on the driver's stature, it unlikely that she was sitting in the rearmost position at the time of the crash. Based on this contractor's experience, the driver's seat was most likely positioned near its middle seat track position and was moved post-crash for extrication purposes. The case vehicle was equipped with both a tilt and a telescoping steering column, but their pre-crash positions could not be determined because the steering wheel was jammed against the left instrument panel.

Based on this contractor's vehicle inspection {and supported by her medical records, the case vehicle's driver was restrained by her available, active, three-point, lap-and-shoulder, safety belt system; the belt system was equipped with a retractor-mounted pretensioner with force limiters, housed within the "B"-pillar. Furthermore, there was medical evidence of belt pattern bruising and/or abrasions to the driver's torso, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate revealed that the pretensioner had actuated. In addition, there was evidence of loading on the belt's webbing.

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the use of her available safety belts, her pre-impact body position did not change just prior to impact. The case vehicle's primary impact with the GMC and Ford enabled the case vehicle's driver to continue forward, leftward, and slightly upward along a path opposite the case vehicle's **340** degree Direction of Principal Force as the case vehicle decelerated. As a result of the impact, the driver loaded her safety belts and contacted her deploying driver air bag. Between the combination of the intrusion into the driver's seating position and the force of the driver loading the air bag and steering column, the steering wheel was jammed into the left instrument panel. The driver most likely rebounded backwards toward her seat back after her forward momentum was halted by the combination of her safety belts and the air bag/steering wheel. As a result of the secondary impact with the Ford, the driver moved to her left into the interior

surface of the driver's door. The exact posture of the driver at final rest is unknown. It is also unknown as to whether she needed assistance to exit her vehicle.

According to the Police Crash Report, the driver was transported by ambulance to the hospital. She sustained moderate injuries and was hospitalized two days post-crash. According to her medical records, the injuries sustained by the case vehicle's driver included: a fracture of her left C_6 transverse process, a moderate nonanatomic brain injury, contusion of her posterior left scalp, seat belt contusions and abrasions across her chest and lower abdomen, and abrasions to her left lateral forearm and knees.

Ford's Occupants: According to the Police Crash Report, the Ford's driver [78-year-old, White (unknown if Hispanic) female] was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. The driver was transported by ambulance to the hospital, and she sustained a police-reported "A" (incapacitating) injury as a result of this crash.

GMC's Occupants: According to the Police Crash Report, the GMC's driver [49-year-old, White (unknown if Hispanic) male] was restrained by his available, active, three-point, lap-and-shoulder, safety belt systems. The driver was examined at the scene but was not transported by ambulance to the hospital, and he did sustain a police-reported "B" (non-incapacitating-evident) injury as a result of this crash.

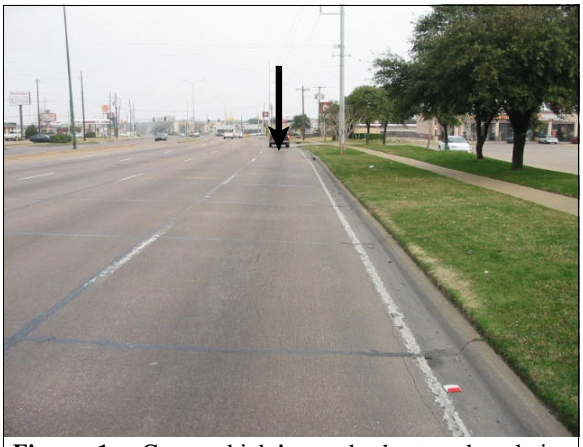


Figure 1: Case vehicle's northerly travel path in outside northbound lane of northbound roadway; Note: arrow indicates approximate point of impact and roadway begins to curve gently leftward (case photo #01)

Figure 2: Approximate location of crash's initial impact between Ford SUV and GMC pickup near beginning of southbound roadway's left-hand turn lane (case photo #05)

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which all three vehicles were traveling was a nine-lane, divided, county trafficway, traversing in a north-south direction, and the case vehicle was approaching a four-leg intersection–the eastern leg of the intersection was a commercial driveway (**Figure 1**). Both the north and south roadways had four through lanes and one left-hand turn lane. The northbound roadway began to curve gently to the left on the south side of the intersection. The northern leg of the southbound roadway was curved gently to the right (**Figure 2**).

The county trafficway began to curve slightly to the left for northbound traffic near the location where the case vehicle became involved in the crash sequence. The trafficway was level

(i.e., actual slope was 0.8%, negative to the north) in the case vehicle's direction of travel, near the area of impact. The pavement was concrete, but traveled, and the width of the outside northbound lane was 3.3 meters (10.8 feet) and the right center northbound lane was also 3.3 meters (10.8 feet). The shoulders were improved (i.e., concrete), with a small (i.e., not measured) shoulder adjacent to a curb on the east side of the northern roadway (**Figure 1** above). Both the northern and southern roadways had improved shoulders and the median consisted of an unprotected raised concrete area (**Figure 2** above) that measured approximately 1.0 meter (3.3 feet) in width on both the northern and southern legs of the four-leg intersection. The trafficway was bordered by mountable curbs. For the northbound roadway, the pavement markings consisted of a single solid yellow "no passing" line on the west side and a solid white edge line on east side. In addition, the through lanes were divided by dashed white lines and the left-hand turn lane was separated from the through lanes by solid white lane lines. The southbound roadway was likewise configured. The median was outlined by the single solid yellow "no passing" lines mentioned above. The estimated coefficient of friction was 0.65. Traffic controls consisted of a regulatory **SPEED LIMIT** sign (MUTCD, R2-1) for the northbound traffic. The four-leg intersection was not controlled. On-colors, pre-timed, vertically mounted traffic control signals were located at the next intersection to the north of the crash site (i.e., relative to the case vehicle's direction of travel). The posted speed limit was 64 km.p.h. (40 m.p.h.). At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry. Traffic density was not determined, and the site of the crash was urban commercial. In addition, the intersecting roadways did not play a role in this crash; see **CRASH DIAGRAM** at end.

Pre-Crash: The case vehicle was traveling north in the outside through lane of the northbound roadway and intended to continue straight ahead (**Figure 1** above). The Ford was traveling in a south-southeasterly direction, moving west-to-east across the southbound roadway (i.e., an unknown number of lanes were crossed). According to the Police Crash Report, the Ford's driver may have been unconscious due to a diabetic condition. The GMC had been traveling southward in the southbound roadway and was entering the southbound roadway's left-hand turn lane (**Figure 2** above). Based on the Police Crash Report, the Ford's driver made no avoidance maneuvers prior to the crash. The crash originated in the left-hand turn lane of the southbound roadway, just north of a four-leg intersection.

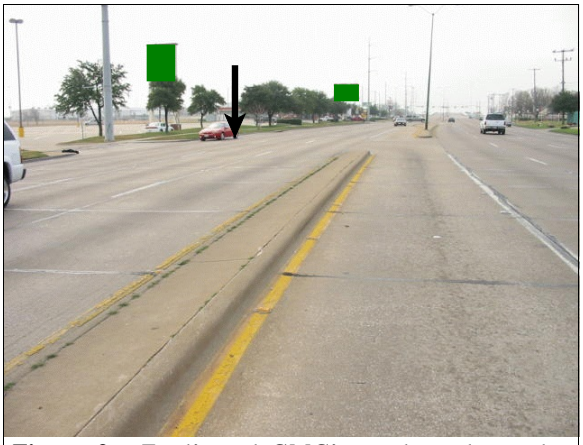


Figure 3: Ford's and GMC's south-southeasterly travel path from southbound left-hand turn lane diagonally across median, northbound lanes, and four-leg intersection into impact (arrow) in outside northbound lane (case photo #07)

Crash: The crash began (1st event) when the front of the Ford impacted the back of the GMC. According to the police schematic, the Ford continued south-southeastward through the median that separated the north-south roadways, diagonally across the junction of the intersecting trafficway, and into the outside through lane of the northbound roadway (**Figure 3**). The GMC also continued across the median of the trafficway, through the intersection, and across all northbound lanes, but its trajectory was slightly to the right of

the Ford's. According to the police schematic, the Ford passed the GMC pickup as it traveled south-southeastward and the GMC did not impact the case vehicle; see **POLICE SCHEMATIC** near end. Based on the Police Crash Report and the converging trajectories of the Ford and the case vehicle, it is unlikely that the case vehicle's driver made any avoidance maneuvers prior to becoming involved in the crash (**Figure 4**). According to the police schematic, the front left of the case vehicle was impacted by the front of the Ford (**Figures 5** and **6**), causing the case vehicle's driver and front right supplemental restraints (air bags) to deploy. It is unknown whether more than one stage of the case vehicle's multi-stage air bags were activated.

Figure 4: Approximate area of impact between case vehicle and Ford; Note: arrow indicates approximate location of initial impact between Ford and GMC (case photo #03)

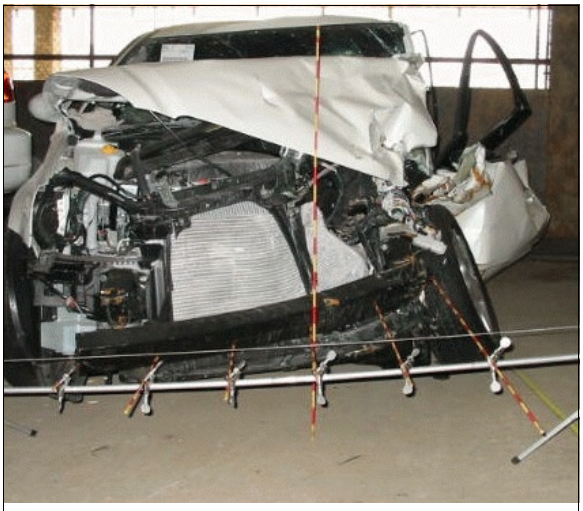


Figure 5: Case vehicle's frontal damage from impacts with GMC pickup and Ford SUV; Note: contour gauge positioned along bumper reinforcement bar (case photo #15)

Figure 6: On-scene police photo looking south in outside through lane of northbound roadway showing final rest positions of case vehicle and Ford SUV; Note: arrow indicates final rest position of GMC pickup (case photo #60)

Figure 7: On-scene police photo looking southeast at final rest positions of case vehicle–center and Ford SUV–right; Note: severity of crush to case vehicle's front and left front (case photo #62)

Based on the police photographs and this contractor's inspection of the case vehicle, this contractor believes that the extensive damage sustained by the case vehicle could not have been caused solely by an impact from the Ford (**Figures 5**, **6**, and **7**). As a result, this contractor believes that the Ford's impact with the back (**Figure 8** below) of GMC pickup (1st event) involved sustained contact, and the Ford pushed the GMC diagonally across the median and roadways and into the northbound roadway's outside through

lane (**Figure 9**). It is this contractor's opinion that the front (**Figure 10**) of the GMC pickup (2nd event) impacted the case vehicle's front and left sides (**Figure 7** above) and that the GMC was in sustained contact with and being pushed south-southeasterly by the Ford. It is unclear whether the Ford and GMC had exactly the same heading angle or whether the GMC's heading angle was slightly clockwise relative to the Ford's. In this contractor's opinion, the GMC was redirected along the case vehicle's left fender, eventually separating from the case vehicle as it continued southward. Next, the front left of the case vehicle was impacted (3rd event) by the front of the Ford (**Figure 11**). The case vehicle's driver and front right supplemental restraints (air bags) deployed, most likely as a result of the impact with the GMC.

Figure 9: North-northwesterly view of Ford's and GMC's south-southeasterly, diagonal, travel path across northbound lanes, through four-leg intersection, and into impact with case vehicle (case photo #11)

Post-Crash: Based on the on-scene police photographs, the case vehicle was redirected to its right and came to rest against the curb near its initial point of impact (**Figure 11**). As a result of impacting the case vehicle, the Ford rotated approximately 140 degrees counterclockwise. Subsequently, the Ford's right quarter panel side slapped (4th event) the case vehicle's left quarter panel. The two vehicles separated, and the Ford

Figure 8: On-scene police photo looking southwest at GMC pickup's back damage from sustained contact impact by Ford SUV; Note: crease line across tailgate of pickup corresponds with Ford's hood deformation (case photo #70)

Figure 10: On-scene police photo looking northeast at GMC pickup's final rest position in junction of driveway and outside through lane of northbound roadway; Note: pickup's frontal damage from impact with case vehicle (case photo #69)

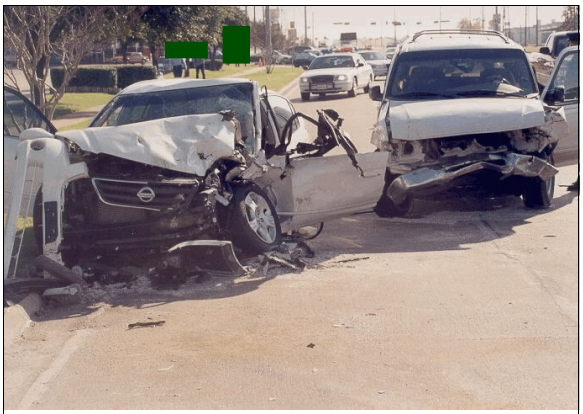


Figure 11: On-scene police photo looking south in outside through lane of northbound roadway showing final rest positions of case vehicle–against curb, and Ford SUV–straddling center and outside through lanes (case photo #61)

came to rest heading north, straddling the right center and outside through lanes of the northbound roadway (**Figure 11** above and **Figure 12**).

The GMC pickup continued in a south-southeasterly direction after impacting the case vehicle. The GMC traveled a considerable distance (not measured) from its impact with the case vehicle to its final rest position, approximately a city block away (**Figure 6** above). In this contractor's opinion, the GMC's driver must have accelerated for unknown reasons, either intentionally or unintentionally, because the GMC departed the right (eastern) side of the northbound roadway and obliquely traversed the grassy roadside (**Figures 13** and **14**), most likely traveling along a sidewalk bordering the roadway before finally re-entering the northbound roadway where it came to rest heading southwest in the junction of a commercial driveway and the northbound roadway straddling the outside north- bound lane (**Figure 15**).

Figure 14: On-scene police photo looking north along eastern roadside showing case vehicle and Ford SUV at final rest and tire marks from GMC pickup in grass (case photo #67)

CASE VEHICLE

The 2003 Nissan Altima S was a front wheel drive, five-passenger, four-door sedan (VIN: 1N4AL11D32C------) equipped with a 2.5L, I-4 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front

Figure 12: On-scene police photo looking north in outside through lane of northbound roadway showing final rest positions of case vehicle–against curb and Ford SUV–straddling right center and outside lanes (case photo #65)

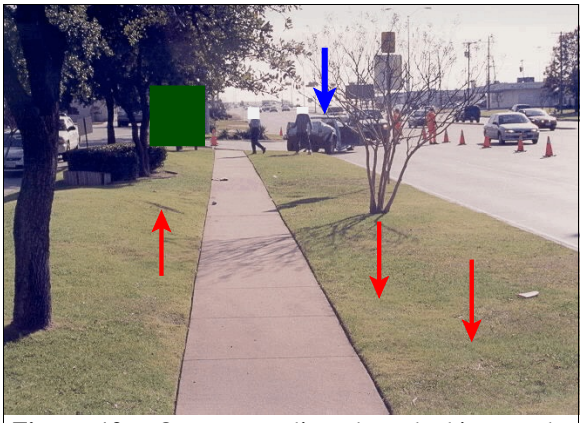


Figure 13: On-scene police photo looking south along sidewalk on east roadside showing (blue arrow) GMC pickup's final rest position on roadway and tire marks (red arrows) on roadside (case photo #66)

Figure 15: On-scene police photo looking north in the outside through lane of the northbound roadway showing final rest position of GMC pickup, frontal damage, and rest positions (arrow in background) of case vehicle and Ford (case photo #68)

and rear disc system. Four-wheel, anti-lock brakes, front seat back-mounted side impact air bags, and front and rear head curtain air bags were all options for this model and were available as part of the ABS & Air Bag Package, but the case vehicle was not so equipped. The case vehicle was equipped with advanced occupant protection system features including dual stage driver and front right passenger air bag inflators and seat belt pretensioners. The case vehicle's wheelbase was 280 centimeters (110.2 inches), and the odometer reading at inspection is unknown because the case vehicle was equipped with an electronic odometer.

Figure 16: Elevated view of case vehicle's frontal damage viewed from right of front with contour gauge positioned along bumper reinforcement bar (case photo #14)

CASE VEHICLE DAMAGE

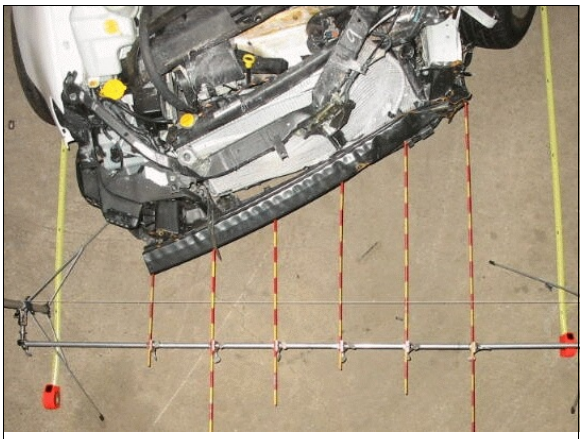


Figure 17: Overhead view of case vehicle's frontal damage with contour gauge position along bumper reinforcement bar; Note: greatest crush at front left bumper corner (case photo #16)

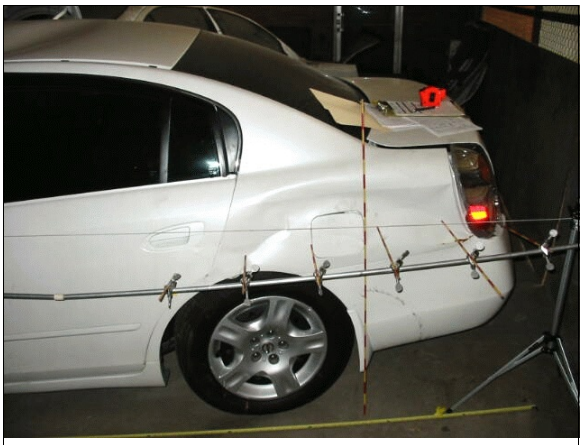


Figure 18: Elevated view of damage to case vehicle's left quarter panel with contour gauge positioned above mid-door level (case photo #22)

Exterior Damage: The case vehicle's initial contact with the GMC and the Ford involved primarily the front left half. The exact location of the direct damage cannot be determined because the case vehicle's bumper fascia was not present at the time of our inspection (**Figure 16**). Direct and induced damage occurred to the entire front bumper which measured 103 centimeters (40.6 inches) in length. Maximum crush was measured as 64 centimeters (25.2 inches) at C_1 (**Figure 17**). The case vehicle's side slap contact–most likely with the Ford, involved primarily the left quarter panel (**Figure 18**). Direct damage began 32 centimeters (12.6 inches) forward of the left rear axle and extended, a measured distance of 119 centimeters (46.9 inches), along the left quarter panel toward the left rear bumper corner. Residual maximum crush was measured as 14 centimeters (5.5 inches) at C_2 (**Figure 19** below). The table below shows the case vehicle's crush profile.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	2&3	Unk	54	139	54	43	31	19	9	1	-18	0
in		Unk	21.3	54.7	21.3	16.9	12.2	7.5	3.5	0.4	-7.1	0.0
cm	4	119	14	119	4	14	13	9	6	2	-154	-119
in		46.9	5.5	46.9	1.6	5.5	5.1	3.5	2.4	0.8	-60.6	-46.9

The wheelbase on the case vehicle's left side was shortened 27 centimeters (10.6 inches) while the right side was extended 6 centimeters (2.4 inches). The case vehicle's front bumper fascia, bumper, grille, hood, radiator, right and left headlight and turn signal assemblies, left fender, left front wheel assembly, and left "A"-pillar were directly damaged and crushed rearward (**Figures 5**, **7**, **11**, and **16** above). The left fender and left front door were directly damaged and crushed inward (**Figure 18** above and **Figure 19**). Both the right and left fenders sustained induced damage as well as the case vehicle's windshield and left "A"-pillar. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

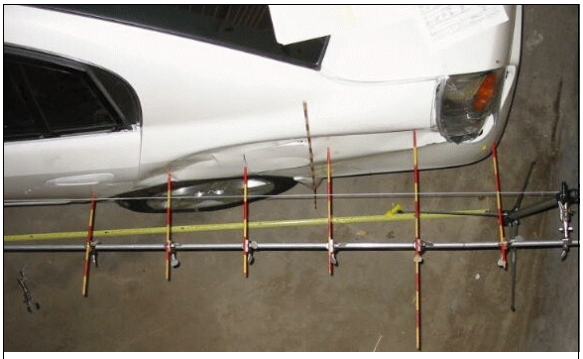


Figure 19: Overhead view of damage to case vehicle's left quarter panel; Note: maximum crush at C_2 (case photo #24)

The recommended tire size was: P205/65R16, and the case vehicle tires were the recommended size. The case vehicle's left front tire was physically restricted, and the top of the tire was rotated inward from the crash. None of the case vehicle's other tires were damaged, deflated, or physically restricted.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	97	14	200	29	7	9	Rotated inward from crash	Yes	No
RF	165	24	200	29	7	9	None	No	No
LR	172	25	200	29	7	9	None	No	No
RR	172	25	200	29	8	10	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior revealed significant intrusion into the driver's seating area (**Figures 20** and **21** below). Specifically, the left "A"-pillar was intruded approximately 30 centimeters (11.8 inches) rearward while the left and center instrument panels were intruded both rearward (longitudinally) and rightward (laterally) from the collisions with the GMC and Ford. The left instrument panel moved approximately 6 centimeters (2.4 inches) laterally and the center instrument panel moved approximately 3 centimeters (1.2 inches) laterally (**Figure 22** below). In addition, the left side panel, forward of the left "A"-pillar, was pushed inward (i.e., laterally) approximately 12 centimeters (4.7 inches). There was obvious contact evidence to the left side of the driver's knee bolster, most likely from the driver's left knee area (**Figure 23** below). On the other hand, there was no evidence of occupant contact to the front right passenger area. In addition, the steering wheel was jammed forward against the intruding left instrument panel. Finally, the steering column compression could not be determined because of the severity of longitudinal and lateral intrusions.

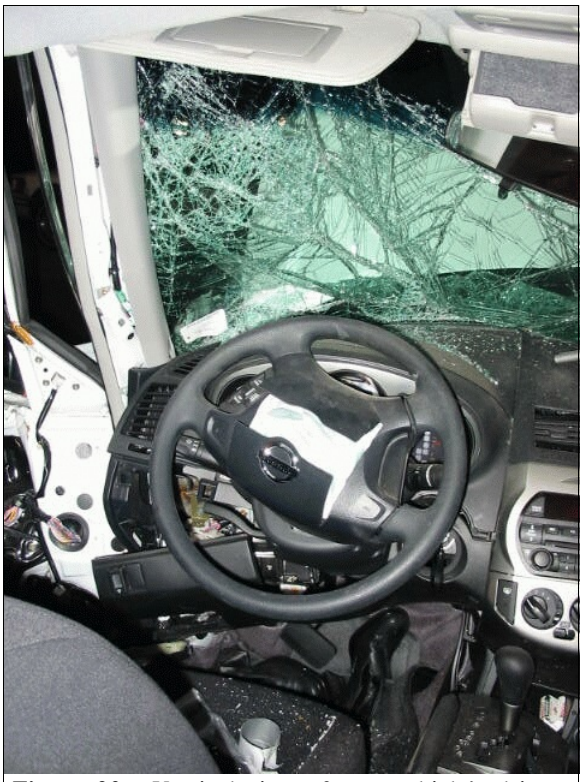


Figure 20: Vertical view of case vehicle's driver seating area showing deployed driver air bag, deformation to left instrument panel area, and occupant contact evidence to left side of driver's knee bolster (case photo #33)

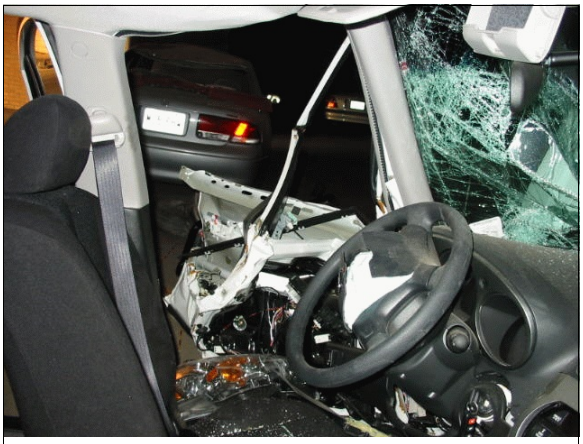


Figure 21: Case vehicle's driver seating area showing intrusion to occupant space from left "A"-pillar and left and middle instrument panels (case photo #32)

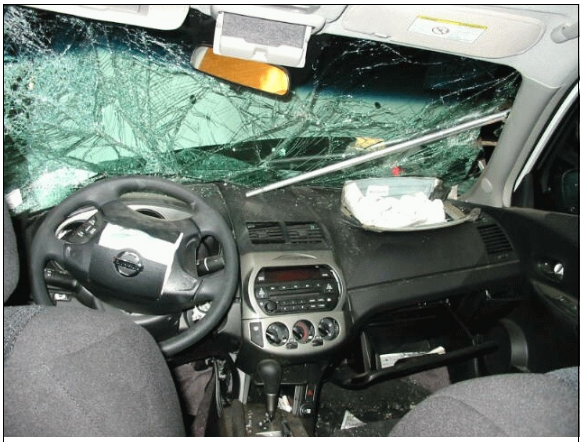


Figure 22: Case vehicle's front right passenger seating area showing deployed front right air bag, lateral (toward the right) movement of center instrument panel, and no apparent evidence of occupant contact (case photo #37)

Damage Classification: Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **11-FYEW-3** (**340** degrees) for the frontal impact and **09-LBEW-1** (**270**

degrees) for the left side slap impact. The frontal CDC is based on the totality of the damage the case vehicle sustained from its impacts with the GMC pickup and the Ford SUV. The WinSMASH reconstruction program, barrier algorithm, was used on the case vehicle's highest severity frontal impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 33.0 km.p.h. (20.5 m.p.h.), -31.0 km.p.h. (-19.3 m.p.h.), and +11.3 km.p.h. (+7.0 m.p.h.). Furthermore, the WinSMASH reconstruction program, missing vehicle algorithm, was used on the case vehicle's left side slap impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 8.0 km.p.h. (5.0 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and +8.0 km.p.h. (+5.0 m.p.h.). Of course the Delta V results for the frontal (barrier) impact are invalid because they are actually a composite of two impacts, but they are provided here as an estimate of the change in velocity that actually occurred. The case vehicle was towed due to damage.

Figure 23: Close-up of occupant contact evidence on left side of case vehicle's driver knee bolster (case photo #34)

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained dual stage frontal air bags at the driver and front right passenger positions. Both frontal air bags deployed as a result of the frontal impacts with the GMC pickup and the Ford sport utility vehicle. It is unknown whether more than one stage of the multi-stage air bags was activated. The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of asymmetrical "H"-configuration cover flaps made of thick vinyl with overall dimensions of 14 centimeters (5.5 inches) at the horizontal seam and 9 centimeters (3.5 inches) vertically for the upper flap and 7 centimeters (2.8 inches) vertically for the lower flap. The distance between the mid-center of the driver's seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 17 centimeters (6.7 inches). An inspection of the air bag module's cover flaps and the air bag's fabric revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed with two tethers, each approximately 8 centimeters (3.1 inches) in width. The driver's air bag had two vent ports, approximately 4.5 centimeters (1.8 inches) in diameter, located at the 11 and 1

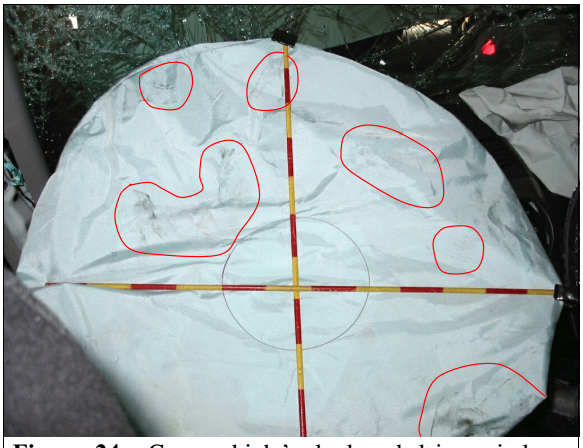


Figure 24: Case vehicle's deployed driver air bag showing scuff evidence (arrows) on air bag's fabric most likely from interaction with case vehicle's driver; Note: air bag rotated approximately 180 degrees–12 o'clock position is at bottom of photo (case photo #47)

o'clock positions. The deployed driver's air bag was round with a diameter of 64 centimeters (25.2 inches). An inspection of the driver's air bag fabric revealed obvious occupant contact evidence (i.e., scuffs) on the air bag's fabric (**Figure 24** above).

The front right passenger's air bag was located in the top of the instrument panel. There were two asymmetrical, "H"-configuration, modular cover flaps made of a thick vinyl over a sheet metal frame/liner which acted as the hinge point for the deploying flaps. The flap's dimensions were: 30 centimeters (11.8 inches) at the top horizontal seam, 33 centimeters (13.0 inches) at the bottom horizontal seam, 9 centimeters (3.5 inches) vertically for the upper flap, and 8 centimeters (3.1 inches) vertically for the lower flap. The distance between the mid-center of the front right seat back, as positioned at the time of the vehicle inspection, and the front surface of the air bag's fabric at full excursion was 36 centimeters (14.2inches). An inspection of the front right air bag module's cover flap and the air bag's fabric revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The front right passenger's air bag was designed without any tethers. The front right air bag had two vent ports, approximately 3 centimeters (1.2 inches) in diameter, located at the 9 and 3 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 51 centimeters (20.1 inches) and a width of approximately 38 centimeters (15.0 inches). An inspection of the front right passenger's air bag fabric revealed two small holes on the top surface of the air bag near the beginning of the front surface (**Figure 25**). Specifically, there was a small hole located 5 centimeters (2.0 inches) from the left surface and 0.8 centimeters (0.3 inches) from the front surface. A second small hole was located 8 centimeters (3.1 inches) from the right surface and 10 centimeters (3.9 inches) from the front surface. It is believed that these holes resulted from contact by shards of flying glass. The air bag's front surface showed no obvious contact evidence on the front right air bag's fabric (**Figure 26**).

Figure 25: Top surface of case vehicle's deployed front right air bag showing small holes in air bag's fabric, possibly from contact with cracked right windshield's glazing (case photo #51)

Figure 26: Front surface of case vehicle's deployed front right air bag showing no apparent evidence of occupant contact (case photo #55)

CASE VEHICLE DRIVER KINEMATICS

Case Vehicle's Driver: The exact posture of the case vehicle's driver [26-year-old, White (Hispanic) female; 163 centimeters and 77 kilograms (64 inches, 170 pounds)] immediately prior

to the crash is unknown. The driver was most likely was seated in a reclined posture with her back against the seat back, her left foot on the floor, her right foot on the accelerator, and at least one hand on the steering wheel. Based on the vehicle inspection, her seat track was located in its rearmost position and the seat back was slightly reclined. Based on the driver's stature, it unlikely that she was sitting in the rearmost position at the time of the crash. Based on this contractor's experience, the driver's seat was most likely positioned near its middle seat track position and was moved post-crash for extrication purposes. The case vehicle was equipped with both a tilt and a telescoping steering column, but their pre-crash positions could not be determined because the steering wheel was jammed against the left instrument panel (**Figure 27**).

Figure 27: Case vehicle's tilt and telescoping column jammed against instrument panel; Note: no steering wheel rim deformation (case photo #28)

Based on this contractor's vehicle inspection and supported by her medical records, the case vehicle's driver was restrained by her available, active, three-point, lap-and-shoulder, safety belt system; the belt system was equipped with a retractor-mounted pretensioner with force limiters, housed within the "B"-pillar. Furthermore, there was medical evidence of belt pattern bruising and/or abrasions to the driver's torso, and the inspection of the driver's seat belt webbing, "D"-ring, and latch plate revealed that the pretensioner had actuated. In addition, there was evidence of loading on the belt's webbing (**Figure 28**).

Figure 28: Loading evidence on webbing of case vehicle's driver safety belt (case photo #38)

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the use of her available safety belts, her pre-impact body position did not change just prior to impact. The case vehicle's primary impact with the GMC and Ford enabled the case vehicle's driver to continue forward, leftward, and slightly upward along a path opposite the case vehicle's **340** degree Direction of Principal Force as the case vehicle decelerated. As a result of the impact, the driver loaded her safety belts and contacted her deploying driver air bag. Between the combination of the intrusion into the driver's seating position and the force of the driver loading the air bag and steering column, the steering wheel was jammed into the left instrument panel. The driver most likely rebounded backwards toward her seat back after her forward momentum was halted by the combination of her safety belts and the air bag/steering wheel. As a result of the secondary impact with the Ford, the driver moved to her left into the interior surface of the driver's door. The exact posture of the driver at final rest is unknown. It is also unknown as to whether she needed assistance to exit her vehicle.

According to the Police Crash Report, the driver was transported by ambulance to the hospital. She sustained moderate injuries and was hospitalized two days post-crash. According to her medical records, the injuries sustained by the case vehicle's driver included: a fracture of her left C_6 transverse process, a moderate nonanatomic brain injury, contusion of her posterior left scalp, seat belt contusions and abrasions across her chest and lower abdomen, and abrasions to her left lateral forearm and knees.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Nonanatomic brain injury with amnesia for event, unknown if loss of consciousness	moderate 160410.2,0	Left side window sill	Probable	Emergency room records
2	Fracture left C_6 transverse process	moderate 650220.2,6	Other noncontact injury source: lateral flexion by impact forces	Possible	Hospitalization records
3	Contusion, small, left posterior parietal scalp	minor 190402.1,2	Left side window sill	Probable	Emergency room records
4	Abrasion diagonally across left chest, not further specified	minor 490202.1,2	Torso portion of safety belt system	Certain	Hospitalization records
5	Contusion diagonally across left chest, not further specified	minor 490402.1,2	Torso portion of safety belt system	Certain	Hospitalization records
6	Abrasion across lower abdomen, involving at least anterior left hip	minor 590202.1,8	Lap portion of safety belt system	Certain	Hospitalization records
7	Contusion {hematoma} across lower abdomen, involving both left and right hips	minor 590402.1,8	Lap portion of safety belt system	Certain	Hospitalization records
8	Abrasion left lateral forearm, not further specified	minor 790202.1,2	Air bag, driver's	Possible	Hospitalization records
9	Abrasion left knee, not further specified	minor 890202.1,2	Knee bolster, driver's, left of steering column	Certain	Emergency room records
10	Abrasion right knee, not further specified	minor 890202.1,1	Knee bolster, driver's, right of steering column	Probable	Emergency room records

1ST OTHER VEHICLE

Based on the VIN and manufacturer's specifications, the 1996 Ford Explorer XL was a rear wheel drive (4x2), five-passenger, four-door sport utility vehicle (VIN: 1FMDU32X5TUC------)

equipped with a 4.0L, V-6 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, front and rear disc, four-wheel, anti-lock system. The Ford's wheelbase was 283 centimeters (111.5 inches), and the odometer reading is unknown because the Ford's interior was not inspected. Furthermore, the vehicle was equipped with driver and front right passenger supplemental restraints (air bags) that deployed as a result of one of this vehicle's frontal impacts (**Figure 29**). In addition, there were manual, three-point, lap-and-shoulder, safety belt systems for the front outboard seating positions. The restraints provided for the back seats are unknown. The interior was equipped with bucket seats for the driver and front right passenger, and the back bench seat was non-adjustable.

Figure 29: On-scene police photo showing Ford SUV's front seating area and deployed driver and front right passenger air bags (case photo #64)

Exterior Damage: Based on the available police photographs, one CDC for the three events that the Ford was most likely involved in is estimated as: **12-FDEW-2** (**0** degrees) for the impacts with the back of the GMC and the front of the case vehicle (**Figure 30**). Damage to the Ford's front is a result of two overlapping impacts. With no clear vehicle photographs of the Ford's right side slap damage, the CDC for this impact (4th event) is most likely estimable as: **03-R{B,Y}{M,E}W-1** (**90** degrees). However, the WinSMASH reconstruction program, missing vehicle algorithm, was used on the Ford's right side slap impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 6.0 km.p.h. (3.7 m.p.h.), 0.0 km.p.h. (0.0 m.p.h.), and -6.0 km.p.h. (-3.7 m.p.h.). According to the Police Crash Report, the Ford was towed due to damage.

Figure 30: On-scene police photo looking south-southeast at Ford's final rest position showing SUV's frontal damage; Note: Ford's front first impacted GMC pickup's back and second case vehicle; compare severity of Ford's frontal damage with damage to case vehicle (case photo #63)

Ford's Occupants: According to the Police Crash Report, the Ford's driver [78-year-old, White (unknown if Hispanic) female] was restrained by her available, active, three-point, lap-and-shoulder, safety belt system. The driver was transported by ambulance to the hospital, and she sustained a police-reported "A" (incapacitating) injury as a result of this crash.

2ND OTHER VEHICLE

Based on the VIN and manufacturer's specifications, the 1996 GMC C1500 Sierra was a rear wheel drive (4x2), ½-ton, two-door, regular cab, standard bed, pick up truck (VIN: 1GTDC14Z0MZ------) equipped with a 4.3L, V-6 engine and a five-speed manual transmission.

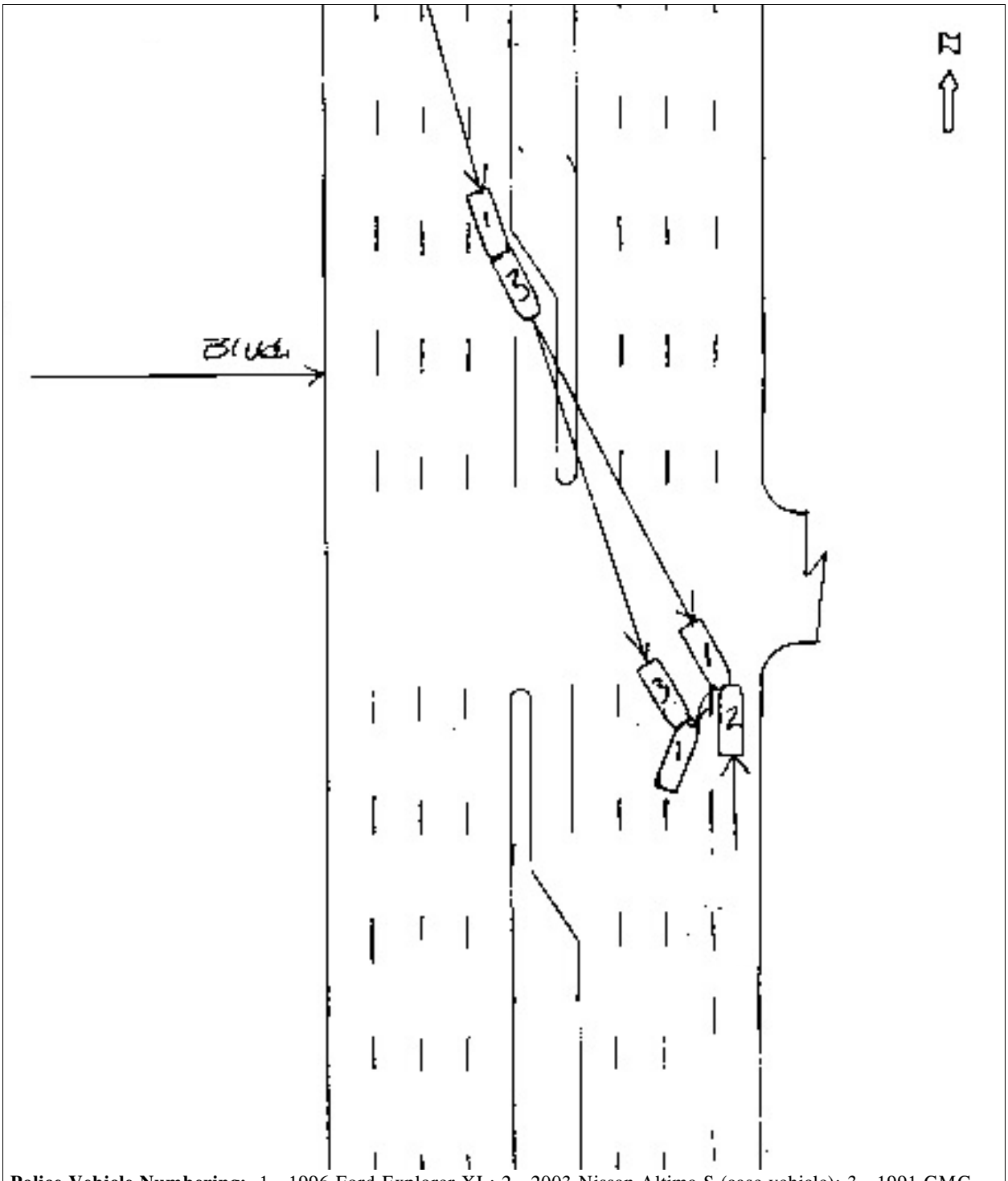
Braking was achieved by a power-assisted, front disc and rear drum, rear anti-lock system. The GMC's wheelbase was 298 centimeters (117.5 inches), and the odometer reading is unknown because the GMC's interior was not inspected. Furthermore, the vehicle was not equipped with front occupant supplemental restraints (air bags), but there were manual, three-point, lap-and-shoulder, safety belt systems for the front outboard seating positions (**Figure 31**). The interior was equipped with bucket seats for the driver and front right passenger.

Figure 31: On-scene police photo showing GMC pickup's front seating area (case photo #72)

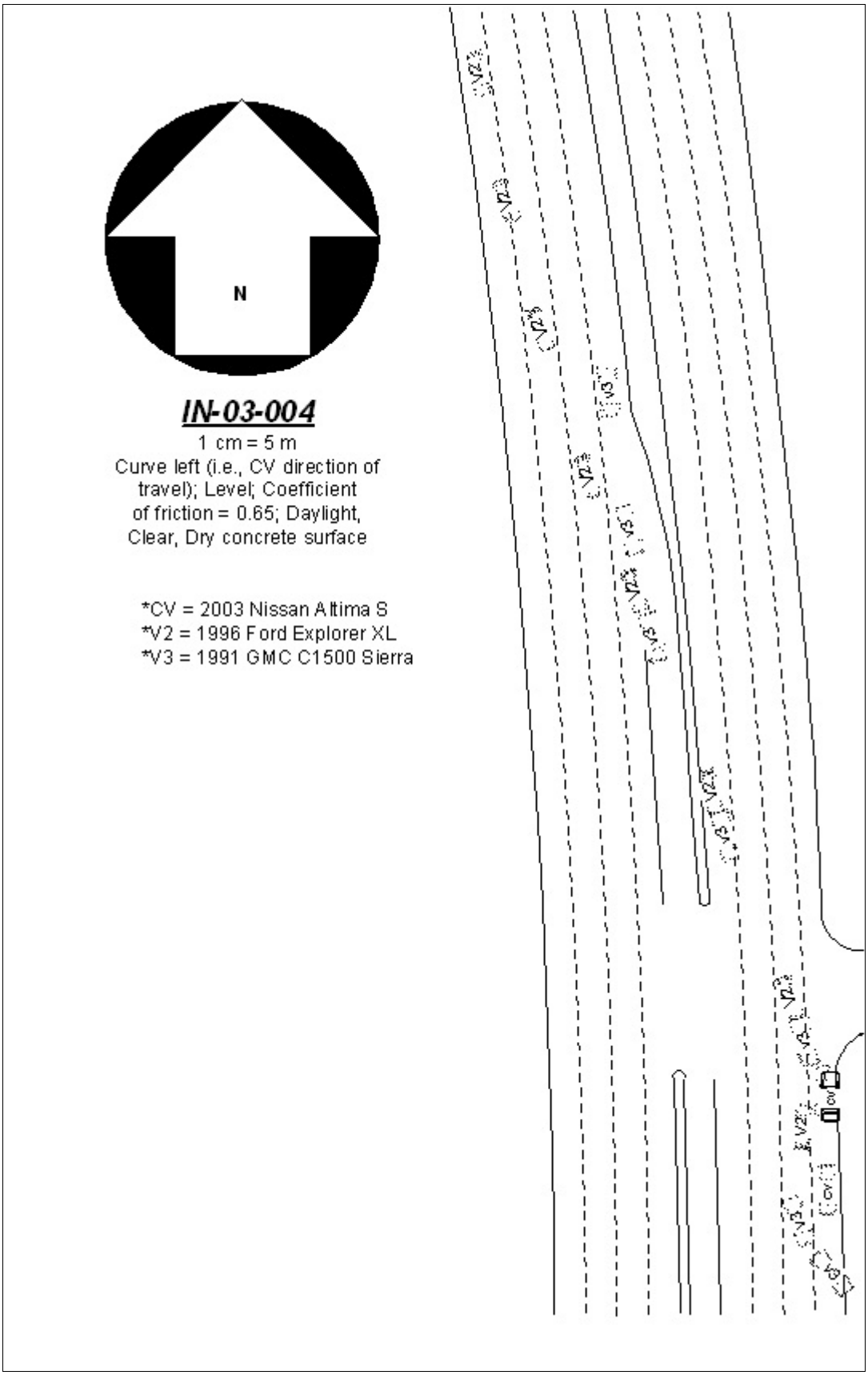
Exterior Damage: Based on the available police photographs, the CDCs for the two events (1st and 2nd) that the GMC was most likely involved in are estimable as: **26-BDEW-2** (**180** degrees) for its back (1st event–**Figure 32**) impact and **12-FDEW-1** (**0** degrees) for its frontal impact (2nd event–**Figure 10** above) with the case vehicle. According to the Police Crash Report, the GMC was towed due to damage.

Figure 32: On-scene police photo looking southeast at sustained contact damage to GMC pickup's truck bed from impact by Ford SUV; Note: upward rotation of truck bed was exacerbated during GMC's impact with case vehicle (case photo #71)

GMC's Occupants: According to the Police Crash Report, the GMC's driver [49-year-old, White (unknown if Hispanic) male] was restrained by his available, active, three-point, lap-and-shoulder, safety belt systems. The driver was examined at the scene but was not transported by ambulance to the hospital, and he did sustain a police-reported "B" (non-incapacitating-evident) injury as a result of this crash.



Police Vehicle Numbering: 1. 1996 Ford Explorer XL; 2. 2003 Nissan Altima S (case vehicle); 3. 1991 GMC C1500 Sierra pickup


N
IN-03-004
1 cm = 5 m
Curve left (i.e., CV direction of travel); Level; Coefficient of friction = 0.65; Daylight, Clear, Dry concrete surface
*CV = 2003 Nissan Altima S
*V2 = 1996 Ford Explorer XL
*V3 = 1991 GMC C1500 Sierra