TRANSPORTATION SCIENCES
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REMOTE REDESIGNED AIR BAG DEPLOYMENT INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

NASS/SCI COMBO CASE NO. 00-08-226C

VEHICLE - 2000 NISSAN ALTIMA

LOCATION - STATE OF PENNSYLVANIA

CRASH DATE - DECEMBER 2000

Contract No. DTNH22-94-D-07058

Prepared for:

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

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

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

TECHNICAL REPORT STANDARD TITLE PAGE

1. *Report No.* 00-08-226C	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* Veridian Remote Redesigned Air Bag Deployment Investigation Vehicle: 2000 Nissan Altima Location: State of Pennsylvania		5. *Report Date*: August 2001 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 Veridian Engineering P.O. Box 400 Buffalo, New York 14225		10. *Work Unit No.* C01115.0343.(0000-0009) 11. *Contract or Grant No.* DTNH22-94-D-07058	
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: December 2000 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* Remote investigation of a run-off-road crash into a bridge support that resulted in the deployment of the redesigned frontal air bag system, side impact protection system, seat belt pretensioners, and the death of the 42-year-old male driver.			
16. *Abstract* This remote investigation involved a 2000 Nissan Altima equipped with redesigned frontal air bags, driver and front right passenger side air bags, and front seat belt pretensioners that deployed as a result of a frontal collision with a concrete bridge support. The Altima was occupied by a 42-year-old male driver that was restrained by the 3-point lap and shoulder belt. The driver was operating the Altima northbound in the outboard lane of a divided highway when he lost consciousness and relinquished control of the vehicle. The Altima drifted to the right and departed the right roadside in a tracking mode. The Altima continued along the road edge and struck a concrete bridge support with the front left area. The severe frontal impact fired the front left seat belt pretensioner, and deployed the redesigned frontal air bag system and both side air bags. The restrained driver initiated a forward trajectory in response to the frontal impact force and loaded the manual restraint which resulted in multiple left rib fractures, a liver laceration, a heart injury, and a lung injury. Due to the high delta-V, he subsequently loaded through the redesigned driver's air bag and loaded the steering wheel rim/hub. He sustained a mandible fracture from probable contact with the steering wheel rim. He sustained multiple lower extremity injuries from contact with the intruded left instrument panel, floor pan and toe pan. The driver was conscious and talking at the scene and removed from the vehicle by rescue personnel. He was transported by helicopter to a regional trauma center and expired 10 days following the crash.			
17. *Key Words* Redesigned Air Bags Seat belt pretensioners Side impact protection system		18. *Distribution Statement* General Public	
19. *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 8	22. *Price*

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BACKGROUND

This remote investigation involved a 2000 Nissan Altima **(Figure 1)** equipped with redesigned frontal air bags, driver and front right passenger side air bags, and front seat belt pretensioners that deployed as a result of a frontal collision with a concrete bridge support. The Altima was occupied by a 42-year-old male driver that was restrained by the 3-point lap and shoulder belt. The driver was operating the Altima northbound in the outboard lane of a divided highway when he lost consciousness and relinquished control of the vehicle. The Altima drifted to the right and departed the right roadside in a tracking mode. The Altima continued along the road edge and struck a concrete bridge support with the front left area. The severe frontal impact fired the front left seat belt pretensioner, and deployed the redesigned frontal air bag system and both side air bags. The restrained driver initiated a forward trajectory in response to the frontal impact force and loaded the manual restraint which resulted in multiple left rib fractures, a liver laceration, a heart injury, and a lung injury. Due to the high delta-V, he subsequently loaded through the redesigned driver's air bag and loaded the steering wheel rim/hub. He sustained a mandible fracture from probable contact with the steering wheel rim. He sustained multiple lower extremity injuries from contact with the intruded left instrument panel, floor pan and toe pan. The driver was conscious and talking at the scene and removed from the vehicle by rescue personnel. He was transported by helicopter to a regional trauma center and expired 10 days following the crash.

Figure 1. Damaged 2000 Nissan Altima

This crash was selected for investigation by the National Automotive Sampling System (NASS) as CDS case number 00–08-226C. The crash occurred in December 2000. Initial notification of this crash was made to the Veridian Special Crash Investigations team following a NASS CDS case review. The NASS PSU performed the vehicle inspection and scene inspection. Due to the presence of the redesigned frontal air bag system and the driver bottoming-out the air bag, NHTSA assigned the tasks of case review and report preparation to the Veridian Special Crash Investigation (SCI) team on February 27, 2001.

SUMMARY

Crash Site

This crash occurred in December 2000 on the east roadside of a four-lane, north/south divided state roadway that traveled through a mountainous region. At the crash site, the north/south roadway passed through a mountain cut in an east/west direction. The roadway was configured with two travel lanes in each

direction separated by a grassy median. At the crash site, the roadway curved left and had a level grade. A bridge crossed the roadway at the scene, and concrete supports were located on the median and on each outboard shoulder. The northbound lanes were bordered by asphalt shoulders. At the time of the crash it was dark with no roadway illumination. There were no adverse weather conditions and the asphalt road surface was dry. The roadside environment consisted of a grassy roadside area adjacent to the right shoulder and a vertical rock face of a mountain cut that was approximately 8 m (25') from the right roadside. The NASS researcher measured the lateral roadside grade to be approximately - 9.0% from the roadside. There were no traffic controls at the crash site, and the posted speed limit was 89 km/h (55 mph).

Pre-Crash

The 42-year-old male driver of the Nissan Altima was operating the vehicle on the outboard northbound lane of a four-lane divided highway during the nighttime hours of December 2000. The police reported that the driver fell asleep, however a family member of the driver stated during the NASS interview that the driver had a history of migraine headaches and that he may have lost consciousness. Due to the driver's inattention, he relinquished control of the vehicle while entering a curve to the left **(Figure 2)**. The Nissan Altima departed the right roadside and traveled north along the grassy roadside in a tracking mode. The Altima passed a roadside sign and drifted to the right toward a concrete bridge support **(Figure 3)**. There did not appear to be any attempted avoidance maneuvers. The Altima traveled a total distance of 104 m (340') along the roadside from the point of departure to impact, based on tire marks documented by the NASS researcher. A cellular phone was present in the vehicle but was not in use at the time of the crash.

Figure 2. Approach view showing the point of roadway departure

Figure 3. 2nd approach view

Crash

The 2000 Nissan Altima impacted the concrete bridge support **(Figure 4)** with the front left area. The bridge support measured 1.5 m (5.0') in width and 5.0 m (16.5') in length. The impact resulted in severe damage to the Altima. The direction of force was in the 12 o'clock sector. The barrier routine of the WinSMASH program computed a total velocity change of 79.4 km/h (49.3 mph) based on the documented crush profile. The impact induced deceleration was sufficient to fire the front left retractor-mounted seat belt pretensioner and deploy the redesigned frontal air bag system in the Altima. Although the Altima sustained a severe frontal impact, the driver's side air bag and right front passenger's side air also deployed. The offset left crash caused it to rotate counterclockwise (CCW) approximately 30 degrees to final rest against the bridge support.

Figure 4. Point of impact - concrete bridge support

Post-Crash

The driver was found trapped in the vehicle due to passenger compartment intrusion and jammed doors. The first responding officer and rescue personnel reported that the driver was conscious and alert and was speaking prior to his removal from the vehicle. The driver verified the loss of consciousness prior to the crash. The roof of the Altima was removed by rescue personnel and the driver was removed vertically and placed on a spinal immobilization board. The extrication of the driver from the vehicle reportedly took 40 minutes. The patient became unresponsive following the extrication and was transported by helicopter to a regional trauma center where he expired 10 days later.

VEHICLE DATA - 2000 Nissan Altima

The 2000 Nissan Altima was identified by the Vehicle Identification Number (VIN): 1N4DL01A6YC (production sequence omitted). The Altima was a four-door sedan equipped with a 2.4 liter, 4-cylinder engine, an automatic transmission, front wheel drive, power steering, power-assisted front disc and rear drum brakes, and a power sun/moon roof. The seating was configured with front bucket seats with adjustable head restraints and a rear bench seat with a split folding back. The Altima was also equipped with a tilt steering column, however, the position of the column could not be determined.

VEHICLE DAMAGE

Exterior Damage - *2000 Nissan Altima*

The 2000 Nissan Altima sustained severe damage as a result of the impact with the concrete bridge support. The direct contact damage began at the front left bumper corner and extended 79 cm (31") laterally across the bumper. The combined direct and induced damage involved the entire frontal width of the vehicle **(Figure 5)**. The bumper fascia was separated from the vehicle. The bumper beam was crushed rearward on the left side and displaced slightly to the right. The maximum crush was located at C1 at the front left bumper corner and measured 121 cm (48"). The hood was buckled at the designated fold points. The left front wheel was crushed rearward to the left A-pillar **(Figure 6)** and was restricted and deflated . The right front wheel was also crushed rearward and was restricted. The severe frontal crush resulted in an 81 cm (32") reduction in the left wheelbase and a 12 cm (5") reduction in the right wheelbase. The left front fender was separated from the vehicle and the left front door was displaced from induced damage and rescue efforts. The front aspect of the right front fender and was pulled toward the center of the vehicle. The left aspect of the front bumper beam was fractured and separated. The roof was removed from the vehicle by rescue personnel. The Collision Deformation Classification for this impact was 12-FYEW-5. Six crush measurements were taken by the NASS researcher at the front bumper level and were as follows: C1 = 121 cm (48"), C2 = 121 cm (48"), C3 = 92 cm (36"), C4 = 70 cm (28"), C5 = 50 cm (20"), C6 = 33 cm (13").

Figure 5. Frontal view of direct damage

Figure 6. Left side view of the damaged Altima

Interior Damage - *2000 Nissan Altima*

Interior damage to the 2000 Nissan Altima was severe and attributed to compartment intrusion and occupant contact. Integrity loss and glazing damage resulting from the crash or occupant contact could not be determined due to the removal of the glazing and removal of the roof by rescue personnel. Multiple intrusions were documented by the NASS researcher. The most severe intruded component into the front left seat area was the left toe pan which intruded 70 cm (28") longitudinally **(Figure 7)**. The instrument panel was damaged from intrusion and occupant contact, and multiple instrument panel components were displaced and separated. The rigid plastic knee bolster was deformed and separated from the lower left instrument panel from contact with the driver's legs. The front left seat back was also deformed rearward and slightly clockwise (CW) from

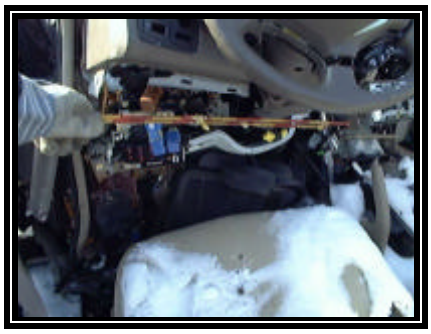

Figure 7. Intruded left toe pan and left instrument panel

occupant contact, and the adjustable head restraint was separated from the seat back. The steering wheel rim was uniformly displaced forward and was partially separated at the inboard edges of the spokes **(Figure 8)**. *Although the NASS case file coded "no steering rim deformation,"* the SCI case review identified that the steering wheel sustained a complete collapse. The glove box door opened as a result of the crash.

Figure 8. Uniform steering wheel rim displacement

MANUAL RESTRAINT SYSTEM - *2000 Nissan Altima*

The 2000 Nissan Altima was configured with manual 3-point lap and shoulder belts with sliding latch plates for both front seat positions. Both frontal restraints were equipped with retractor-mounted pretensioners. The pretensioners were located at the base of each B-pillar. The front left pretensioner fired as a result of the crash, however, the front right pretensioner did not. Both frontal lap and shoulder belts were configured with adjustable D-rings. The front left D-ring position was unknown and the front right D-ring was in the full down position. The front left lap and shoulder belt webbing was cut by rescue personnel and the latch plate was still engaged in the buckle during the NASS vehicle inspection. The second row was configured with manual 3-point lap and shoulder belts for the outboard seating positions and a lap belt for the rear center position.

REDESIGNED AIR BAG SYSTEM - *2000 Nissan Altima*

The 2000 Nissan Altima was equipped with redesigned frontal air bags for the driver and front right positions that deployed as result of the impact with a concrete bridge support. The driver's redesigned air bag was housed in the center of the steering wheel with H-configuration module cover flaps. The top flap measured 15 cm (6") in width and 7 cm (3") in height. The bottom flap measured 15 cm (6") in width and 9 cm (4") in height. The redesigned air bag was circular in shape and measured 60 cm (24") in diameter in its deflated state **(Figure 9)**. It was vented by two ports that were located at 10 and 2 o'clock on the rear aspect of the air bag. The redesigned air bag was not tethered. Blood spattering was noted on the lower front quadrants and on the lower rear left aspect of the air bag membrane.

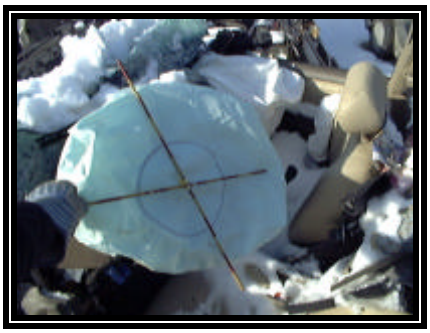

Figure 9. Redesigned driver's air bag

The front right passenger's redesigned air bag deployed from a top-mounted module with H-configuration module cover flaps. The entire module panel measured 32 cm (13") in width and 15 cm (6") in height and was configured with a horizontal tear seam. The upper and lower cover flaps within the module panel were symmetrical and measured 15 cm (6") in width and 5 cm (2") in height. The redesigned front right passenger's air bag was rectangular in shape and measured 30 cm (12") in width and 50 cm (20") in height in its deflated state **(Figure 10)**. It was vented by two circular ports located on the side aspects at the 9 and 3 o'clock positions. The air bag was not tethered. There was no contact evidence on the membrane of the air bag.

Figure 10. Redesigned front right passenger's air bag

SIDE IMPACT PROTECTION SYSTEM - ***2000 Nissan Altima***

The 2000 Nissan Altima was equipped with a seat mounted side air bags for both front seated occupants that deployed as a result of the impact with the bridge support. Although the side impact occupant protection system is not designed to deploy in a frontal collision, the severe impact force in this crash resulted in deployment of the system. Both side air bags offered head and thorax protection. The driver's side air bag deployed in a forward direction from the left aspect of the front left seat back **(Figure 11)**. The vertical tear seam extended along the outboard forward stitching on the seat back from the top aspect to the bottom aspect. The driver's side air bag measured 30 cm (12") in width at the top aspect and 70 cm (28") in height. The air bag was not vented and there were no internal tethers. No contact evidence was found on the driver's side air bag.

Figure 11. Driver's side air bag

The front right passenger's side air bag deployed in a forward direction from the right aspect of the front right seat back. The vertical tear seam extended along the outboard forward stitching on the seat back from the top aspect to the bottom aspect **(Figure 12)**. The front right passenger's side air bag measured 30 cm (12") in width at the top aspect and 70 cm (28") in height. The air bag was not vented and there were no internal tethers. No contact evidence was found on the front right passenger's side air bag.

Figure 12. Right front passenger's side air bag tear seam

OCCUPANT DEMOGRAPHICS 2000 - Nissan Altima

Driver

Age/Sex:	42-year-old male
Height:	180 cm (71")
Weight:	79 kg (174 lb)
Seat Track Position:	Mid-track
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	NASS vehicle inspection, injury data
Eyewear:	Prescription eyeglasses
Type of Medical Treatment:	Transported by helicopter to a regional trauma center and expired 10 days following the crash

Driver Injuries

Injury	Injury Severity (AIS 90)	Injury Mechanisms
Left intertrochanteric femur fracture	Serious (851810.3,2)	Indirect - force transferred through femur from bolster contact
Left femur shaft fracture (distal third)	Serious (851814.3,2)	Knee bolster
Multiple left rib fractures, NFS	Moderate (450210.2,2)	Shoulder belt webbing
Liver laceration, NFS	Moderate (541820.2,1)	Shoulder belt webbing
Severely comminuted right calcaneus fracture	Moderate (851400.2,1)	Left floor pan and toe pan intrusion
Left fibula fracture, NFS	Moderate (851605.2,2)	Left lower instrument panel intrusion
Right oblique mid-shaft fibula fracture	Moderate (851606.2,1)	Left lower instrument panel intrusion
Right 5th comminuted metatarsal fracture	Moderate (852200.2,1)	Left floor pan and toe pan intrusion
Left tibia shaft fracture	Moderate (853420.2,2)	Left lower instrument panel intrusion
Mandible fracture, NFS	Minor (250600.1,9)	Steering wheel rim
Heart injury (myocardium), NFS	Minor (441099.1,4)	Shoulder belt webbing

Injury	Injury Severity (AIS 90)	Injury Mechanisms
Fracture of the right 5th proximal toe	Minor (853602.1,1)	Left floor pan and toe pan intrusion

*Injury source: Post emergency room hospital record

Driver Kinematics

The 42-year-old male driver of the 2000 Nissan Altima was presumed to have been seated in an upright posture with the seat adjusted to the mid-track position and the seat back slightly reclined. He was properly restrained by the manual 3-point lap and shoulder belt. He lost consciousness, possibly due to a medical condition, which caused him to relinquish control of the vehicle. At impact the front left seat belt pretensioner fired and the redesigned frontal air bag system deployed. The driver's side and right front passenger side air bags also deployed due to the severity of the crash. The driver initiated a forward trajectory and loaded the manual restraint. *Contrary to the NASS CDS case file*, the loading to the manual restraint resulted in multiple left rib fractures, a liver laceration, and a heart injury. The intrusion of the frontal components and high Delta-V caused the driver to load through the redesigned driver's air bag and subsequently load the steering wheel rim/hub. This was evidenced by the uniform forward displacement of the steering wheel rim and partial separation at the inboard aspects of the spokes. He sustained a mandible fracture from probable facial contact with the steering wheel rim. The loading to the steering wheel assembly most likely caused compression of the steering column, however, it could not be confirmed. The driver loaded the knee bolster which resulted in a left distal third femur shaft fracture with a lateral angulation. The impact force from the bolster was transmitted through the proximal portion of the shaft which caused a left intertrochantaric femur fracture. The driver loaded the intruded lower left instrument panel which resulted in a left fibula fracture, a right oblique mid-shaft fibula fracture, and a left tibia shaft fracture. He also loaded the intruded floor pan and toe pan which caused a severely comminuted right calcaneus fracture, a right 5th comminuted metatarsal fracture, and a fracture of the right 5th proximal toe.

The driver was entrapped in the vehicle due to jammed doors and frontal passenger compartment intrusion. The driver was found seated in the vehicle by rescue personnel and was conscious and alert prior to his removal from the vehicle. Rescue personnel removed the roof of the Altima and removed the driver vertically from the vehicle and onto a spinal immobilization board. Extrication of the driver took 40 minutes to complete. The driver became unresponsive after he was removed from the vehicle and was transported by helicopter to a regional trauma center. He expired 10 days following the crash due to multi-organ system failure from blunt force trauma of the trunk and extremities.