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CRASH DATA RESEARCH CENTER

Veridian Engineering
Buffalo, New York 14225

AIR BAG RELATED EYE INJURY INVESTIGATION

VERIDIAN CASE NO: CA02-052

VEHICLE: 1994 NISSAN ALTIMA

LOCATION: WASHINGTON, DC

CRASH DATE: APRIL 2002

Contract No. DTNH22-94-07058

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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 of the involved vehicle(s) or their safety systems.

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This investigation focused on the injury mechanisms and injuries sustained by the 73 year old male front right passenger in a 1994 Nissan Altima that was involved in a fixed-object frontal crash. The Nissan Altima was equipped with a Supplemental Restraint System that consisted of driver and front right passenger air bags that deployed as a result of the impact. The front right male passenger suffered bilateral ocular trauma (ruptured globes) and subsequent blindness, as a result of the deploying front right passenger air bag. The 21 year old male driver, the 25 year old male rear left passenger and the 17 year old male rear right passenger of the Nissan were not injured in the crash.

The Special Crash Investigations team at Veridian Engineering was assigned the task of an on-site vehicle inspection by the Crash Investigations Division of the National Highway Traffic Safety Administration at the request of the Office of Defects Investigation (ODI). The Nissan was in storage and under the control of a law firm representing the injured party. Coordination with ODI and the law firm was initiated upon assignment and the vehicle inspection occurred on November 14, 2002. Representatives from NHTSA ODI and an attorney representing the injured passenger witnessed the inspection.

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TABLE OF CONTENTS

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BACKGROUND

This investigation focused on the injury mechanisms and injuries sustained by the 73 year old male front right passenger in a 1994 Nissan Altima that was involved in a fixed-object frontal crash. The Nissan Altima was equipped with a Supplemental Restraint System that consisted of driver and front right passenger air bags that deployed as a result of the impact. The front right male passenger suffered bilateral ocular trauma (ruptured globes) and subsequent blindness, as a result of the deploying front right passenger air bag. The 21 year old male driver, the 25 year old male rear left passenger and the 17 year old male rear right passenger of the Nissan were not injured in the crash.

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SUMMARY

Crash Site

This single vehicle crash occurred during the daylight hours of April, 2002. At the time of the crash, it was daylight and the weather was rain. The road surface was wet. The crash occurred on the eastbound lanes of a limited access four-lane divided interstate highway in an urban setting. At the crash scene, the roadway configuration splits into two separate eastbound arteries. **Figure 1** is an eastbound trajectory view approaching the change in the highway's configuration. A raised concrete divider protected by an impact attenuator separated the continuation of the eastbound lanes. The impact attenuator was the point of impact. Details regarding the attenuator present at the time of the April 2002 crash were unknown. **Figure 2** is a view of the repaired attenuator that was installed during the scene inspection conducted on November 14, 2002. The attenutaor consisted of four Type 1 and three Type 2 Quad-Guard crash cushions manufactured by Energy Absorption Systems, Chicago, Illinois. The crash cushions were surrounded by a flexible end-treatment and a W-beam guard-rail. The speed limit in the area on the crash was 89 km/h (55 mph).

Figure 1: Eastbound trajectory view approximately 200 m (650 ft) west of the impact attenuator.

Figure 2: End-view of the impact attenuator.

Pre-Crash

The 1994 Nissan Altima was eastbound in the center left lane (third lane from the right) driven by a 21 year old male. The Nissan was occupied by three additional male passengers seated in the vehicle's outboard positions. The front right passenger was a 73 year old male, the rear left passenger was a 17 year old male and the rear right passenger was a 25 year old male. The front right passenger was the father of the other occupants in the Nissan. The police report coded manual restraint use as unknown.

As the Nissan approached the change in the highway's configuration, the driver realized late in the pre-crash sequence that he needed to change lanes to the right due to his unfamiliarity with the highway. It was the driver's intention to travel on the right fork of the split. Reportedly, the driver slowed the vehicle and steered clockwise (right) through the gore area preceding the impact attenuator. The travel speed of the Nissan was not known. **Figure 3** is a schematic of the crash depicting the approximated crash sequence.

Crash

The crash occurred with the central and left frontal areas of the Nissan striking the end of the impact attenuator. The principle direction of the impact force was within the vehicle's 12 o'clock sector (an estimated +10 degrees). The left bias of the impact coupled with the eastward momentum of the vehicle caused the Nissan to initiate a counterclockwise rotation as it slid to rest. Reportedly, the Nissan came to rest in the inboard lane (lane 3 of the right fork) facing northward. The driver reported the front of the Nissan was in-close proximity to the center divider at final rest.

The impact induced deceleration was sufficient to cause the deployment of the vehicle's Supplemental Restraint System. Due to the energy absorbing nature of the struck impact attenuators, reconstruction of the crash via the WINSMASH model violated the basic assumptions of the model and its use was not appropriate. Considering the crash dynamics and vehicular damage, the Nissan's estimated delta V based on SCI experience was approximately 8 to 16 km/h (5 to 10 mph).

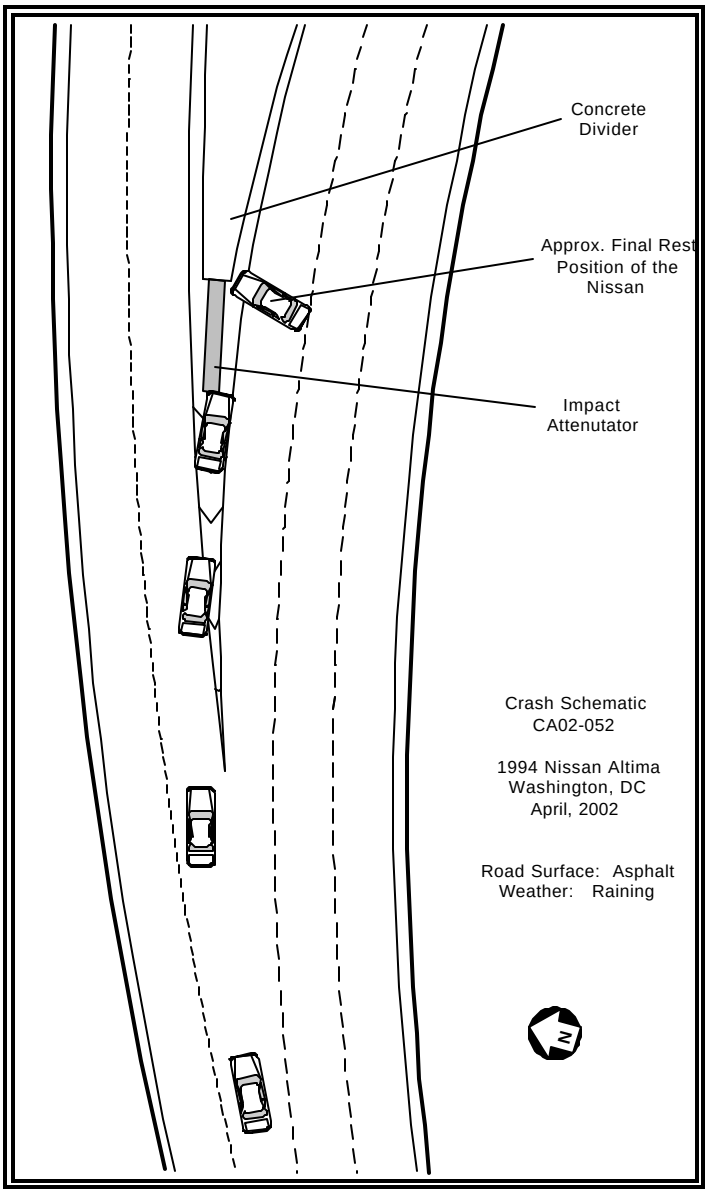

Figure 3: Crash Schematic.

Post-crash

After the crash, the driver reportedly exited the Nissan through the left front door. Realizing the front right passenger was injured, he attempted to move around the front of the vehicle to reach the right side. Due to the vehicle's close proximity to the concrete divider, he had to turn around and travel around the rear of the vehicle to reach the passenger. At this time, reportedly the rear seated passengers had exited the vehicle as well. The front right passenger reportedly had lost his vision at this time.

Ambulance personnel responded to the scene and transported the front right passenger due to the seriousness of his injury to a trauma center located within 10 km (6 miles) of the crash. The Nissan was

mechanically operational and was driven from the scene. Reportedly, the police arrived at the crash site after the Nissan and injured party had left the scene and began their investigation. It should be noted that the crash dynamics reflected in the police report were incorrect.

1994 NISSAN ALTIMA

The 1994 Nissan Altima GXE, 4-door sedan, was identified by the Vehicle Identification Number (VIN): 1N4BU31D4RC (production sequence deleted) and is depicted in **Figure 4**. The Nissan was powered by a 2.4 liter, I4 engine linked to a 4-speed automatic transmission. The manual restraint system consisted of 3-point lap and shoulder belts in the four outboard positions. The center rear position was equipped with a lap belt. The Supplemental Restraint System (SRS) consisted of driver and front right passenger air bags that had deployed as a result of the crash. The odometer had registered 237,468 km (147,560 miles) at the time of the inspection. The vehicle had been pre-owned and was purchased by a family member on July 16, 2001. The mileage at the time of purchase was unknown. Reportedly, the vehicle had no prior crash history.

Figure 4: Front view of the Nissan.

Exterior Damage

The Nissan sustained minor frontal damage during the crash that was managed primarily by the front bumper system. There was no residual crush at the bumper level. The direct contact damage on the fascia and hood face began 3.3 cm (1.3 in) right of the vehicle's center line and extended to the front left corner. The width of the direct contact measured 77.0 cm (30.3 in). The undeformed end width measured 147 cm (58 in). The frontal components damaged in the crash included the bumper fascia, the center grille, the left head lamp, and the left turn signal. The hood was buckled and there was minor deformation of the left front fender, **Figure 5**. The direct contact on the surface of the hood extended longitudinally rearward 48 cm (19 in). **Figure 6** is a view into the engine compartment depicting the residual damage along the upper radiator support. The residual crush profile measured along the support was as follows: C1 = 4.6 cm (1.8 in), C2 = 7.6 cm (3.0 in), C3 = 4.6 cm (1.8 in), C4 = 0.8 cm (0.3 in), C5 = 0, C6 = 0. There was no measurable change in the wheelbase dimensions. All the doors were operational and windshield and side windows remained intact. The Collision Deformation Classification was 12-FYEW-1. The delta V sustained by the Nissan was approximately 8 to 16 km/h (5 to 10 mph) based on SCI experience. An analysis using the Barrier Algorithm of the Winsmash model, for comparison purposes, determined the total delta V of the Nissan was approximately (10.9 km/h) 6.7 mph.

Figure 5: Left side view.

Figure 6: Engine compartment view.

Interior Damage

The only interior damage identified during the inspection of the Nissan was associated to the deployment of the vehicle's Supplemental Restraint System. There was no interior damage or intrusion associated to the exterior forces of the crash.

At the inspection, the manually adjusted driver seat was adjusted to the full rear position. The seat track travel measured 22.4 cm (8.8 in). The seat back was reclined 6 degrees aft of vertical. The horizontal measurement from the center of the steering wheel hub to the seat back was 61.2 cm (24.1 in). This measurement was taken 41 cm (16 in) above the seat bight. There was no contact evidence to the rear aspect of the seat back from loading by the left rear passenger.

The steering wheel was a four spoke rim with the spokes in the 3-5-7-9 o'clock positions. There was no deformation of the rim. Examination of the steering column's shear capsule was unremarkable. There was no shear capsule displacement. No occupant contacts were identified on the driver's knee bolster.

The front right passenger seat was adjusted to the full rear position at the time of the inspection. The seat track travel measured 22.9 cm (9.0 in). The seat back was reclined 15 degrees aft of vertical. The horizontal distance from the vertical face of the instrument panel to the seat back measured 87.6 cm (34.5 in). The horizontal distance from the aft edge of the front right passenger air bag module to the seat back measured 94.0 cm (37.0 in). These measurements were taken 38 cm (15 in) above the seat bight. There was no contact evidence to the rear aspect of the seat back from loading by the right rear passenger.

Minor post-crash blood spatters were noted on the front right window glazing and on the right front door's interior trim panel. There were no identified contacts to the front right bolster or glove box.

The at-crash positions of the front seats crash could not be verified. At the time of the crash, the vehicle was transporting four adult males. Based on SCI field experience investigating crashes involving similar

vehicles and carrying similar occupant loading, the front seats are generally adjusted to a mid-track position. The mid-track seat position of the front seats allocated extra space for the comfort and convenience of the rear seated adults.

Manual Restraint System

The Nissan Altima's manual restraint system consisted of 3-point lap and shoulder belts with continuous loop webbing and sliding latch plates in the four outboard positions. The retractors were both inertial and webbing sensitive. The D-rings for the front restraints were adjustable. The rear center position was equipped with a lap belt.

The driver's restraint was stowed within the retractor at the time of the inspection. The D-ring was adjusted to the full up position. The webbing extended smoothly from the retractor, but the retractor spool had a weak return spring. The webbing had to be fed back into the retractor to position the belt. Examination of the webbing, D-ring and latch plate did not reveal any crash related evidence. However, considering the minor nature of the crash, crash related evidence would not be expected. The latch plate revealed indications of some historical use. However, the vehicle was purchased used, therefore the historical usage evidence was not entirely reflective of the driver's seat belt habits. It was not possible to determine the at-crash restraint condition of the driver based only the physical evidence identified at the time of the inspection.

The front right passenger's restraint was stowed in the retractor at inspection. The D-ring was adjusted to the full up position. The operation of the retractor was similar in nature to the driver's retractor, i.e. the return spring was weak and the return of the webbing was intermittent. Examination of the webbing and hardware did not reveal any crash related evidence. The latch plate revealed indications of historical evidence, but the use was not as frequent as the driver's restraint. It was not possible to determine the restraint condition of the front right passenger based only on the physical evidence identified during the inspection.

Examination of the restraints in the rear outboard positions was unremarkable. Both restraints were stowed at the time of the inspection and operated properly. The latch plate exhibited minimal historical use. There was no crash related evidence identified on either restraint.

Reportedly, the individuals involved in the crash had cleared the scene prior to the arrival of the investigating police officer. The police investigation reported restraint use as unknown. The occupants of the Nissan indicated they were all restrained at the time of the crash. Considering the lack of interior occupant contacts to the knee bolsters, glove box and the rear aspect of the front seat backs, it was probable the occupants were restrained at the time of the crash.

Supplemental Restraint System

The Nissan Altima's Supplemental Restraint System (SRS) consisted of driver and front right passenger air bags that deployed as a result of the crash. The SRS was monitored and controlled by a control module

mounted under the forward aspect of the center console. A satellite impact sensor was mounted on the center aspect of the radiator support and a safing sensor was mounted under the rear aspect of the center console.

The driver air bag was located in the typical manner in the center hub of the steering wheel rim. The air bag module cover flaps were designed in an H-configuration. The dimensions of the upper and lower flap measured 14.7 cm by 12.2 cm (5.8 in by 4.8 in) and 14.7 cm by 5.1 cm (5.8 in by 2.0 in), width by height, respectively. There was no occupant contact to the cover flaps. The deployed driver air bag measured 64.8 cm (25.5 in) in its deflate state. It was tethered by four 6.4 cm (2.5 in) wide internal straps sewn to the face of the bag in a 16.5 cm (6.5 in) circle. The bag was vented by two 3.8 cm (1.5 in) diameter ports located in the 11/1 o'clock positions on the back side of the bag. The face of the bag was soiled in the 9 and 6 o'clock sectors from probable post-crash handling. The physical nature of evidence in these areas was not representative of occupant contact. The back side of the bag exhibited minor evidence of contact to the steering wheel rim.

The front right passenger air bag was a top mount design located in the right aspect of the instrument panel, **Figure 7**. The air bag module cover flap was rectangular in shape and conformed to the contour of the instrument panel. The flap was comprised of vinyl with a sheet metal backer. The sheet metal deformed during the deployment and acted as a hinge during cover flap rotation. The flap measured 32.5 cm by 13.5 cm (12.8 in by 5.3 in), width by height. There was no contact evidence to the exterior surface of the cover flap.

Figure 7: View of the deployed front right passenger air bag.

The face of the deflated passenger air bag measured 46 cm by 61 cm (18 in by 24 in), width by height. The rearward excursion of the bag measured 52.1 cm (20.5 in) from the aft edge of the module, **Figure 8**. The air bag module was located 5 cm (2 in) forward of the vertical face of the instrument panel, therefore the bag excursion measured 47.0 cm (18.5 in) from the vertical face of the instrument panel. The air bag was not tethered and was vented by two 5 cm (2 in) diameter ports located on the side panels of the bag.

The air bag was comprised of four fabric sections. Two fabric sections formed the top, face, and bottom sections of the bag. These sections were joined together with a fabric seam located on the face of the bag, 43 cm (17 in) below the top surface of the bag. The side panels attached with seams at the perimeter. The center focus of the fold pattern was evident via inspection of the bag. This center was located approximately 2.5 cm (1 in) above the seam on the face of the bag.

Figure 9 is view of the face of the passenger air bag and **Figure 10** is a dimensional schematic depicting the identified contact evidence. The bag's face exhibited evidence of direct occupant contact. The contact pattern appeared brown in color and was a probable pigment transfer from the face of the front right passenger. The contact area was approximately centered laterally on the face of the bag with gross overall dimensions that measured 19.1 cm by 19.1 cm (7.5 in by 7.5 in), width by height. The contact pattern began approximately 7.6 cm (3 in) above the construction seam.

Figure 8: Right lateral view depicting the excursion of the air bag.

Figure 9: View of the PAB face.

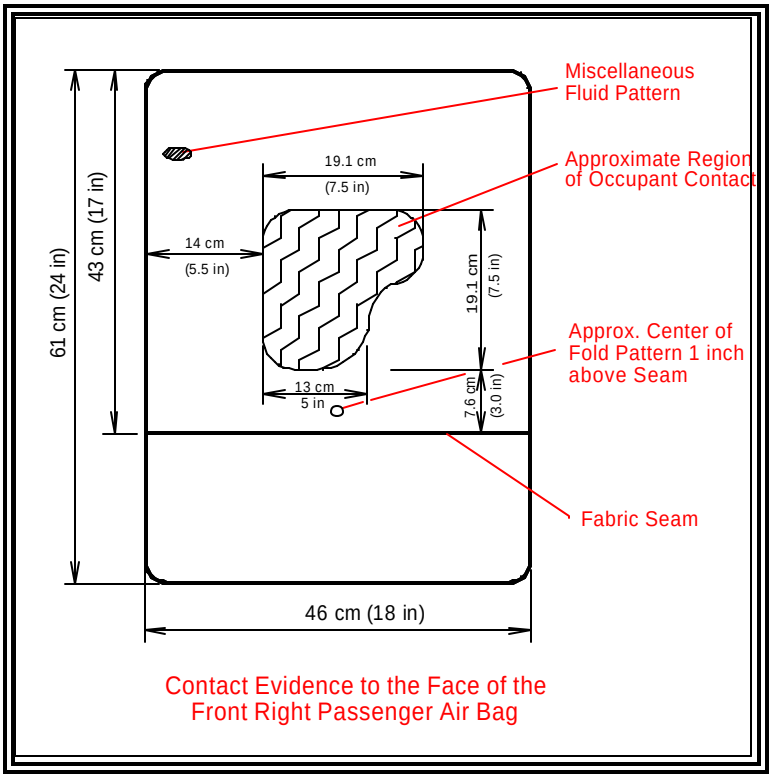

Figure 10: Schematic of the contact evidence to the face of the PAB.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex:	73 year old/ Male
Height:	Pending further information
Weight:	Pending further information
Eye wear:	None, reading glasses only, not on at the time of the crash
Restraint Use:	Restrained by the manual 3-point lap and shoulder belt
Usage Source:	Testimony, lack of interior occupant contacts and the occupant kinematics support the restrained condition
Medical Treatment:	Transported and hospitalized

FRONT RIGHT PASSENGER INJURIES

The medical record indicated the 73 year old male front right passenger was admitted to the hospital through the emergency room as a result of the ocular trauma sustained in the crash. He had an immediate loss of vision at the time of the crash. There was no reported loss of consciousness. The passenger sustained no other injuries aside from the ocular injuries identified in the table below. The following injuries were identified in the emergency room records, ophthalmology consultation, discharge summary and operative report from his initial hospitalization.

Injury	***Injury Severity (AIS Update 98)***	***Injury Mechanism***
Bilateral ruptured globes	Moderate (241202.2,1) (241202.2,2)	Deploying front right passenger air bag
Comminuted fracture of the left orbit	Serious (251204.3,2)	Deploying front right passenger air bag
Conjunctiva laceration, right eye	Minor (240416.1,1)	Deploying front right passenger air bag
Complete hyphema, right eye	Minor (240604.1,1)	Deploying front right passenger air bag
Right eyelid contusion (soft tissue injury)	Minor (297402.1,1)	Deploying front right passenger air bag

The passenger underwent surgery the day of the crash for exploration and repair of his injuries. A primary repair of the right eye was then conducted. Repair of the left eye injury was not possible due to the severity

of the injury. The left eye was eviscerated and closed. The passenger tolerated the procedure well and was discharged from the hospital 3 days post-crash.

The passenger followed-up his initial hospitalization with an ophthalmology specialist. The medical records indicated a secondary right ocular repair was conducted 22 days post-crash. That procedure revealed that further repair to the right eye was not possible. It was determined that the entirety of the choroid and retina were expelled from the eye in the original trauma. There was no viable retina attached to the optic nerve and it was elected that the right eye be closed. The following additional injuries were identified in the operative notes of the secondary surgical procedure:

Injury	***Injury Severity (AIS update 98)***	***Injury Mechanism***
Retinal detachment, right eye	Moderate (241002.2,1)	Deploying front right passenger air bag
Vitreous hemorrhage, right eye	Minor (241699.1,1)	Deploying front right passenger air bag

FRONT RIGHT PASSENGER KINEMATICS

Immediately prior to the crash, the front right passenger was seated in a presumed normal posture with his seat adjusted to an unknown track position. The use of the available 3-point lap and shoulder belt could not be determined based on physical evidence. The passenger was restrained based on his statements and the lack of interior occupant contact evidence.

Upon impact, the seat belt retractors locked and the frontal air bags in the Nissan deployed. The occupant responded to the 12 o'clock direction of the impact force by exhibiting a forward trajectory and loading the locked belt system. The sudden restraint imparted to his chest caused his neck/head complex to flex forward. Coincident to this kinematic pattern, the front right passenger air bag was escaping from the module and unfolding. The expanding air bag struck the occupant about the eyes causing the ocular trauma identified above. As the air bag expanded more fully into a cushion, the occupant continued to load the bag evidenced by the contact pattern to the face of the bag. The occupant then rebounded to rest in his seat where he was found.