Child Safety Seat Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS04021
2003 Nissan Altima
California
September, 2004

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

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

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16. Abstract

This on-site investigation focused on a forward facing booster seat that was installed in the left rear position of a 2003 Nissan Altima. The Nissan Altima was occupied by a 48-year-old female restrained driver and a 4-year-old female who was seated in the booster seat. The booster seat was being used as a belt positioning booster and the vehicle lap and shoulder belt was in use. This two-vehicle crash occurred in September, 2004 at approximately 1108 hours in an urban area of southern California. The crash occurred at the approach to a four-leg intersection. The Nissan was struck in the rear by a Ford E-350 cutaway van. The driver of the Nissan sustained a head injury. The rear left occupant was fatally injured. The driver of the Ford E-350 did not report any injuries. The Nissan was pushed forward into the intersection at approximately a 45 degree angle. The Nissan came to rest in the intersection facing east. The Ford continued forward into and through the intersection at approximately a 45 degree angle. The Ford traveled 61 m (200 ft) before impacting the concrete curb and coming to rest on the western corner of the intersection.

| 17. Key Words | 18. Distribution Statement |
|---|---|
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**Dynamic Science, Inc.**
**Crash Investigation**
**Case Number: DS04021**

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## BACKGROUND:

Description:

This on-site investigation focused on a forward facing booster seat that was installed in the left rear position of a 2003 Nissan Altima. The Nissan Altima was occupied by a 48-year-old female restrained driver and a 4-year-old female who was seated in the booster seat. The booster seat was being used as a belt positioning booster and the vehicle lap and shoulder belt was in use. The Nissan was struck in the rear by a 1994 Ford E-350 cutaway van. The driver of the Nissan sustained a head injury. The rear left occupant was fatally injured. The driver of the Ford E-350 did not report any injuries.

**Figure 1**. Rear right, 2003 Nissan Altima

This Child Safety Seat investigation was identified from a news article. Information from the article was forwarded to NHTSA. DSI was notified on September 22, 2004 with instructions to locate both the case vehicle and the child safety seat. DSI located the vehicle and obtained permission to conduct the inspection on September 30, 2004. The vehicle inspection occurred on October 1, 2004. The scene inspection took place on October 6, 2004.

## SUMMARY

### Crash Site

This two-vehicle crash occurred in September, 2004 at approximately 1108 hours in an urban area of southern California. The crash occurred at the approach to a four-leg intersection. The approaching seven lane roadway has a right hand curve with a positive 5 degree grade and a radius of 1314 m (4310 ft). The roadway is comprised of three westbound travel lanes, a left hand turn lane, and three eastbound travel lanes. The asphalt roadway was dry and free of any defects. The roadways are bordered by 21.0 cm (8.2 in) concrete curbs. The intersection is controlled by tri-color traffic signals that were functioning properly at the time of the crash. The speed limit is 80 km/h (50 mph). The ambient air temperature was 28 degrees C (82 degrees F).

**Figure 2**. Approach to area of impact (Northwest)

**Pre-Crash**

The case vehicle is a 2003 Nissan Altima four-door sedan (VIN: 1N4BL11DX3Cxxxxxx) driven by a restrained 48-year-old age female (173 cm/68 in, 70 kg/155 lbs). The second row left seat was occupied by a 4-year-old female (112 cm/44 in, 17 kg (37 lbs) seated in a Graco booster seat. The Nissan was traveling west in the second lane from the right. The vehicle was slowing as it approached the intersection with an estimated speed of 0-5 km/h (0-3 mph).

The other vehicle was an 1994 Ford E350 (1FDKE37G3RHxxxxxx) configured as a delivery style truck that was being driven by a 40-year-old age male. The Ford was traveling west approaching the intersection at a calculated speed of 114 km (71 mph)[1].

**Crash**

According to witnesses and the lack of physical evidence on the roadway, the driver of the Ford did not attempt to stop. The front of the Ford struck the rear of the Nissan. The Ford completely over-rode the rear bumper of the Nissan. The Nissan sustained a calculated velocity change of between 89-93 km/h (55-58 mph)[2]. The Ford sustained a calculated velocity change of 20.3 km/h (12.6 mph).

The Nissan was pushed forward into the intersection at approximately a 45 degree angle. The Nissan traveled 37 m (123 ft) while rotating in a counterclockwise direction before coming to rest in the intersection facing east. The Ford continued forward into and through the intersection at approximately a 45 degree angle. The Ford traveled 61 m (200 ft) before impacting the concrete curb and coming to rest on the western corner of the intersection.

**Post-Crash**

The driver of the Nissan sustained an acute closed head injury, a cervical strain, and abrasion/contusion to the back of her head. She was able to exit the vehicle under her own power, but witnesses described her condition as “dazed”. She attempted to open the left rear door. A witness assisted her but she became dizzy and was forced to lie down. She was transported by ground ambulance to a local hospital where she arrived with a Glasgow Coma Scale (GCS) score of 15. She underwent a CT scan that proved unremarkable. She was treated and released later that same day. She returned to this same hospital two days later complaining of headaches, dizziness and pain. She was diagnosed as having post-concussive syndrome[3]. She was treated and then released approximately two hours after arrival.

The rear left occupant was fatally injured. A witness helped to extricate the child. Shortly after

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[1]Calculated using in-line linear momentum formula. See Attachment 2.

[2]Calculated using pre-impact speeds ranging from 0 to 3 mph

[3]A central nervous system dysfunction occurring after minor head injury with or without initial loss of consciousness.

the crash two off-duty nurses arrived on scene and began treating the child prior to the arrival of paramedics. The child was transported by ambulance to a local trauma center. She arrived with a GCS score of 3. On examination she was found to be unconscious and unresponsive. CT scans revealed that she had sustained a severe traumatic brain injury with multiple skull and facial fractures, subdural hematoma and subarachnoid hemorrhage, and a right lung contusion. She was admitted into the intensive care unit. She was hospitalized overnight but did not improve. She was declared brain dead at 1318 hours on the following day. She was evaluated for organ donation and several organs were later harvested. An autopsy was conducted the following day.

The driver of the Ford was able to exit his vehicle on his own. He did not sustain any reported injuries.

Both vehicles were towed from the scene due to damage.

**VEHICLE DATA - 2003 Nissan Altima**

The 2003 Nissan Altima was identified by the Vehicle Identification Number (VIN): 1N4BL11DX3Cxxxxxx. The mileage was 16,822 km (10,453 miles). The Altima was equipped with a 3.5 liter V-6 engine, an automatic transmission, 4-wheel disc brakes, air conditioning, a tilt steering wheel, and cruise control.

The 2003 Nissan Altima was equipped with Bridgestone Turanza P215/55R17 brand tires. The specific tire data is as follows:

| Tire | Tread | Measured Pressure | Manufacture's Recommended Pressure |
|---|---|---|---|
| LF | 4 mm (5/32 in) | 179 kPa (26 psi) | 303 kPa (44 psi) |
| LR | 7 mm (9/32 in) | 179 kPa (26 psi) | 303 kPa (44 psi) |
| RF | 3 cm (4/32 in) | 186 kPa (27 psi) | 303 kPa (44 psi) |
| RR | 7 mm (9/32 in) | Flat | 303 kPa (44 psi) |

The front seating positions in the 2003 Nissan Altima were configured with leather covered bucket seats with adjustable head restraints. Both front seats were slightly reclined at the time of inspection. The rear seating positions were configured with a split bench seat with integral head restraints for the outboard positions.

**Figure 3**. Front left, Nissan Altima

## VEHICLE DAMAGE

### Exterior Damage - 2003 Nissan Altima

| | | |
|---|---|---|
| Damage Description: | Major rear end damage. Both right side doors jammed shut. Left rear door partially jammed shut. Trunk overridden. Crush to C pillar on right, as well as backlight frame. Backlight disintegrated. Wheelbase on left side shortened by 3.3 cm (1.3 in). | |
| CDC: | 06BDAW6 | |
| Delta V[4]: | Total | 89-93 km/h (55-58 mph) |
| | Longitudinal | 89-93 km/h (55-58 mph) |
| | Latitudinal | 0 km/h (0 mph) |
| | Energy | Unknown |

There was 152.0 cm (59.8 in) of direct contact to the rear end from the impact with the truck. The rear end was entirely overridden. The bumper and bumper backing bar were both separated from the rear mounting structure. The residual crush was measured at two locations in line with the bumper mounting brackets. A second set of measurements were taken above bumper at these locations. The averaged residual crush was as follows: C1=66.0 cm (25.9 in) and C2=69.0 cm (27.2 in). Additional measurements were taken along the backlight header. The residual crush at this location measured: C1=4.0 cm (1.6 in), C2=4.0 cm (1.6 in), C3=4.0 cm (1.6 in), C4=2.0 cm (0.8 in).

**Figure 5**. Left rear, Nissan Altima

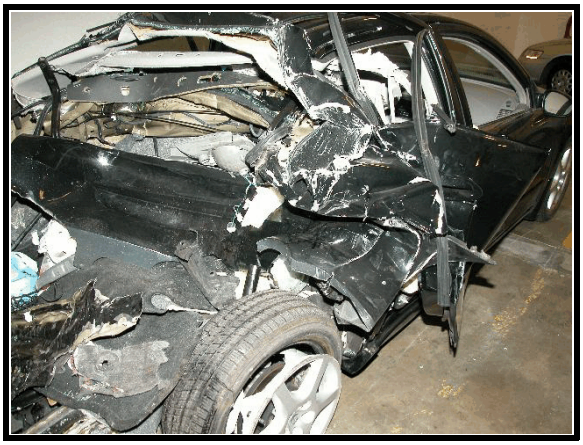


**Figure 4**. Right rear, Nissan Altima

[4]Provided for informational purposes only. Vehicle was overridden.

**Interior Damage - 2003 Nissan Altima**

This Nissan Altima sustained interior damage from passenger compartment intrusion and occupant contacts. The second row seat back intruded from 63.0 cm (24.8 in) longitudinally on the right to 37.0 cm (14.6 in) on the left. There was intrusion of the backlight frame and the C pillar. The right rear and backlight glazing disintegrated due to damage. Both right doors were jammed shut. There was a skin contact to the back of the driver's seat.

The specific passenger compartment intrusions were documented as follows:

| Position | Intruded Component | Magnitude of Intrusion | Direction |
|---|---|---|---|
| LR | Rear seat back | 37.0 cm (14.6 in) | Longitudinal |
| LR | Backlight | 7.0 cm (2.8 in) | Longitudinal |
| LR | Driver's seat back | 40.0 cm (15.7 in) | Longitudinal |
| MR | Top of backlight | 8.0 cm (3.1 in) | Longitudinal |
| MR | Rear seat back | 42.0 cm (16.5 in) | Longitudinal |
| RR | Rear seat back | 63.0 cm (24.8 in) | Longitudinal |
| RR | C pillar | Unknown | Longitudinal |
| MR | Trunk latch assembly | Unknown | Longitudinal |

**Figure 6**. Rear seat intrusion, Nissan Altima

**MANUAL RESTRAINT SYSTEMS - 2003 Nissan Altima**

The Nissan Altima was configured with manual 3-point lap and shoulder belts for both front positions and all three rear seat positions. The front seat restraints were configured with adjustable shoulder belt upper anchorages. The driver anchorage had been adjusted to the full down position. The front right anchorage had been adjusted to the full down position. All the seat belts were equipped with sliding latch plates. The driver's seat belt was equipped with an emergency locking retractor. The front right passenger's seat belt and all three rear seat belts were equipped with switchable retractors (retractors that can be changed from an emergency locking retractor to an automatic locking retractor to assist in securing child seats).

**FRONTAL AIR BAG SYSTEM - 2003 Nissan Altima**

The Nissan Altima was equipped with frontal air bags for the driver and front right passenger positions. The driver's air bag was housed in the steering wheel hub. The front right passenger's air bag was housed on top of the instrument panel. There were no air bag deployments.

**Child Safety Seat Discussion**

The 4-year-old female rear left occupant was seated in a GRACO Ultra CarGo Booster Car Seat 8487 (Manufacture date 07/21/2003). According to the manufacturer, the seat is designed to accommodate a child weighing between 9 kg (20 lbs) and 36 kg (80 lbs). For smaller children 14-18 kg (30-40 lbs), the seat is equipped with a 5-point harness. As the child grows 14-36 kg (30-80 lbs), the harness is removed and the car seat becomes a belt positioning booster which allows the child to use the vehicle combination lap and shoulder belt. The seat was being used as a belt positioning booster in this case. The child weighed 17 kg (37 lbs), making the use of the seat as a belt positioning booster appropriate. The child seat had been placed on the leather covered split bench seat that was equipped with folding backs. The seat bottom angle was 16 degrees from horizontal. The child was wearing the available lap and shoulder belt. The lap and shoulder belt was equipped with a switchable retractor and a sliding latch plate. It is believed that the seat belt was being used in the emergency locking mode. The belt was found in the spooled out (used) position.

**Figure 7**. Left rear seat position

At impact, the seat was forced forward due to intrusion. The child safety seat back was stressed/bent at the top right and to the right middle. The rear left seat back had a post crash angle of 11 degrees forward from vertical.


**Figure 8**. GRACO Ultra CarGo Booster Car Seat 8487


**Figure 9**. Booster seat with cover on and off. Right image locates stress marks.

**Figure 10**. Close up view of top stress mark

**Figure 11**. Close up of right seat back stress mark

**VEHICLE DATA - 1994 Ford Econoline cutaway van**

| | | |
|---|---|---|
| Description: | 1994 Ford Econoline E350 4x2 commercial cutaway van, 10,000-14,000 GVWR | |
| VIN: | 1FDKE37G3RHxxxxxx | |
| Odometer: | Unknown | |
| Engine: | 7.5L V-8 | |
| Reported Defects: | None related to this crash. | |
| Cargo: | Large commercial type carpet cleaning apparatus (unknown weight). | |
| Damage Description: | Front bumper pushed inward on left side, front grille broken out, bumper pushed down on right side, hood pushed back and buckled upward. Windshield had spider web type fractures on the right and left sides. (Per police report). | |
| CDC: | Unknown | |
| Delta V: | Total | Unknown |
| | Longitudinal | Unknown |
| | Latitudinal | Unknown |
| | Energy | Unknown |

**OCCUPANT DEMOGRAPHICS - 2003 Nissan Altima**

| | Driver | Occupant 2 |
|---|---|---|
| Age/Sex: | 48/Female | 4/Female |
| Seated Position: | Front left | Second row left seat |
| Seat Type: | Leather covered bucket seat. Seat adjusted to forward most track position. Post crash seat back angle = 44.8 degrees. Seat bottom angle = 18.9 degrees. Seat back deformed. | Leather covered split bench seat. The seat back angle measured -11 degrees, post-crash. The seat back was deformed by intrusion. |
| Height: | 173 cm (68 in) | 112 cm (44 in) |
| Weight: | 70 kg (155 lbs) | 17 kg (37 lbs) |
| Occupation: | Unknown | Unknown |
| Pre-existing Medical Condition: | On Zoloft and Xanax[5] before crash | None noted |
| Alcohol/Drug Involvement: | None | NA |
| Driving Experience: | Presumed to be greater than 20 years | NA |
| Body Posture: | Normal, upright | Normal, upright |
| Hand Position: | Unknown | Unknown |
| Foot Position: | Right foot likely on accelerator, left on floor | NA |
| Restraint Usage: | Lap and shoulder belt available, used. | Lap and shoulder belt used with belt positioning booster safety seat. |
| Air bag: | Steering wheel mounted front air bag, did not deploy. | None |

[5]Used primarily for short-term relief of mild to moderate anxiety and nervous tension.

## OCCUPANT DEMOGRAPHICS - Ford E350

| | |
|---|---|
| Age/Sex: | 40/Male |
| Seated Position: | Front left |
| Seat Type: | Unknown |
| Height: | 188 cm (74 in) |
| Weight: | 95 kg (210 lbs) |
| Occupation: | Carpet cleaner |
| Pre-existing Medical Condition: | None noted |
| Alcohol/Drug Involvement: | None |
| Driving Experience: | Greater than 20 years |
| Body Posture: | Normal, upright |
| Hand Position: | Unknown |
| Foot Position: | Right foot on brake, left on floorboard. |
| Restraint Usage: | Lap and shoulder belt available, used |

**OCCUPANT INJURIES -2003 Nissan Altima**

Driver: Injuries obtained from EMS records, emergency room records (initial and follow up visit), and CT scan.

| Injury | OIC Code | Injury Mechanism | Confidence Level |
|---|---|---|---|
| Concussion, no loss of consciousness, dizziness | 160402.1,0 | Seat back | Certain |
| Cervical strain | 640278.1,6 | Impact forces | Certain |
| Abrasion/contusion, posterior scalp | 190202.1,6<br>190402.1,6 | Seat back | Certain |

Second row left occupant: Injury information obtained from autopsy report, a hospital death summary, a history and physical examination report, radiology reports, and operative reports.

| Injury | OIC Code | Injury Mechanism | Confidence Level |
|---|---|---|---|
| Multiple comminuted fractures to the left frontal, parietal and temporal bones. Some were linear down to the frontal skull base. Herniating brain through the fracture sites of the dural lacerations. Marked flattening of the cortical convolutions. | 150406.4,5<br>150406.4,2<br>150200.3,8 | Driver's seat back | Certain |
| Left orbit fracture (CT) | 251202.2,2 | Driver's seat back | Certain |
| Marked softening of the brain substance throughout including the midbrain, pons and cerebellum[6] | 140210.5,8 | Driver's seat back | Certain |
| Hematoma, left side of forehead | 290402.1,7 | Driver's seat back | Certain |
| Hematoma, left eye | 297402.1.2 | Driver's seat back | Certain |

[6]A localized softening of the brain substance, due to hemorrhage or inflammation. Coded as injury involving hemorrhage.

| | | | |
|---|---|---|---|
| L shaped laceration of the anterior axillary fold area (under arm), right side | 490600.1,1 | Torso belt | Certain |
| Pulmonary contusion, right side | 441402.3,1 | Torso belt | Probable |
| Severe cerebral edema (CAT) | 140660.3,9 | Driver's seat back | Certain |

**OCCUPANT INJURIES - 1994 Ford E350**

| | Injury | OIC Code | Injury Mechanism | Confidence Level |
|---|---|---|---|---|
| Driver: | No reported injuries | | | |

## OCCUPANT KINEMATICS - 2003 Nissan Altima

### Driver kinematics

The 48-year-old female driver was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt. The leather covered bucket seat was adjusted to forward most track position. The adjustable head restraint was just above the bottom most position. At the time of inspection the seat back angle was 44.8 degrees and the seat bottom angle was 18.9 degrees. Her right foot was likely on accelerator with the left on the floorboard. At impact, the female driver initiated a rearward trajectory in response to the 180 degree direction of force. She loaded and deformed the seat back and head restraint with her head and back—causing contusions/abrasions to the posterior portion of her head, a concussion, and a cervical strain. After impact, she rebounded to some degree and came to rest upright in her seat. She was able to exit the vehicle on her own, but witnesses described her condition as "dazed".

**Figure 12**. Driver's seat with deformed seat back

### Rear left occupant kinematics

The 4-year-old female rear left occupant was seated in an upright posture in a Graco Booster seat. The child seat was placed on a leather covered split bench seat with folding back. The child seat was being used as a belt positioning booster and the child was restrained by the 3-point manual lap and shoulder belt. The lap and shoulder belt was equipped with a switchable retractor and a sliding latch plate. It is believed that the seat belt was being used in the emergency locking mode. The belt was found in the spooled out (used) position. At impact, the 4-year-old initiated a rearward trajectory in response to the 180 degree direction of force. She loaded the child restraint and does not appear to have been injured at this point. As the crash continued, the second row seat back was forced forward due to intrusion. The seat back angle measured -11 degrees, post-crash. This forced the child seat forward also. The combination of the rear seat moving forward and the driver's seat moving rearward caused the distance between the two seats to significantly decrease. The child occupant was forced forward

**Figure 13**. Distance between the driver's seat and the second row seat

and the left side of her head/face engaged the back of the driver's seat–causing the skull, brain, and facial injuries. As she was moved forward, the torso belt engaged the area of the right armpit–causing an L shaped laceration and a right pulmonary contusion. A witness helped to extricate the child. Shortly after the crash two off-duty nurses arrived on scene and began treating the child prior to the arrival of paramedics. The child was transported by ambulance to a local trauma center. She was declared brain dead at 1318 hours on the following day. She was evaluated for organ donation and several organs were later harvested. An autopsy was conducted the following day.

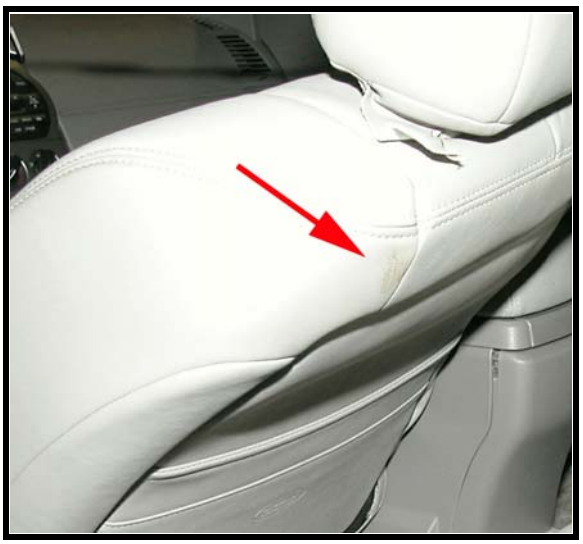
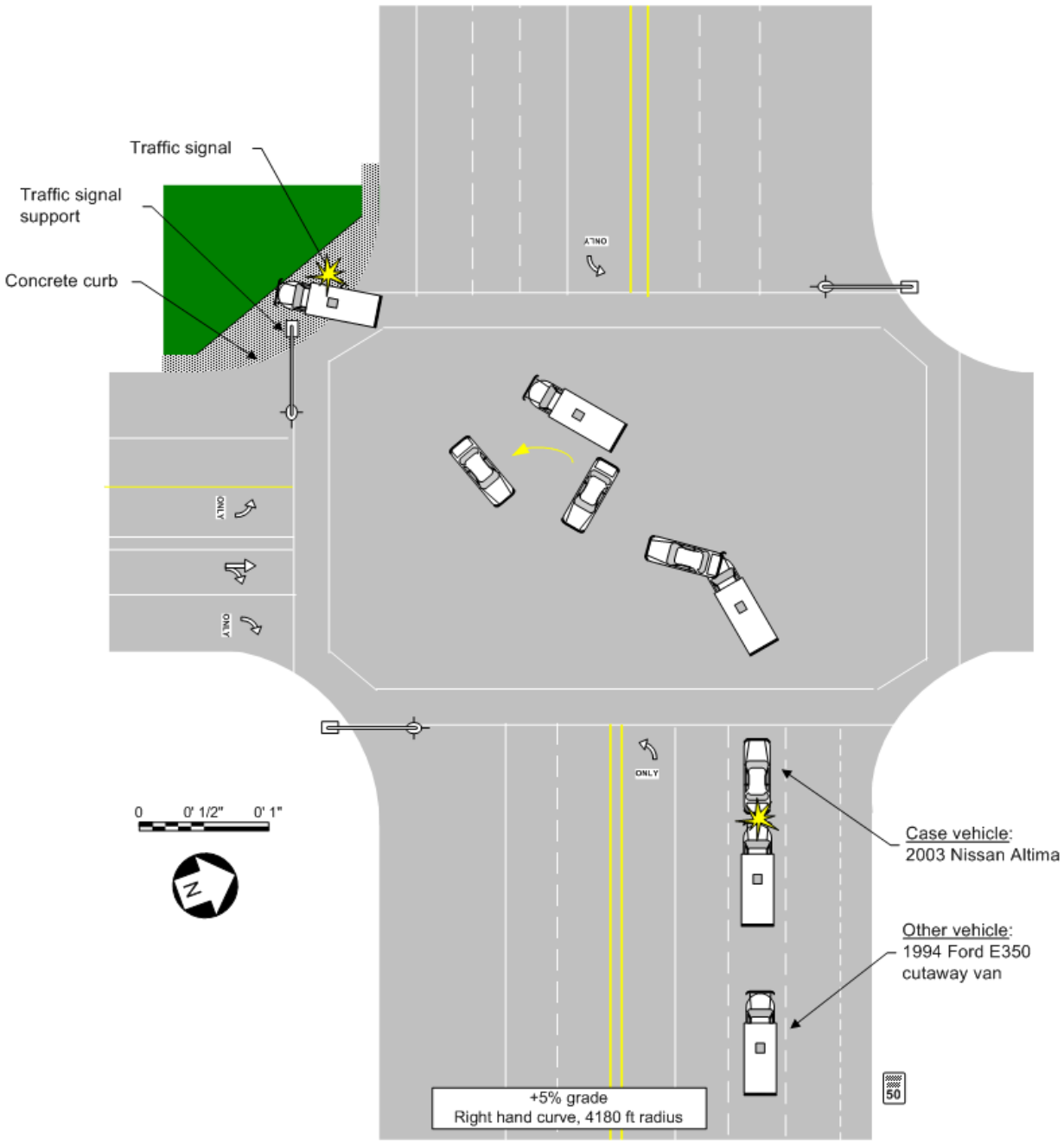


**Figure 14**. Skin/blood contact to rear of driver's seat

**Attachment 1. Scene Diagram**



## Attachment 2. Calculations

**CASE NUMBER: DS04021**

Comments: v2 is struck nissan, range from stopped to 3 mph

*** * LINEAR MOMENTUM * ***

W1 × V1 + W2 × V2 = W1 × V3 + W2 × V4
14010.00 × V1 + 3304.00 × 0.00 = 14010.00 × 58.00 + 3304.00 × 58.00
14010.00 × V1 + 0.00 = 812580.00 + 191632.00
14010.00 × V1 + 0.00 = 1004212.00
14010.00 × V1 = 1004212.00 - 0.00
14010.00 × V1 = 1004212.00

$$V1 = \frac{1004212.00}{14010.00}$$

V1 = 71.67

W1 = The Wt of Veh 1 in Pounds.
W2 = The Wt of Veh 2 in Pounds.
V1 = The Speed of Veh 1 in MPH.
V2 = The Speed of Veh 2 in MPH.
V3 = The Spd After Impact, Veh 1.
V4 = The Spd After Impact, Veh 2.

| INPUTS: | |
|---|---|
| The Wt of Veh 1 in Pounds is: | 14010.00 |
| The Min. Spd After Impact, Veh 1 is: | 58.00 |
| The Wt of Veh 2 in Pounds is: | 3304.00 |
| The Impact Spd of Veh 2 is: | 0.00 |
| The Min. Spd After Impact, Veh 2 is: | 58.00 |

| RESULTS: | |
|---|---|
| The Spd of Veh 1 in MPH is: | 71.67 |
| The Vel of Veh 1 in FPS is: | 105.06 |

| IS V2 | Speed |
|---|---|
| 0.00 | 71.67 |
| 1.00 | 71.44 |
| 2.00 | 71.20 |
| 3.00 | 70.97 |
| | |
| | |
| | |
| | |
| | |
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INCREMENTATION CALCs:

| IS V2 | Speed |
|---|---|
| | |
| | |
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| | |
| | |

**CASE NUMBER: DS04021**

Comments: Ford E350

*** * DELTA V * ***

$\Delta V = \sqrt{V2^2 + V4^2 - (2 \times V2 \times V4 \times \cos\beta)}$

$\Delta V = \sqrt{70.00^2 + 58.00^2 - (2 \times 70.00 \times 58.00 \times 1.00)}$

$\Delta V = \sqrt{4900.00 + 3364.00 - 8103.76}$

$\Delta V = \sqrt{8264.00 - 8103.76}$

$\Delta V = \sqrt{160.24}$

$\Delta V = 12.65$

$\Delta V$ = Delta V (change in Velocity).
V2 = The Pre-Impact Vel of Veh 2.
V4 = The Post-Impact Vel of Veh 2.
2 = A Constant.
$\beta$ = The Approach - Departure Angle.

| INPUTS: | |
|---|---|
| The Pre-Impact Vel of V2 is: | 70.00 |
| The Post-Impact Vel of V2 is: | 58.00 |
| The Angle is: | -4.00 |

| RESULTS: | |
|---|---|
| Delta V is: | 12.65 |

**CASE NUMBER: DS04021**

Comments: Nissan

*** * DELTA V * ***

$\Delta V = \sqrt{V1^2 + V3^2 - (2 \times V1 \times V3 \times \cos\Theta)}$

$\Delta V = \sqrt{0.00^2 + 58.00^2 - (2 \times 0.00 \times 58.00 \times 1.00)}$

$\Delta V = \sqrt{0.00 + 3364.00 - 0.00}$

$\Delta V = \sqrt{3364.00 - 0.00}$

$\Delta V = \sqrt{3364.00}$

$\Delta V = 58.00$

$\Delta V$ = Delta V (change in Velocity).
V1 = The Pre-Impact Vel of Veh 1.
V3 = The Post-Impact Vel of Veh 1.
2 = A Constant.
$\Theta$ = The Departure Angle.

| INPUTS: | |
|---|---|
| The Pre-Impact Vel of V1 is: | 0.00 |
| The Post-Impact Vel of V1 is: | 58.00 |
| The Depart Angle, Veh 1 is: | 4.00 |

| RESULTS: | |
|---|---|
| Delta V is: | 58.00 |

| Pre Vel | Delta V |
|---|---|
| 0.00 | 58.00 |
| 1.00 | 57.00 |
| 2.00 | 56.00 |
| 3.00 | 55.00 |
| | |
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INCREMENTATION CALCs:

| Pre Vel | Delta V |
|---|---|
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