

Rollover Investigation  
Dynamic Science, Inc. / Case Number: DS07025  
2006 Nissan Armada  
Washington  
May 2007

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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 <p>This on site investigation focused on a 2006 Nissan Armada that was involved in a rollover crash. This single vehicle crash occurred in May 2007 at 1805 hours. The crash occurred on a three-lane divided interstate highway. The speed limit at this location is 115 km/h (70 mph). The case vehicle was a 2006 Nissan Armada that was being driven by a restrained 45-year-old male. There were three additional occupants in the vehicle, including: a 43-year-old female front right seat occupant, a 7-year-old female second row left occupant, and an 11-year-old male second row right occupant. All occupants were restrained. The case vehicle was traveling northbound on the three-lane interstate highway. The vehicle was pulling an 18-foot long travel trailer. The case vehicle was initially in the far right hand lane. As it approached slower traffic, the driver changed lanes to the left. When he changed lanes back to the right, the trailer began to oscillate. The driver lost control of the vehicle and it went into a counterclockwise rotation. The vehicle tripped and rolled one quarter turn onto its right side. The Nissan Armada was towed from the scene due to damage. It was later declared to be a total loss by the insurance company.</p>				
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## BACKGROUND

This on site investigation focused on a 2006 Nissan Armada (Figure 1) that was involved in a rollover crash. This single vehicle crash occurred in May 2007 at 1805 hours. The crash occurred on a three-lane divided interstate highway. The speed limit at this location is 115 km/h (70 mph). The case vehicle was a 2006 Nissan Armada that was being driven by a restrained 45-year-old male. There were three additional occupants in the vehicle, including a 43-year-old female front right seat occupant, a 7-year-old female second row left occupant, and an 11-year-old male second row right occupant. All occupants were restrained.



**Figure 1.** Rollover damage, 2006 Nissan Armada

The case vehicle was traveling northbound on the three-lane interstate highway. The vehicle was pulling an 18-foot long travel trailer. The case vehicle was initially in the far right hand lane. As it approached slower traffic, the driver changed lanes to the left. When he changed lanes back to the right, the trailer began to oscillate. The driver lost control of the vehicle and it went into a counterclockwise (CCW) rotation. The vehicle tripped and rolled one quarter turn onto its right side. The Nissan Armada was towed from the scene due to damage. It was later declared to be a total loss by the insurance company.

This rollover investigation was identified by the local NASS team during a visit to a tow facility. DSI was instructed to contact Nissan and obtain their Event Data Recorder (EDR) download tool. Nissan was contacted and the tool was shipped to the NASS team office. The case vehicle was located and the insurance company put a hold on the vehicle. On June 30, 2007 DSI obtained a copy of the police report. The case vehicle was inspected and the EDR was downloaded using the Nissan Consult II tool on July 2, 2007. The data was collected and forward to Nissan on July 6, 2007 for analysis. A copy of the readout is included as Attachment 2 to this report.

## SUMMARY

### Crash Site

This single vehicle crash occurred in May 2007 at 1805 hours. The crash occurred on a three-lane divided interstate highway (Figure 2). At the time of the crash, there were no adverse weather conditions and the concrete roadway surface was dry. The highway was configured with three lanes that were separated by broken white lines. The roadway was bordered on the east by an asphalt shoulder that was separated from the roadway by a solid white line. The roadway was bordered on the west by an asphalt shoulder that was



**Figure 2.** Area of overturn (north)

separated from the roadway by a solid yellow line. Beyond the shoulder to the east, a narrow patch of grass, followed by a cable median divider, was present. The speed limit at this location was 97 km/h (60 mph) for trucks and 113 km/h (70 mph) for other vehicles.

### **Pre Crash**

There were three additional occupants in the vehicle, including: a 43-year-old female front right seat occupant, a 7-year-old female second row left occupant, and an 11-year-old male second row right occupant. All the occupants were restrained. The case vehicle was traveling northbound on the three-lane interstate highway. The vehicle was pulling an 18-foot long travel trailer. The trailer was attached to the Armada with a DrawTite trailer hitch. The hitch was rated for a maximum gross trailer weight of 4,536 kg (10,000 lbs). The case vehicle was initially in the far right hand lane. As the vehicle approached slower traffic, the driver changed lanes to the left.

### **Crash**

When the driver of the Nissan changed lanes back to the right, the trailer began to oscillate. The driver lost control of the vehicle and it began to rotate CCW. The vehicle tripped and overturned one quarter turn onto its right side.

### **Post Crash**

The four occupants inside the the case vehicle were able to exit under their own power through the driver's door. The driver and front right occupant sustained multiple contusions. The second row left occupant was not injured. The second row right occupant sustained a left ankle contusion. They were examined at the scene, but were not transported.

The Nissan Armada was towed from the scene due to damage. It was later declared to be a total loss by the insurance company

**VEHICLE DATA - 2006 Nissan Armada**

The 2006 Nissan Armada LE was identified by the Vehicle Identification Number (VIN): 5N1AA08B56Nxxxxxx. The vehicle's digital odometer showed the vehicle had been driven 12,473 km (7,751 miles). The Nissan Armada was a four-door sport utility vehicle that was equipped with 5.6 liter, V-8 engine, an automatic five-speed transmission, four-wheel drive, front/rear disc brakes with ABS, power steering, and a tilt steering wheel. According to the NHTSA NCAP website, the Armada had a Static Stability Factor (SSF)<sup>1</sup> of 1.15 with a chance of rollover at 21%. The Armada was configured with Continental Contitrac P265/70R18 tires. The vehicle manufacturer's recommended tire pressure was 241 kPa (35 psi); the tire manufacturer's recommended tire pressure was 303 kPa (44 psi). The specific tire information is as follows:

<b>Position</b>	<b>Measured Pressure</b>	<b>Measured Tread Depth</b>	<b>Restricted</b>	<b>Damage</b>
LF	193 kPa (28 psi)	8 mm (10/32 in)	No	None
LR	283 kPa (41 psi)	7 mm (9/32 in)	No	None
RR	172 kPa (25 psi)	6 mm (8/32 in)	No	None
RF	290 kPa (42 psi)	8 mm (10/32 in)	No	None

The seating in the seven passenger Armada was configured with front leather covered bucket seats with adjustable active head restraints, second row bucket seats, and a third row 60/40 bench seat. The driver's seat was located 44.0 cm (17.3 in) rear of the A pillar; the front right passenger's seat was located 46.0 cm (18.1 in) rear of the A pillar. The driver's head restraint was adjusted to 19.0 cm (7.5 in) above the seat back; the front right passenger's head restraint was adjusted to 24.5 cm (9.6 in) above the seat back.

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<sup>1</sup>The Static Stability Factor (SSF) of a vehicle is an at-rest calculation of its rollover resistance based on its most important geometric properties. SSF is a measure of how top-heavy a vehicle is. A vehicle's SSF is calculated using the formula  $SSF=T/2H$ , where T is the "track width" of the vehicle and H is the "height of the center of gravity" of the vehicle. The lower the SSF number, the more likely the vehicle is to roll over in a single-vehicle crash.

## Vehicle Damage

### Exterior Damage -2006 Nissan Armada

The 2006 Nissan Armada sustained minor rear damage as a result of the intra-unit contact with the travel trailer, possibly prior to the rollover (Figure 3). The direct damage began 12.0 cm (4.7 in) left of the vehicle centerline and extended 60.0 cm (23.7 in) to the left. The maximum crush measured 12.0 cm (4.7 in) on the tailgate. There was also a light scratch that began 14.0 cm (5.5 in) right of the centerline and extended 66.0 cm (25.9 in) to the right. The CDC for the intra-unit contact was 06BDMW1. There also appeared to be some damage to the stop on the trailer hitch that occurred during the movement between the vehicle and the trailer (Figure 4).

The Armada sustained moderate right side damage as a result of the one quarter turn rollover (Figures 5 and 6). The direct damage began at the front right bumper corner and extended 462.0 cm (181.9 in) rearward along the right side plane. The maximum crush was located near the base of the C pillar at the right rear door edge and measured 4.0 cm (1.6 in). The CDC for the rollover was 00RDAO2.

Both right side doors were jammed shut. The windshield cracked. It was later holed by heat sag. The third row right side glass disintegrated.



**Figure 3.** Trailer damage, Nissan Armada



**Figure 4.** Damage to trailer hitch



**Figure 5.** Right side rollover damage



**Figure 6.** Close up of rollover damage



### Interior Damage - 2006 Nissan Armada

The 2006 Nissan Armada sustained minor interior damage as a result of passenger compartment intrusion. The right side doors, right roof rail and right B pillar sustained lateral intrusion.

The specific passenger compartment intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
Right front	Roof rail	2.0 cm (0.8 in)	Lateral
Right front	B pillar	3.0 cm (1.2 in)	Lateral
Right front	Door	4.0 cm (1.6 in)	Lateral
Second row right	Door	3.0 cm (1.2 in)	Lateral



**Figure 7.** Front right door/B pillar intrusion



**Figure 8.** Second row right door intrusion

### Manual Restraints -2006 Nissan Armada

The 2006 Nissan Armada was configured with manual 3-point lap and shoulder belts for all seven seating positions. Both front seat belts were equipped with retractor and buckle pretensioners and adjustable D-rings that were in the full down positions. According to the EDR report, both front seat belt pretensioners actuated. The driver's safety belt was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). At the time of the vehicle inspection, the driver's retractor was restricted in the used position as a result of pretensioner actuation. There were loading marks found on the driver's seat belt webbing (Figure 8).

The right front seat belt had a sliding latch plate and a switchable ELR/automatic locking retractor (ALR). The second and third row safety belts had sliding latch plates and switchable ELR/ALR retractors.



**Figure 9.** Load marks to driver's seat belt webbing



**Figure 10.** Front right passenger seat belt D ring/shoulder adjustment

## Supplemental Restraint Systems -2006 Nissan Armada

The 2006 Nissan Armada was equipped with dual-stage advanced frontal air bags, driver and front right seat seatback mounted side air bags, and roof rail mounted side inflatable curtains (IC). The frontal air bags were Certified Advanced 208-Compliant (CAC). A CAC vehicle is certified by the manufacturer to be compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The frontal air bags and seat back mounted side air bags did not deploy. The left and right IC air bags deployed during the rollover.

The side IC bags deployed from the roof rail cladding. The IC bags provide coverage for all three rows of seats. The IC was anchored to the A pillar in the front by a tether/sail that measured 34.0 cm (13.4 in) along the base by 27.0 cm (10.6 in) along the top. The IC height at this location was 39.0 cm (15.4 in). The IC extended rearward to the C pillar for 159.0 cm (62.6 in). The IC height at this location was 43.5 cm (17.1 in). There was a gap of 28.0 cm (11.0 in) between the IC in the second row seat and the IC in the third row seat. The IC that covered the third row was connected to the second row IC by a 63.0 cm (24.8 in) tether. The IC in the third row was 63.0 cm (24.8 in) wide by 53.0 cm (20.9 in) high.



**Figure 11.** Front right IC



**Figure 12.** Right side deployed IC



**Figure 13.** Exterior view of third row portion of side IC

## Event Data Recorder

The EDR was downloaded with the Nissan Consult II tool on July 2, 2007. A copy of the data readout from the EDR was forwarded to Nissan on July 6, 2007 for analysis. A copy of the data readout is included as Attachment 2 to this report.

The following data were provided by the vehicle manufacturer and from the download of the EDR:

- Rollover detected
- Roll angle = 22 degrees
- Roll rate = 98 deg/sec
- Time to deploy = 10 ms
- There were no prior problems with the air bag system
- The front seats in the Armada have two pretensioners, one at the retractor and one at the buckle. All pretensioners actuated.

**OCCUPANT DEMOGRAPHICS - 2006 Nissan Armada**

	<b>Driver</b>	<b>Front right occupant</b>
Age/Sex:	45/Male	43/Female
Seated Position:	Front left	Front right
Seat Type:	Leather covered bucket seat	Leather covered bucket seat
Height:	180 cm (71 in)	168 cm (66 in)
Weight:	82 kg (180 lbs)	61 kg (130-140 lbs)
Occupation:	Unknown	N/A
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	None	None
Driving Experience:	>20 years	N/A
Body Posture:	Normal, upright	Normal, upright
Hand Position:	10 and 2 o'clock positions	Unknown
Foot Position:	Right foot on brake, left on floor	Both feet on floor board
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used
Air bag:	Steering wheel mounted frontal air bag, did not deploy. Seat back mounted side air bag, did not deploy. IC, deployed.	Instrument mounted frontal air bag, did not deploy. Seat back mounted side air bag, did not deploy. IC, deployed.

	<b>Second row left occupant</b>	<b>Second row right occupant</b>
Age/Sex:	7/Female	11/Male
Seated Position:	Second row left	Second row right
Seat Type:	Leather covered bucket seat	Leather covered bucket seat
Height:	122 cm (48 in)	157 cm (62 in)
Weight:	27 kg (60 lbs)	52 kg (115 lbs)
Occupation:	N/A	N/A
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	N/A	N/A
Driving Experience:	N/A	N/A
Body Posture:	Normal, upright	Normal, upright
Hand Position:	Unknown	Unknown
Foot Position:	Both feet on floor board	Both feet on floor board
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used
Air bag:	IC available, deployed	IC available, deployed

## **OCCUPANT KINEMATICS**

### **Driver Kinematics**

The 45-year-old male driver was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt. The seat track was positioned 44.0 cm (17.3 in) rear of the bottom A pillar. The seat back angle was 12 degrees from vertical. The seat cushion angle was 11 degrees from horizontal. The head restraint was positioned 19.0 cm (7.5 in) above the driver's seat back. Initially, the driver had his hands at the 10 and 2 o'clock positions on the steering wheel and his right foot on the accelerator. The driver changed lanes to the left to pass a slower moving vehicle. After the lane change, the vehicle began oscillating and the driver began steering left and braking. The vehicle eventually went into a CCW rotation, tripped and overturned onto its right side. During the rollover, the side IC bags deployed and the seat belt pretensioners actuated. The driver was held in place during the rollover. He sustained multiple contusions from loading his seat belt. He was examined at the scene but was not transported.

### **Front Row Right Seat Occupant Kinematics**

The 43-year-old female front right seat occupant was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt. The seat track was positioned 46.0 cm (18.1 in) rear of bottom aspect of the A pillar. The seat back angle was 12 degrees from vertical. The seat cushion angle was 11 degrees from horizontal. The head restraint was positioned 24.5 cm (9.6 in) above the front right passenger's seat back. As the vehicle overturned, the side IC bags deployed and the seat belt pretensioners actuated. The front right seat passenger was held in place during the rollover. She sustained multiple contusions from loading her seat belt. She was examined at the scene but was not transported.

### **Second Row Left Seat Occupant Kinematics**

The 7-year-old female second row left seat occupant was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt. The seat back angle was 12 degrees from vertical. The seat cushion angle was 10 degrees from horizontal. During the rollover, the second row left seat passenger was held in place by her safety belt. She did not sustain any injuries. She was examined at the scene but was not transported.

## Second Row Right Seat Occupant Kinematics

The 11-year-old male second right row seat occupant was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt. The seat back angle was 12 degrees from vertical. The seat cushion angle was 11 degrees from horizontal. During the rollover, the second row right seat passenger was held in place by his safety belt. He sustained a contusion to the left ankle. He was examined at the scene but was not transported.

## OCCUPANT INJURIES - 2006 Nissan Armada

Driver: Injuries obtained from interviewee.

<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Shoulder contusion, left	790402.1,2	Seat belt webbing	Certain
Chest contusion, central	490402.1,4	Seat belt webbing	Certain
Abdomen contusion, right	590402.1,1	Seat belt webbing	Certain

Front Right Seat Occupant: Injuries obtained from interviewee.

<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Shoulder contusion, right	790402.1,1	Seat belt webbing	Certain
Chest contusion, central	490402.1,4	Seat belt webbing	Certain
Abdomen contusion, left	590402.1,2	Seat belt webbing	Certain

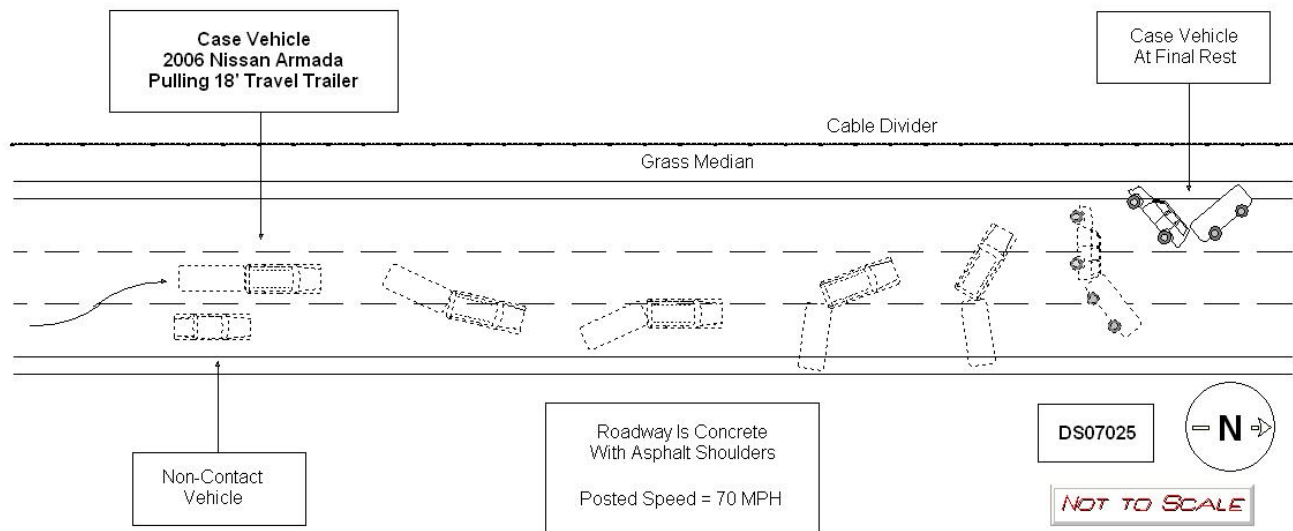


Second Row Left Seat Occupant: Not injured.

Second Row Right Seat Occupant: Injuries obtained from interviewee.

<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Ankle, contusion, left	890402.1,2	Seat bottom	Possible

### Attachment 1. Scene Diagram



**Attachment 2. Readout from Nissan Consult II tool**

SYSTEM AIR BAG  
 DATE 01/01/1980 00:18:00  
 PROG No. 303A

SELF-DIAG [CURRENT]

DTC RESULTS

ROLLOVER DETECTION

[B1211]  
 PRE-TEN FRONT RH  
 [OPEN]  
 [B1081]  
 PRE-TEN FRONT LH  
 [OPEN]  
 [B1086]  
 CURTAIN MODULE RH  
 [OPEN]  
 [B1145]  
 CURTAIN MODULE LH  
 [OPEN]  
 [B1150]  
 FR CURTN MODULE RH  
 [OPEN]  
 [B1193]  
 FR CURTN MODULE LH  
 [OPEN]  
 [B1198]  
 PRE-TEN2 FRONT RH  
 [OPEN]  
 [B1177]  
 PRE-TEN2 FRONT LH  
 [OPEN]  
 [B1182]

SYSTEM AIR BAG  
 DATE 01/01/1980 00:18:52  
 PROG No. 303A

SELF-DIAG [PAST]

DTC RESULTS

NO DTC IS DETECTED.  
 FURTHER TESTING  
 MAY BE REQUIRED.

SYSTEM AIR BAG  
 DATE 01/01/1980 00:19:21  
 PROG No. 303A

TROUBLE DIAG RECORD

DTC RESULTS

NO DTC IS DETECTED.  
 FURTHER TESTING  
 MAY BE REQUIRED.

SYSTEM AIR BAG  
 DATE 01/01/1980 00:21:39  
 PROG No. 303A

RECORDED DATA READOUT

f:00	r:01
a0:D3	a1:51
a2:56	a3:91
a4:96	a5:C1
a6:C6	a7:B1
a8:B6	a9:00
aa:00	ab:00
ac:00	ad:00
ae:00	af:00
A1:00	A2:00
A3:00	A4:00
A5:00	B1:00
B2:00	B3:00
B4:00	B5:00
C1:00	C2:00
C3:00	C4:00
C5:00	D1:00
D2:00	D3:00
D4:00	D5:00
E1:00	E2:00
E3:00	E4:00
E5:00	F1:00
F2:00	G:00
U:3C	I1:00
J1:00	K1:00

L1:00	M1:00
I2:00	J2:00
K2:00	L2:00
M2:00	IR:00
JR:00	KR:00
LR:00	MR:00
IL:00	JL:00
KL:00	LL:00
ML:00	R:00
S1:00	S2:00
S3:00	S4:00
S5:00	S6:00
S7:00	S8:00
W:00	O1:0A
O2:00	O3:00
O4:FF	O5:08
O6:12	O7:28
O8:03	O9:80
OA:00	OB:00
OC:00	OD:5A
P:F62F	