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## ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN-06-021

LOCATION - MISSOURI

VEHICLE - 2006 NISSAN MURANO

CRASH DATE - May 2006

Submitted:

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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.

**Technical Report Documentation Page**

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15. <i>Supplementary Notes</i> On-site rollover investigation involving a 2006 Nissan Murano with manual safety belts, dual stage front air bags, side curtain air bags and seat back-mounted side impact air bags.					
16. <i>Abstract</i> This report covers an on-site rollover investigation that involved a 2006 Nissan Murano (case vehicle), which ran-off-road, impacted a stump and rolled over. This crash is of special interest because the case vehicle rolled over and the case vehicle's driver (50-year-old, female) sustained only superficial injuries as a result of the crash. The case vehicle was traveling east in the eastbound lane of a two-lane county roadway and was approaching a left curve. A deer entered the roadway from the right. The driver steered left and braked in an attempt to avoid the deer. The driver then steered right and ran off the right side of the roadway. The case vehicle rotated slightly counterclockwise as the driver attempted to steer back onto the roadway and the right rear door and right rear wheel impacted a tree stump (event 1) deploying the right side curtain air bag and the front right seat back-mounted side impact air bag. The impact caused the case vehicle to rotate clockwise and it rolled over driver side leading (event 2) deploying the left side curtain air bag. As the vehicle rolled over, it ran off a steep embankment on the right roadside and essentially fell into a group of trees damaging the hood (event 3) and rear hatch (event 4). The case vehicle rolled over a total of two quarter rolls and came to rest upside down wedged between two trees approximately 1.5 meters (5 feet) off the ground. The case vehicle's driver was restrained by her manual, three-point, lap-and-shoulder safety belt and sustained only minor injury. She was not transported to a medical facility and received no subsequent medical treatment.					
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This on-site investigation was brought to NHTSA's attention on or before July 21, 2006 by NASS GES sampling activities. This crash involved a 2006 Nissan Murano (case vehicle), which ran-off-road, impacted and stump and rolled over. The crash occurred in May, 2006, at 4:25 p.m., in Missouri and was investigated by the applicable county police department. This crash is of special interest because the case vehicle rolled over and the case vehicle's driver [50-year-old, White (Hispanic) female] sustained only superficial injuries as a result of the crash. In addition, the case vehicle is certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. This contractor interviewed the driver and inspected the scene and case vehicle on August 16, 2006. This report is based on the police crash report, interview with the case vehicle's driver, scene and vehicle inspections, occupant kinematic principles, and this contractor's evaluation of the evidence.

## SUMMARY

The case vehicle was traveling east in the eastbound lane of a two-lane county roadway and was approaching a left curve. A deer entered the roadway from the right. The driver steered left and braked in an attempt to avoid the deer. The driver then steered right and ran off the right side of the roadway. The case vehicle rotated slightly counterclockwise as the driver attempted to steer back onto the roadway and the right rear door and right rear wheel impacted a tree stump (event 1) deploying the right side curtain air bag and the front right seat back-mounted side impact air bag. The impact caused the case vehicle to rotate clockwise and it rolled over driver side leading (event 2) deploying the left side curtain air bag. As the vehicle rolled over, it ran off a steep embankment on the right roadside and essentially fell into a group of trees damaging the hood (event 3) and rear hatch (event 4). The case vehicle rolled over a total of two quarter rolls and came to rest upside down wedged between two trees approximately 1.5 meters (5 feet) off the ground.

The CDCs for the case vehicle were determined to be: **01-RZEW-2** (20 degrees) for the stump impact (event 1), **00-LDAO-2** for the rollover (event 2) and **00-FCMN-1** (event 3) and **00-BDMW-1** (event 4) for impacts with the two trees that occurred during the rollover. The case vehicle sustained 15 centimeters (5.9 inches) of residual maximum crush to the right side occurring at C<sub>4</sub>. The WinSMASH reconstruction program was not used to reconstruct the case vehicle's Delta Vs for the impact with the tree stump due to the swiping nature of the impact and subsequent snagging of the right rear wheel. However, based on the damage to the case vehicle, the severity of the stump impact was estimated to be low [14-23 km.p.h. (9-14 m.p.h)]. Also based on the damage to the case vehicle, the rollover severity and the severity of the two tree impacts were estimated to be minor. The case vehicle was towed due to damage.

The case vehicle's driver was restrained by her manual, three-point, lap-and-shoulder safety belt system. She sustained only an abrasion to her left shoulder from her safety belt and a small laceration to her left ankle from contact with the foot controls. The driver's use of her safety belt and the deployment of her side curtain air bag mitigated her interaction with the case vehicle's interior and reduced her injury potential.

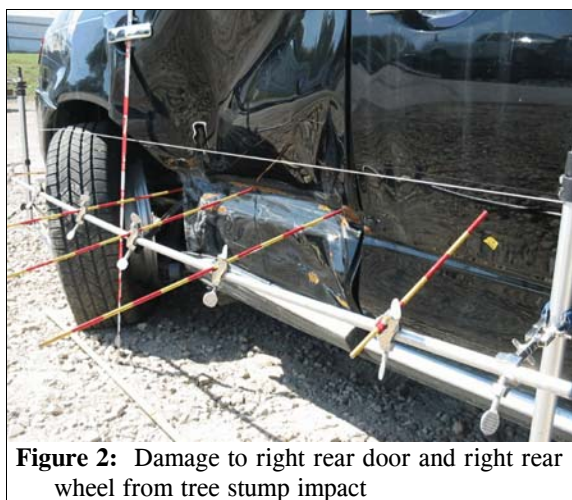
**Crash Environment:** The trafficway on which the case vehicle was traveling was a two-lane, undivided, county roadway, generally traversing in an east-west direction and then curved north. The roadway was 7.4 meters (24.3 feet) in width. It did not have a designated center line. The estimated roadway coefficient of friction was 0.70, and the curve's superelevation was 2.9%. The roadway grade in the area of the rollover initiation was 3.2% negative. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry bituminous. There was no other traffic present at the time of the crash, and the site of the crash was rural. See the Crash Diagram at the end of this report.

**Pre-Crash:** The case vehicle was traveling east in the eastbound lane and was approaching a left curve (**Figure 1**). The driver was intending to continue through the curve. The case vehicle's driver stated that a deer entered the roadway from the right. The driver steered left and braked in an attempt to avoid the deer. The driver then steered right and ran off the right side of the roadway where the crash occurred.

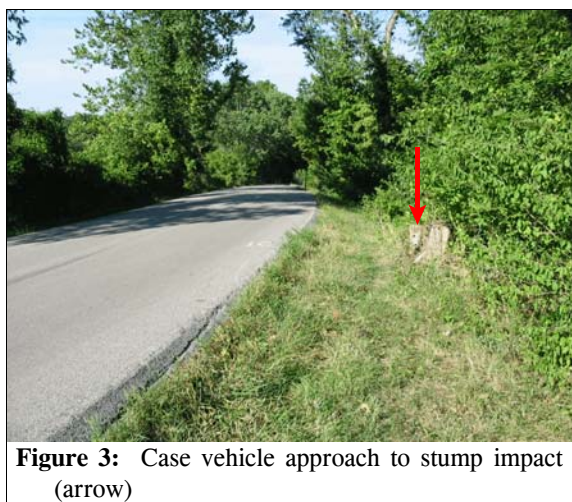
**Crash:** As the case vehicle ran off the right side of the roadway, it rotated slightly counterclockwise as the driver attempted to steer back onto the roadway. As the vehicle was in the slight counterclockwise yaw, the right rear door and right rear wheel (**Figure 2**) impacted a tree stump (event 1, **Figure 3**) on the roadside deploying the right side curtain air bag and the front right seat back-mounted side impact air bag. This impact caused the case vehicle to rotate clockwise and the back end of the vehicle reentered the roadway. As the case vehicle rotated clockwise due to the impact, it began to rollover driver side leading (event 2). The left rear wheel rim (**Figure 4** below) gouged the roadway (**Figure 5** below), the vehicle continued to roll left and it ran off a steep embankment on the right roadside and essentially fell into a group



**Figure 1:** Case vehicle approach to roadway departure, number on roadway shows meters to area of rollover initiation



**Figure 2:** Damage to right rear door and right rear wheel from tree stump impact



**Figure 3:** Case vehicle approach to stump impact (arrow)



of trees (**Figure 5**) damaging the hood (event 3) and rear hatch (event 4). The case vehicle's left side curtain air bag deployed as a result of the rollover. The case vehicle rolled over a total of two quarter rolls.

**Post-Crash:** The case vehicle came to rest upside down wedged between two trees. It was heading southeast and was stuck in the trees approximately 1.5 meters (5 feet) off the ground.

### CASE VEHICLE

The 2006 Nissan Murano S was an all wheel drive, four-door sport utility vehicle (VIN: JN8AZ08WX6W-----) equipped with four wheel, anti-lock brakes with brake assist and electronic brake force distribution. The front seating row was equipped with bucket seats with active head restraints, dual stage driver and front right passenger air bags and manual, three-point, lap-and-shoulder safety belts with adjustable upper anchors, usage sensors, pretensioners and load limiters. Furthermore, there was an occupant weight sensor for the front right passenger seating position. In addition, the case vehicle was equipped with front seat back-mounted side impact air bags and right and left side curtain air bags with rollover sensor. The rear seating row was equipped with a split bench seat with adjustable head restraints, three-point, lap-and-shoulder safety belts and LATCH system features in the outboard seating positions. The case vehicle is certified by the manufacturer to be compliant to the Advanced Air Bag portion of Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Lastly, the case vehicle's wheelbase was 282 centimeters (111 inches) and the odometer reading at the time of the inspection was 13,433 kilometers (8,347 miles).

The various sensors in the case vehicle's advanced occupant restraint system analyze a combination of factors including the predicted crash severity and driver and front right passenger safety belt usage to determine the front air bag inflation level appropriate for the severity of the crash. For the front right seat position, an occupant weight sensor in the seat cushion determines if an occupant is on the seat and enables or suppresses deployment of the air bag based on the amount of weight on the seat. The case vehicle's rollover sensor determines if a rollover is about



**Figure 4:** Arrows show rim abrasions to left rear wheel from gouging roadway surface, gras was also jammed in bead when case vehicle rotated clockwise off tree stump impact



**Figure 5:** Left rear wheel gouge in roadway (arrow) and embankment case vehicle rolled down

to occur and deploys the side curtain air bags. The side curtain air bags remain inflated long enough to provide enhanced protection during the rollover. In the event of a side impact, a sensor located in the lower “B”-pillar will command deployment of the case vehicle’s side curtain air bag and seat back-mounted side impact air bag when the impact is of sufficient severity to require side air bag deployment.

**CASE VEHICLE DAMAGE**

**Exterior Damage:** The case vehicle’s impact with the stump (event 1)involved the right side. The right rear door was crushed inward and the right rear wheel was displaced rearward and angled outward. Direct damage began 138 centimeters (54.3 inches) rear of the right front axle and extended 180 centimeters (70.9 inches) along the right rear door and right rear wheel. Residual maximum crush was measured as 15 centimeters (5.9 inches) occurring at C<sub>4</sub>. The table below shows the case vehicle’s right side crush profile.

Units	Event	Direct Damage		Field L	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	180	15	180	0	0	14	15	10	2	-74	-74
in		70.9	5.9	70.9	0.0	0.0	5.5	5.9	3.9	0.8	-29.1	-29.1

The damage occurring during the rollover (event 2) involved multiple areas of the case vehicle as follows: The vehicle’s hood was directly damaged and minimally crushed rearward from contact with a tree (event 3). The hatch was also directly damaged and minimally crushed forward as well as downward, also due to contact with a tree (event 4). The lower portion of the hatch was made of composite material and broke free from the vehicle. Finally, the left rear wheel was directly damaged from it’s contact with the roadway, and the left fender, left rear door and left quarter panel were directly damaged as well.

The case vehicle’s left side wheelbase was extended 2 centimeters (0.8 inches) while the right side wheelbase was extended 17 centimeters (6.7 inches). Induced damage involved the hood, right rear door and both quarter panels. The front bumper fascia was pulled partially off by the fork lift that moved the vehicle to the inspection site. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle’s exterior. **Figures 6 and 7** below show overviews of damage to the case vehicle.





**Figure 6:** Overview of front and left side of case vehicle



**Figure 7:** Back and right side of case vehicle

The case vehicle’s recommended tire size was: P235/65R18, and the vehicle was equipped with tires of this size. The case vehicle’s tire data are shown in the table below.

Tire	Measured Pressure		Recommend Pressure		Tread Depth		Damage	Restricted	Deflated
	kpa	psi	kpa	psi	milli-meters	32 <sup>nd</sup> of an inch			
LF	290	42	303	44	7	9	Slight scuffs on rim, some grass in bead	No	No
RF	296	43	303	44	7	9	None	No	No
LR	283	41	303	44	8	10	Heavy scrapes to rim	No	No
RR	0	0	303	44	8	10	Broken rim	No	Yes

**Vehicle Interior:** Inspection of the case vehicle’s interior ( **Figure 8** and **Figure 9** below) revealed loading evidence to the driver’s safety belt webbing. No other occupant contacts were noted. In addition, there was no evidence of occupant compartment intrusions or deformation of the steering wheel and energy absorbing energy column.



**Figure 8:** Case vehicle’s steering wheel and left front door

**Damage Classification:** Based on the vehicle inspection, the CDCs for the case vehicle were determined to be: **01-RZEW-2** (20 degrees) for the stump impact (event 1), **00-LDAO-2** for the rollover (event 2) and **00-FCMN-1** (event 3) and **00-BDMW-1** (event 4) for impacts with the two

trees that occurred during the rollover. The WinSMASH reconstruction program was not used to reconstruct the case vehicle's Delta Vs for the impact with the tree stump due to the swiping nature of the impact and subsequent snagging of the right rear wheel. However, based on the damage to the case vehicle, the severity of the stump impact was estimated to be low [14-23 km.p.h. (9-14 m.p.h)]. Also based on the damage to the case vehicle, the rollover severity and the severity of the two tree impacts occurring during the rollover were estimated to be minor. The case vehicle was towed due to damage.

#### AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with dual stage driver and front right passenger air bags as well as side curtain air bags and seat back-mounted side impact air bags. The front air bags did not deploy in this crash. Both side curtain air bags and the front right seat back-mounted side impact air bag deployed in this crash due to the right side impact and subsequent rollover.

The case vehicle's driver air bag was located in the steering wheel hub and the front right passenger air bag was located in the middle of the instrument panel. Neither of these air bags deployed because the case vehicle did not sustain a longitudinal deceleration severe enough to require their deployment. Both air bag modules had been removed prior to this contractor's investigation (**Figure 8** above and **Figure 9**). The modules were most likely salvaged for resale.

The case vehicle's left side curtain air bag (**Figures 10** and **11**) deployed as a result of the rollover. It was located along the roof side rail below the headliner. There was no evidence of damage to the air bag due to deployment. The side curtain air bag was approximately 142 centimeters (55.9 inches) in length and 40 centimeters (15.7 inches) in height. The curtain was constructed of two primary inflatable sections. The front section measured approximately 48 centimeters (18.9 inches) in length and 40 centimeters (15.7 inches) in height and was adjacent



**Figure 9:** Case vehicle's instrument panel, windshield and steering wheel, driver and front right air bag modules had been removed, probably for salvage



**Figure 10:** Forward section of left side curtain air bag, each increment on rods is 5 cm (2in)



**Figure 11:** Rear section of left side curtain air bag

to the driver’s seat. The rear section measured approximately 42 centimeters (15.5 inches) in length and 40 centimeters (15.7 inches) in height and was adjacent to the back left seat position. The front inflatable section included three approximately 15 centimeter (5.9 inches) long double stitched “tethers,” bonding the inboard and outboard walls of the curtain to control curtain inflation width. The rear inflatable section included an L-shaped, double stitched “tether.” It is likely that the driver contacted the side curtain air bag, but no obvious occupant contact marks were observed on the air bag.

The case vehicle’s right side curtain air bag was located along the roof side rail below the headliner. It deployed as a result of the case vehicle’s right side impact with the stump. Its dimensions and features were identical to the left side curtain air bag. There were no occupant contacts or damage to this air bag.

The case vehicle’s front right passenger seat back-mounted side impact air bag (**Figure 12**) deployed as a result of the case vehicle’s right side impact with the stump. The air bag was located in the outboard side of the front right passenger’s seat back. This air bag was approximately oval-shaped and measured approximately 23 centimeters (9 inches) in width and 27 centimeters (10.6 inches) in height. It was constructed without tethers and vent ports. There were no occupant contacts or damage to this air bag.



**Figure 12:** Front right seat back-mounted side impact air bag

**CASE VEHICLE DRIVER KINEMATICS**

Immediately prior to the crash the case vehicle's driver [50-year-old, White (Hispanic) female; [163 centimeters and 52 kilograms (64 inches, 145 pounds)] was seated in an upright position with her back against the seat back and both hands on the steering wheel. The driver stated she was braking, so her right foot was most likely on the brake and her left foot was most likely on the floor. Her seat track was located between its middle and rear-most positions, the seat back was slightly reclined, the tilt steering column was located in its center position and the adjustable foot controls (**Figure 13**) were located in the full-rear position.



**Figure 13:** Case vehicle’s adjustable brake pedal

Based on this contractor’s vehicle inspection, the case vehicle's driver was restrained by her manual, three-point, lap-and-shoulder safety belt system. The belt system was equipped with a retractor-mounted pretensioner and force load limiter housed within the “B”-pillar. The driver’s

safety belt was found spooled out of the retractor and would not retract indicating actuation of the pretensioner and usage of the safety belt in the crash. In addition, there was a small load abrasion on the shoulder belt, and the driver reported a belt-pattern abrasion on her left shoulder. The front right safety belt was also locked and spooled tight in its retractor.

After the case vehicle departed the roadway to the right, the driver steered left and braked, attempting to return to the roadway. As a result of these attempted avoidance maneuvers and the off-road excursion, her safety belt retractor most likely locked and she most likely moved slightly forward and to her right and loaded her safety belt. The case vehicle’s contact to the stump caused the driver to continue forward and right along a path opposite to the case vehicle’s 20 degree direction of principal force as the case vehicle decelerated longitudinally and accelerated laterally to the left. As the case vehicle rotated clockwise and began to roll over driver side leading, the driver moved to the left and toward the roof. Her head most likely contacted the deployed left side curtain air bag as the case vehicle rolled over onto its roof. She sustained an abrasion on her left shoulder from her safety belt and her head may have also contacted the roof as the vehicle wedged between the two trees upside down approximately 1.5 meters (5 feet) off the ground. The case vehicle driver exited the vehicle with some assistance through the sunroof. The driver’s use of her safety belt and the deployment of her side curtain air bag mitigated her interaction with the case vehicle’s interior and reduced her injury potential.

**CASE VEHICLE DRIVER INJURIES**

The police crash report indicated that the driver did not sustain any injury and was not transported from the scene to a treatment facility. The driver stated she did not seek any medical treatment subsequent to the crash. The injuries reported by the driver during her interview and the injury mechanisms are show in the table below.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Abrasion {friction burn}, slight, left ventral shoulder, not further specified	minor 790202.1,2	Torso portion of safety belt system	Probable	Interviewee (same person)
2	Laceration {cut}, less than 2.5 cm (< 1 in), on left ankle, not further specified	minor 890600.1,2	Floor, foot controls	Probable	Interviewee (same person)



