CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
GRACO SNUG RIDE REAR FACING CHILD SAFETY SEAT

CASE NO: CA06-008

VEHICLE: 2000 FORD EXPLORER

LOCATION: FLORIDA

CRASH DATE: MARCH 2006

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

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

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16. Abstract This investigation focused on the performance of a Graco Snug Ride rear-facing Child Safety Seat (CSS) installed in the center rear position of a 2000 Ford Explorer that was involved in a rollover crash. The Ford was driven by a 23 year old restrained female and occupied by a 5 month old female restrained within the child safety seat. The Ford was eastbound in the center lane of a three-lane, limited access divided highway at a reported speed of 97 km/h (60 mph). An active road construction zone was in place at the time of the crash. The eastbound Ford encountered a utility ladder blocking the lane and the driver steered right to avoid the obstruction. In the process of this maneuver, the front right aspect of the Explorer sideswiped the left rear aspect 1998 Ford (unknown model) work truck. The driver then over-steered the subject vehicle back to the left and lost control. The Ford tripped over the right front tire and rolled four-quarter turns. As the vehicle came back onto its tires, the left aspect of the Ford's front plane struck the center Jersey-style construction barrier. A witness trailing the Ford notified the authorities of the crash via the 9-1-1 system and stopped to render aid. As the witness approached the Ford Explorer, he saw that the driver had sustained a visible arm injury and heard the infant crying from the rear seat. With the assistance of a police officer, the witness opened the rear door and found the infant still restrained within the child safety seat. She was not injured. The infant was taken by ground ambulance to a local hospital for observation and released. The driver was removed from the Ford Explorer, transported by ground ambulance, and hospitalized for nine days. She sustained a deep abrasion to her left forearm (near the wrist) and tendon lacerations due to ground contact during the rollover sequence. The driver of the 1998 Ford work truck was not injured in the crash and the vehicle was driven from the scene at the conclusion of the police investigation.			
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BACKGROUND

This investigation focused on the performance of a Graco Snug Ride rear-facing Child Safety Seat (CSS) installed in the center rear position of a 2000 Ford Explorer that was involved in a rollover crash, **Figure 1**. The Ford was driven by a 23 year old restrained female and occupied by a 5 month old female restrained within the child safety seat. The Ford was eastbound in the center lane of a three-lane, limited access divided highway at a reported speed of 97 km/h (60 mph). An active road construction zone was in place at the time of the crash. The eastbound Ford encountered a utility ladder blocking the lane and the driver steered right to avoid the obstruction. In the process of this maneuver, the front right aspect of the Explorer sideswiped the left rear aspect 1998 Ford (unknown model) work truck. The driver then over-steered the subject vehicle back to the left and lost control. The Ford tripped over the right front tire and rolled four-quarter turns. As the vehicle came back onto its tires, the left aspect of the Ford's front plane struck the center Jersey-style construction barrier. A witness trailing the Ford notified the authorities of the crash via the 9-1-1 system and stopped to render aid. As the witness approached the Ford Explorer, he saw that the driver had sustained a visible arm injury and heard the infant crying from the rear seat. With the assistance of a police officer, the witness opened the rear door and found the infant still restrained within the child safety seat. She was not injured. The infant was taken by ground ambulance to a local hospital for observation and released. The driver was removed from the Ford Explorer, transported by ground ambulance, and hospitalized for nine days. She sustained a deep abrasion to her left forearm (near the wrist) and tendon lacerations due to ground contact during the rollover sequence. The driver of the 1998 Ford work truck was not injured in the crash and the vehicle was driven from the scene at the conclusion of the police investigation.

Figure 1: Front view of the Ford Explorer.

This crash was identified through an Internet news search by the Crash Investigation Division of the National Highway Traffic Safety Administration. The crash was subsequently assigned as an on-site investigation to the Calspan Special Crash Investigations team on March 31, 2006 due to the agency's interest in child passenger safety. Calspan SCI initiated follow-up investigation and established cooperation with the investigating police department and driver. The driver was in possession of the child safety seat and consented to an interview and an inspection of the child safety seat following her discharge from the hospital. The Ford Explorer was located at a local

tow facility. It was possible to visually inspect and photograph the subject vehicle; however, the tow yard's owner would not allow any extensive measurements to be taken. The SCI investigator was ordered to leave the premises after approximately 90 minutes. Although the vehicle inspection was not as in-depth as a typical SCI inspection, it was still possible to reconstruct the crash dynamics and the occupant kinematics, and to source the injuries sustained in the event.

SUMMARY

Crash Site

This rollover crash occurred during the afternoon hours of March 2006. At the time of the crash, it was daylight and the weather was not a factor. The crash occurred on the eastbound lanes of a three-lane, limited access interstate highway that was undergoing reconstruction. An active construction zone was in place over an estimated 24 km (15 mile) section of the interstate that further reduced access to the highway due to construction at several of the entrance/exit ramps. The construction zone was still in place at the time of the SCI scene inspection and prevented a detailed scene inspection because of safety concerns. **Figure 2** is an eastbound view of the highway near the reported crash location.

Figure 2: Eastward view at the crash site.

As depicted, the respective outboard aspects of the roadway were bordered by Jersey barriers that channeled traffic through the construction zone. The traffic lanes were an estimated 7.5 m (12 ft) in width and separated by broken white lines. The respective shoulders (outboard the travel lanes) were narrow with an estimated 1 m (3 ft) width. The speed limit in the area of the crash was 97 km/h (60 mph).

CRASH SEQUENCE

Pre-Crash

The 2000 Ford Explorer was eastbound in the center lane driven by a 23 year old restrained female. The driver's 5 month old daughter was restrained within a Graco Snug Ride rear-facing Child Safety Seat installed in the center rear position of the Ford. The driver was in the process of traveling to her home located approximately 16 km (10 miles) from the crash site. The driver reported that the traffic was moderate and her speed was approximately 97 km/h (60 mph). Immediately prior to the crash, the driver encountered a ladder in the center lane that obstructed her path of travel.

Crash

The driver steered suddenly to the right to avoid the ladder and sideswiped a 1998 Ford (unknown model) work truck in the outboard lane. The right front corner of the Ford Explorer contacted the left rear aspect of the 1998 Ford that was traveling in the outboard eastbound lane. In response to this minor crash, the driver of the Ford Explorer steered suddenly back to the left.

The sudden right/left steering maneuver caused an over-steer condition and the rear tires of the Explorer lost traction. The driver of the Ford Explorer lost directional control and the vehicle began to rotate counterclockwise. The dynamics of these maneuvers caused a weight shift toward the front right aspect of the vehicle, which in-turn caused the front right tire to air out. The deflation of the front right tire allowed the rim to contact the road which initiated a tripping mechanism and resultant right side leading roll. The Ford Explorer rolled four-quarter turns along a northeastward trajectory. As the vehicle returned to its wheels, the left aspect of the Explorer's front bumper struck the center median Jersey barriers. The vehicle came to rest in the inboard lane of the interstate in-close proximity to the barrier facing northeast. **Figure 11**, at the end of this narrative report, is a generalized schematic of the crash sequence.

Post-Crash

A witness traveling behind the subject vehicle called 9-1-1 on his cell phone to alert authorities of the crash and then stopped to render assistance. Reportedly, he approached the Ford and observed the driver visibly injured in the left front seat and then he heard the infant crying from the rear seat. The infant was still restrained within the child safety and was not injured. With the help of a responding police officer, the witness opened the left rear door and removed the infant from the child safety seat. The responding emergency personnel cut the roof off the Ford Explorer and removed the driver due to perceived serious injuries. The driver was transported to a local hospital and admitted for nine days. The driver reported that she sustained tendon lacerations and a deep abrasion to the forearm near the wrist. She was hospitalized for such a lengthy period due to the risk of infection. She will reportedly require skin grafts to repair the wound. The baby was transported via ground ambulance to a local hospital as a precaution, examined and then released. The driver the 1998 Ford work truck was not injured in the event and removed the vehicle at the conclusion of the investigation. This vehicle was not located or inspected.

VEHICLE DATA

2000 Ford Explorer

The 2000 Ford Explorer was identified by the Vehicle Identification Number (VIN): 1FMDU74E9YZ (production sequence deleted). **Figure 3** is a view of an exemplar Ford Explorer. The 4x2, four-door, rear wheel drive sport utility vehicle was manufactured with a 283 cm (111.6 in) wheelbase and was equipped with the *"Eddie Bauer"* trim package. The power train consisted of a 4.0 liter/V6 engine linked to a four-speed automatic transmission. The service brakes were a four-wheel disc system with ABS. The vehicle seating was configured for five passengers (2/3). The front row consisted of leather upholstered bucket seats. The second row seat system consisted of a 60/40 split bench seat with folding backs. The manual restraint system consisted of

Figure 3: Front view of an exemplar 2000 Ford Explorer.

three-point lap and shoulder belts for the four outboard positions. The center rear position was equipped with a retractable lap belt. The Ford Explorer was also equipped with redesigned driver and front right passenger air bags that did not deploy during the crash. The vehicle was not equipped with side impact protection. The Explorer was manufactured in September 1999. The odometer reading was unknown.

Exterior Damage

Frontal views of the Ford Explorer are depicted in **Figure 4**. Visual inspection of the Ford's exterior revealed three regions of direct contact damage consistent with the multiple event crash. The right aspect of the vehicle's front plane sustained approximately 16 cm (6 in) of direct contact damage that began 61 cm (24 in) right of the centerline and extended to the right corner. Refer to **Figure 4**. This damage was related to the minor sideswipe impact to the 1998 Ford (Event 1). The crush at the right corner was an estimated 5 cm (2 in). The direct contact was isolated to the outboard corner of the bumper system. The right fog lamp and right headlamp were not damaged in the impact. The Collision Deformation Classification of the impact was 12-FRLE1.

The left aspect of the frontal plane struck the median construction barrier as the vehicle neared final rest (Event 3). The direct contact had an estimated width of 58 cm (23 in) that began 20 cm (8 in) left of center and extended to the left bumper corner. The estimated maximum crush at the left bumper corner was 15 cm (6 in). The crush was uniform over its vertical height indicative of a barrier impact and involved the left headlamp assembly. The CDC of the impact was 11-FYEW1.

Figure 4: Frontal views of the Ford Explorer.

The vehicle's rollover damage consisted of a minor localized impact to the left A-pillar area of the roof and abrasions to the left side body panels. There was no noted damage to the right side of the vehicle and no surface abrasions to the roof. Refer to **Figure 5**. The first ground contact during the rollover (Event 2) occurred at the left A-pillar as the Ford was rolling between quarter turns 2 and 3. The vertical deformation at the left A-pillar was an estimated 5 cm (2 in). There was no lateral deformation of the greenhouse. The surface abrasions to the left side panels were oriented primarily in a single direction indicative of a single ground contact (quarter turn 4), **Figure 6**. The abrasions were oriented in a 2/8 o'clock direction. There was no measurable change in the wheelbase dimensions. All the side glazing disintegrated during the rollover with the exception of the glazing of the right rear door. All the side pillars were cut and the roof was removed during the operations to rescue of the driver. The windshield was also cut and removed. The CDC of the rollover damage was 00-LDAO1.

Figure 5: Right and left side views of the Ford Explorer.

Figure 6: 8/2 o'clock surface abrasions to the left rear quarterpanel of the Ford.

The subject Ford Explorer was equipped with Goodyear Tracker P255/70R16SL tires on OEM alloy wheels. This was the recommended tire size for the vehicle. The recommended tire pressure was 207 kPa (30 PSI). All four tires had adequate tread estimated at a minimum of 6 mm (8/32 in). Inspection of the tires revealed all four had aired out and debeaded during the course of the rollover. An inspection of the front right wheel rim identified a 10 cm (4 in) long abrasion along the edge of the rim's circumference, **Figure 7**. This rim abrasion could only have occurred as a result contact with the road and was identified as the tripping mechanism of the crash. Examination of the right rear wheel rim was unremarkable. The left front and left rear wheel rims both exhibited minor surface abrasions about the circumference of the rim. In addition, the valve stems of both left rims were torn and separated from the rim. These damages to the left rims occurred when the vehicle was rolling through three quarter turns and was sliding on its left side.

Figure 7: View of the front right tire and rim abrasion.

Interior Damage

Inspection of the vehicle's interior was limited due to the terminated cooperation with the tow yard. There was no noted interior damage or intrusion related to the exterior force of the crash sequence. There were no noted interior occupant contacts. The driver seat was adjusted to an estimated mid-track position consistent with the driver's stature. **Figures 8 and 9** are views of the Explorer's driver interior and second row respectively.

Figure 8: Driver's interior view.

Figure 9: Right view of the second row.

Manual Restraint System

The driver's manual restraint consisted of a three-point lap and shoulder with continuous loop webbing, sliding latch plate, and a B-pillar mounted Emergency Locking Retractor (ELR). Upon inspection, the driver belt had been cut below the D-ring by the first responders during the

driver's rescue. The cut webbing section was attached to the outboard anchor and was lying on the driver seat. The balance of the webbing had spooled back into the retractor. The driver reported in her interview that she was restrained at the time of the crash. She also reported that she habitually wore the safety belt. The lack of interior driver contacts, and the nature and extent of her injury support that she was restrained at the time of the crash.

The manual restraint in the rear center position of the Ford Explorer consisted of a lap only belt that spooled from an Automatic Locking Retractor (ALR). The latch plate was sewn onto the webbing. Upon inspection, the webbing was stowed within the retractor and freely spooled at extension. The retractor locked as designed when extension of the belt ceased and the retractor would not allow the extended belt to lengthen again until the webbing was fully retracted. There was no noted physical evidence on the webbing related to the crash.

CHILD SAFETY SEAT

The Graco Snug Ride rear-facing Child Safety Seat (CSS) consisted of a carrier shell with a five-point harness and a detachable base, **Figure 10**. The CSS was manufactured on January 14, 2005 and was designated with the following Model and Serial numbers: *7235GGA, JJ0114050076.* The seat was labeled for use by infants who weigh less than 9 kg (20 lb) and are less than 66 cm (26 in) in height. The CSS was an appropriate size for the weight and height of the 5-month old infant. The five point harness was adjusted to the top slots. The length of the left and right harness strap measured 52 cm (20.5 in) and 55 cm (21.7 in), respectively. The straps were not twisted or roped. The chest retainer clip was present and was located 18 cm (7 in) below the top slots. The CSS base was designed with an adjustable foot to control the recline angle of the CSS. The base was adjusted to position the carrier in the most reclined installed position. The CSS was designed and equipped with a LATCH belt that was not in use at the time of the crash.

The infant's father had installed the CSS in the center rear position of the Ford several weeks prior to the crash. He had not read the instruction manual, but was familiar with child safety seats from experience. This was his third child. The father and the driver (mother) were not familiar with child safety seat check points. The father routed the lap belt through the rear-facing belt path, compressed the seat, and back-fed the webbing into the ALR retractor. He indicated the CSS installation was tight and the seat did not move side-to-side or fore and aft. They both recalled periodically checking the "tightness" of the installation by moving the seat. It always seemed to be tight. The angle indicator on the side of the CSS was in the "Blue" area.

During the SCI inspection, the 5 month old was observed sitting in the CSS carrier. She was restrained by the harness straps at that time. The driver (mother) reported that the straps had not been adjusted since the time of the crash. The chest retainer chip was positioned over the center of her chest and was typically adjusted to that location. The mother did report that the infant could move the retainer clip and at times would teethe on the clip or push it down. She did not know the at-crash position of the clip. With the infant in the carrier, the harness straps were a loose fit with approximately 5 cm (2 in) of slack in the harness strap at the shoulder level. The harness straps exited the carrier shell at the level of the infant's shoulders. There was no noted damage to the CSS.

Figure 10: View of the child safety seat and base.

OCCUPANT DEMOGRAPHICS

	Driver	***Rear Center Passenger***
Age/Sex:	23 year old/Female	5 month old/Female
Height:	157 cm (62 in)	56 cm (22 in)
Weight:	68 kg (150 lb)	7 kg (15.5 lb)
Seat Track Position:	Mid track	Center position of a fixed bench
Restraint Use:	Three-point lap and shoulder	Restrained within a 5-point harness in a rear facing CSS
Usage Source:	SCI inspection, PAR	First responder, PAR
Medical Treatment:	Transported via ground ambulance; hospitalized for nine days	Transported via ground, examined and released

PRELIMINARY DRIVER INJURY

Injury	***Injury Severity (AIS 98 Update)***	***Injury Mechanism***
Tendon lacerations	Minor (740220.1,2)	Ground contact
Deep abrasion of the left forearm	Minor (790202.1,2)	Ground contact

Note: the above preliminary injury data was based on and interview with the driver.

DRIVER KINEMATICS

The 23 year old driver was seated in a mid track position and was restrained by the three-point lap and shoulder belt system. The driver lost directional control of the Ford while executing a right/left evasive maneuver to avoid an obstacle in the road and subsequent side-swipe impact. The magnitude of the sideswiping impact to the 1998 Ford was not great enough to alter the driver's position. During the process of the maneuver, the driver over-steered to the left and the vehicle began to rotate counterclockwise. During these aggressive steering maneuvers, the driver most likely maintained her upright position through the effects of her grip on the steering wheel rim.

The weight shift induced by the maneuver caused the right front tire to air out. The rim of the tire contacted the pavement and induced a tipping mechanism resulting in a right side leading roll. The vehicle rolled between 2 and 3 quarter turns and impacted the ground with the left A-pillar area and then slid on its left side evidenced by the left body panel abrasions. As the Ford rolled over, the driver would have been displaced to the left and downward (relative to the vehicle). The ELR retractor locked. As the vehicle rolled inverted and then impacted the ground, the driver loaded the safety belt system and rode down the crash. The left side glazing disintegrated upon ground contact. The driver's left arm was displaced outside the plane of the left front window and contacted the ground resulting in the aforementioned injuries.

The Ford then rolled onto its wheels and struck the center median barrier. The safety belt remained locked throughout this sequence. The driver responded to the 11 o'clock direction of this impact by her continued loading of the manual restraint. The driver then rebounded back in to seat where she was found. The use of the manual restraint help to maintain the driver in her occupant space and help to mitigate her injury potential in this crash.

CENTER REAR PASSENGER INJURY

The 5 month old female infant was not injured in the event.

CENTER REAR PASSENGER KINEMATICS

The 5 month old female infant was restrained by a 5-point harness system in a rear facing CSS in the center position of the second row. During the pre-crash maneuvers and crash sequence, the child likely loaded the harness straps with her shoulders and the centrifugal force of the rotation kept the infant within the CSS. The shell of the seat provided a volume of protection for the child and minimized her potential injuries. The child came to rest secured within the CSS uninjured.

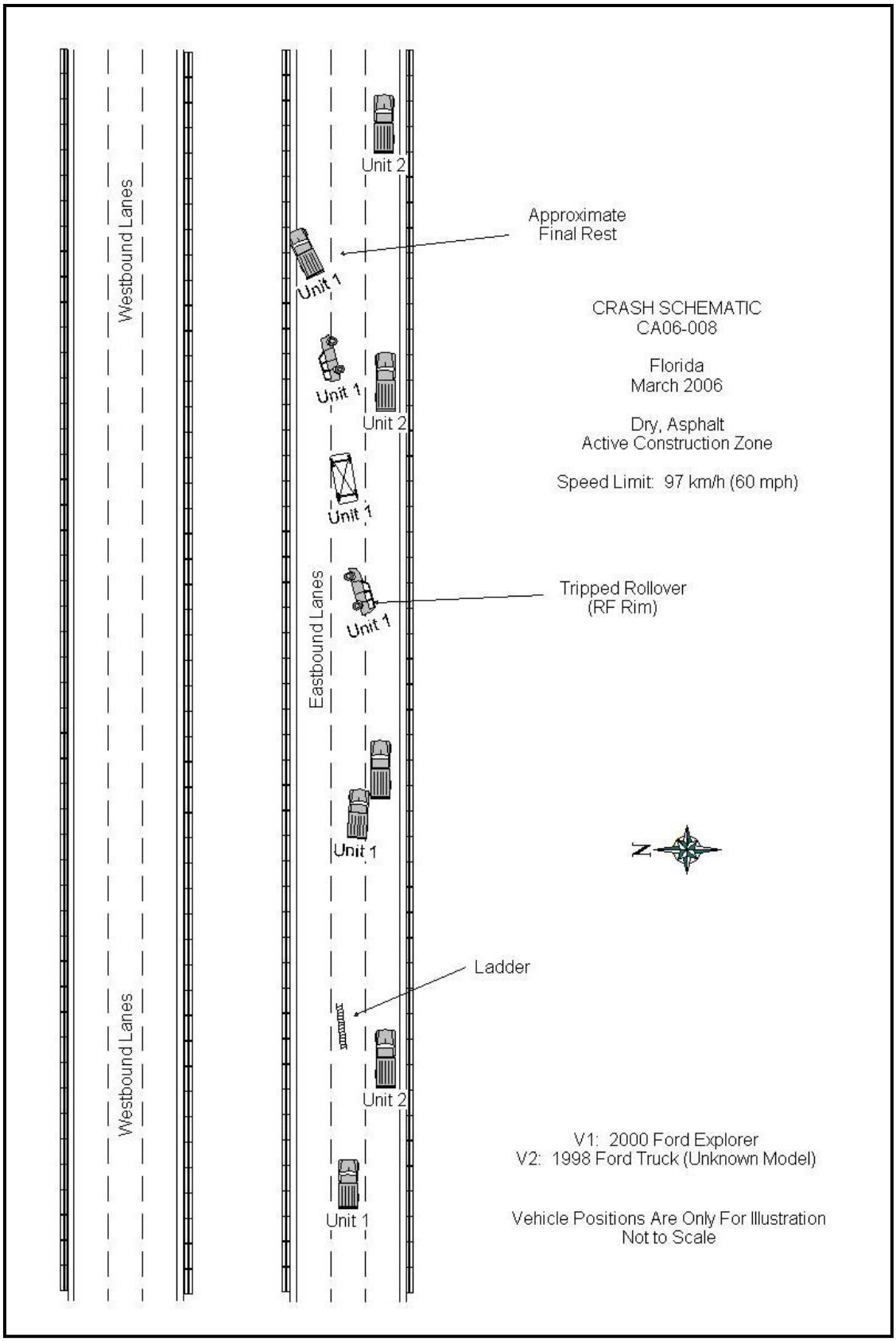

Figure 11: Crash Schematic.