TRANSPORTATION SCIENCES
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VERIDIAN ON-SITE LOW-SPEED FRONTAL AIR BAG DEPLOYMENT INVESTIGATION

VERIDIAN CASE NO. CA02-046

VEHICLE: 2001 FORD FOCUS

LOCATION: NEW YORK

CRASH DATE: SEPTEMBER 2002

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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 on-site investigation resulted from an attorney notification to the Veridian SCI team of an alleged low-speed crash that resulted in the deployment of the frontal air bag system in a 2001 Ford Focus and deployment induced thermal burns to the driver's right wrist/forearm. The Ford Focus that was involved in a minor severity front-to-rear crash with a stopped 1999 Ford E150 conversion van. The 29-year old female driver of the Ford Focus was restrained by the manual 3-point lap and shoulder belt system. She sustained a first-degree thermal burn of the anterior aspect of the right forearm and wrist from the exhaust gases venting onto her cotton sweatshirt. A 5-year old female rear right passenger was restrained by the 3-point belt system and was not injured in the crash. Although the Focus did not sustain disabling damage, the vehicle was towed from the scene of the crash. The Ford van sustained minor rear bumper damage and was driven from the scene.			
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BACKGROUND

This on-site investigation resulted from an attorney notification to the Veridian SCI team of an alleged low-speed crash that resulted in the deployment of the frontal air bag system in a 2001 Ford Focus **(Figure 1)** and deployment induced thermal burns to the driver's right wrist/forearm. The Ford Focus that was involved in a minor severity front-to-rear crash with a stopped 1999 Ford E150 conversion van. The 29-year old female driver of the Ford Focus was restrained by the manual 3-point lap and shoulder belt system. She sustained a first-degree thermal burn of the anterior aspect of the right forearm and wrist from the exhaust gases venting onto her cotton sweatshirt. A 5-year old female rear right passenger was restrained by the 3-point belt system and was not injured in the crash. Although the Focus did not sustain disabling damage, the vehicle was towed from the scene of the crash. The Ford van sustained minor rear bumper damage and was driven from the scene.

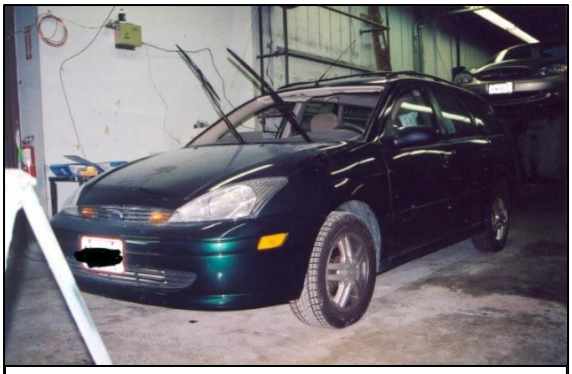

Figure 1 - Subject 2001 Ford Focus

The Veridian SCI team received notification of the September crash on October 7, 2002. Details of the crash were forwarded to the NHTSA Crash Investigation Division on the same day and the crash was assigned as an Office of Defects Investigation (ODI) case on October 10. At the time of case assignment, the exterior of the Ford Focus was under repair by a local Ford dealer. Photographs of the driver's thermal burns and the burned sweatshirt were obtained for review and documentation for this investigation.

SUMMARY

Crash Site

The crash occurred at an oblique four-leg intersection of a two-lane local street and a four-lane state route. Traffic flow through the intersection was controlled by an overhead signal system. The Ford Focus and the stopped E150 van were traveling in a westerly direction on the two-lane local street. The asphalt surfaced road consisted of a 3.0 m (9.8') wide westbound lane and a 2.6 m (8.5') wide eastbound lane with respective asphalt shoulder

Figure 2. Overall view of the crash site from a northerly direction.

widths of 1.6 m (5.2') and 1.7 m (5.6'). The local street was marked with a double yellow centerline, white edge lines, and a white stop line. The street was straight with a grade of two percent, negative to the west. The four lane state route was 13.6 m (34.5') in overall width with paved shoulders. The posted speed limits were 72 km/h (45 mph) for the state route and 48 km/h (30 mph) for the local street. **Figure 2** is an overall view of the crash site in a northerly direction.

Vehicle Data

2001 Ford Focus

The 29-year old female driver purchased the Ford Focus SE as a used vehicle approximately 11 months prior to the crash. The vehicle was a four-door station wagon and was equipped with a 2.0 liter transverse mounted gasoline engine linked to a 4-speed automatic transmission with a console mounted shifter. The Focus was front-wheel drive with power-assisted front disc/rear drum brakes. The interior was configured as a five passenger vehicle with front bucket seats and a rear bench seat with a folding back. Additional interior equipment included power windows, keyless entry which included power door locks, and the frontal air bag system for the driver and right passenger positions.

The Focus was equipped with OEM 5-spoke alloy wheels and all-season radial tires. All four tires were P195/60R15. The front tires were Lemans HR while the rears were Supreme SE II Touring. None of the tires were labeled with an identifiable brand name. The specific inflation and tread depth data are listed in the following table.

Tire Position	Tread Depth	Inflation Pressure
LF	4.8 mm (6/32")	219 kPa (32 PSI)
RF	4.8 mm (6/32")	212 kPa (31 PSI)
LR	5.6 mm (7/32")	178 kPa (26 PSI)
RR	5.6 mm (7/32")	206 kPa (30 PSI)

1999 Ford E150 Conversion Van

The struck vehicle was a 1999 Ford E150 conversion van, configured as a seven passenger vehicle. The body of the Ford van was modified with the placement of three large windows, two on the left side and one on the right, aft of the dual hinged right side doors. Paint striping, aftermarket running boards, and alloy wheels completed the exterior modification of the vehicle. The interior was configured with four captain's chairs and a third row bench seat that folded flat. The vehicle identification number was 1FDRE14W2XH (production number deleted). The keys were not available at the time of the evening inspection; therefore the odometer reading was unknown.

Crash Sequence

Pre-Crash

The 41-year old female driver of the Ford E150 conversion van was traveling in a northerly direction on the local street. On her approach to the signalized intersection, the signal phase changed to red for east/westbound traffic flow through the intersection. The driver stopped at the stop line and waited for northbound traffic to clear the intersection

prior to initiating a right turn onto the four-lane state route. The Crash Schematic is attached as **Figure 17**, page 11.

The 29-year old female driver of the 2001 Ford Focus was traveling in a northerly direction on an approach to the signalized intersection. The driver of the Focus stated that she noted the red signal phase and decelerated as she approached the intersection. She further noted that she did not detect the stopped Ford conversion van. The driver may have been distracted from her driving task by the child in the rear seat of the Focus. The driver stated she approached the mouth of the intersection at an estimated speed of 8-11 km/h (5-7 mph).

Crash

The center and right front bumper area of the Ford Focus impacted the center and right area of the rear bumper of the Ford E150 van. Resultant directions of force were 12 o'clock for the Focus and 6 o'clock for the struck van. The impact resulted in minor superficial damage to the front bumper fascia of the Focus with no residual crush to the underlying bumper system. The rear bumper of the Ford van sustained 7.0 cm (2.75") of crush to the steel bumper, located between the rear frame rails. The damage algorithm of the WinSMASH program computed total velocity changes of 15.0 km/h (9.3 mph) for the Focus and 10.0 km/h (6.2 mph) for the struck van. The longitudinal components were -15.0 km/h (-9.3 mph) and 9.8 km/h (6.1 mph) respectively. As a result of the impact, the frontal air bag system in the Focus deployed.

Post-Crash

The vehicles came to rest at or near the point of impact. The driver of the Ford van stated that she felt the impact; however, her vehicle was not displaced forward by the crash. Immediately following the crash, the driver of the Ford Focus noted the right sleeve of her cotton sweatshirt was burning. She immediately wiped her sleeve on her right thigh to extinguish the flame. The driver of the Focus unbuckled her manual restraint system and exited the vehicle. At this point, she realized that she sustained a burn of the anterior aspect of her right wrist and forearm.

The investigating officer arrived on scene and initiated his investigation of the crash. The driver of the Focus refused medical attention at the scene of the crash. The investigating officer requested towing of the Focus due to the windshield damage that resulted from deployment of the frontal air bag system. The driver of the Focus and her child passenger were driven from the scene in a private vehicle. The day following the crash, the driver of the Focus called her physician who prescribed a medicated cream to apply to the thermal burns. The cream was delivered to the driver by a staff member of the physician's office. The driver did not seek follow-up medical treatment.

Vehicle Damage

2001 Ford Focus – Exterior

The exterior of the 2001 Ford Focus sustained minor exterior damage as a result of the crash. The impact was reported to have involved the right corner area of the front bumper system. The front bumper fascia was removed from the vehicle to allow an

inspection of the underlying bumper beam and frame components. No damage was found and the fascia was replaced. Superficial abrasions to the fascia were repaired and the component was repainted. Superficial scratches were reported to the hood of the Focus. Although no direct contact damage occurred to the hood, these scratches possibly resulted from the fractured windshield glazing due to the deployment of the front right passenger air bag. The hood was also repainted. All body damage was repaired prior to the SCI inspection. There was no crush reported to the Focus. Based on the reported damage by the insurance company and the body repair shop, a Collision Deformation Classification (CDC) of 12-FZEW-1 was estimated for this impact event. **Figures 3 and 4** are frontal views of the repaired exterior of the Ford Focus.

Figure 3. Front left three-quarter view of the repaired Ford Focus.

Figure 4. Front right view of the bumper fascia.

2001 Ford Focus - Interior

The interior of the Ford Focus sustained moderate damage that resulted from deployment of the frontal air bag system. The driver and front right air bags deployed from their respective modules. The front right air bag module cover flap opened in an upward direction from its top instrument panel mount and impacted the windshield. This impact fractured the glazing.

The front safety belt systems were equipped with pretensioners. The front left belt system utilized a retractor pretensioner while the front right position utilized a buckle pretensioner. The front left retractor pretensioner fired which produced a subtle D-ring transfer on the belt webbing in conjunction with driver loading. The front right buckle pretensioner fired, although the seat position was not occupied.

The insurance company repair order called out a parts replacement cost of $2,927.24, exclusively from replacement of the interior safety systems.

1999 Ford E150 Conversion Van

The front right corner area of the Focus impacted the center aspect of the van's rear bumper **(Figure 5)**. The direct contact damage on the chromed bumper involved superficial abrasions and wipe marks (removal of road film). The contact damage began 26.4 cm (10.4") left of the vehicle's centerline and extended 71.8 cm (28.25") to the right. The impact crushed the mid point of the bumper between the frame rails that were

spaced on 71.1 cm (28.0”) centers. Maximum crush was 7.0 cm (2.75”), located (7.0”) right of center **(Figure 6)**. The crush at bumper level was as follows: C1 = 1.6 cm (0.625”), C2 = 2.5 cm (1.0”), C3 = 5.3 cm (2.1”), C4 = 7.0 cm (2.75”), C5 = 0.3 cm (0.1”), C6 = 0.6 cm (0.25”). The CDC for this impact damage was 06-BZEW-1.

Figure 5. Rear bumper damage to the conversion van.

Figure 6. Extent of crush to the mid point of the rear bumper.

Manual Restraint Systems – Ford Focus

The Ford Focus was configured as a five-passenger vehicle with front bucket seats and a split rear bench seat with forward folding seat backs. All seated positions were equipped with 3-point lap and shoulder belt systems.

The front safety belt systems consisted of a continuous loop webbing that retracted onto a B-pillar mounted retractor. The latch plates were sliding and the D-rings were adjustable. Both D-rings were found adjusted 5.4 cm (2.125”) above the full down position, or 2.9 cm (1.125”) below the full up position. The front left belt system utilized an emergency locking retractor (ELR) while the front right was equipped with an ELR that was switchable to an automatic locking retractor (ALR) mode.

The front belt systems were equipped with pretensioners that fired in conjunction with the frontal air bag system. The front left retractor pretensioner, in combination with driver loading of the belt system, produced a D-ring transfer on the webbing located 200.1-207.0 cm (79.0-81.75”) above the floor anchor point. The transfer was full width across the belt webbing, 4.8 cm (1.875”) wide. The front right belt system utilized a buckle pretensioner. Although this seat position was not occupied and the belt system was not buckled, the buckle pretensioner

Figure 7. Fired front right buckle pretensioner.

fired **(Figure 7)**. Post-crash, the cable protruded 2.5 cm (1.0") from the end of the pretensioner barrel.

The rear belt systems were comprised of continuous loop webbings that retracted onto dual mode ELR/ALR retractors with sliding latchplates. The right rear position was occupied by a 5 year old child passenger. Although there was no loading evidence on the belt system, the driver of the Focus stated that the child passenger was restrained by the lap and shoulder belt system.

Frontal Air Bag System – 2001 Ford Focus

The 2001 Ford Focus was equipped with a redesigned frontal air bag system for the driver and right passenger positions. The driver air bag module was housed in the center aspect of the steering wheel while the front right air bag was top mounted in the right instrument panel. A single point Restraints Control Module (RCM) that was located on the center tunnel under the mid instrument panel controlled the system. In addition to the air bags, the Focus was equipped with front seat safety belt pretensioners.

The driver air bag was concealed within H-configuration module cover flaps that opened at the designated tear seams **(Figure 8)**. The upper flap was 17.8 cm (7.0") wide at the horizontal tear seam with a maximum width of 19.7 cm (7.75") and a height of 4.8 cm (1.875"). The top hinge of the upper flap was 11.7 cm (4.6") in width. The lower module cover flap was 17.8 cm (7.0") wide at the horizontal tear seam and reduced in width to 6.0 cm (2.375") at the bottom hinge. The vertical height of the flap was 7.9 cm (3.125"). The cover flaps are illustrated in **Figure 9**.

Figure 8. Deployed front left air bag.

Figure 9. Cover flaps and rip-stitch pattern.

The front left air bag was a unique design that utilized a rip-stitch pattern to control the deployment shape and path of the bag membrane. The rip-stitch pattern utilized four rows at the top aspect of the bag, three on each side, and five rows at the bottom aspect of the bag. This rip-stitch design replaced the internal tethers that are commonly used in air bags. The deployment shape of the driver's air bag was controlled by the rip-stitch design. The front left air bag measured 59.7 cm (23.5") in diameter. There was no damage to the bag membrane or evidence of driver contact.

Figure 10. Petal vents and the rip-stitch patterns.

Figure 11. Close-up view of the petal vents.

The bag was vented by a series of nine petal vents **(Figure 10)** that were located on the backside of the bag membrane away from the driver, ranging from the 11:30-12:30 o'clock positions. The petal vents were semi-circular (gill-shaped) cuts in the bag membrane that were positioned in two rows, five on the bottom (closest to the inflator) with four on top, 15.9 cm (6.25") from the peripheral seam **(Figure 11)**. The open aspect of the two rows of vents were opposed to one-another. The vents measured 15.9 mm (0.625") in width at the hinge and 9.5 mm (0.375") in height. The exterior surface of the inboard vent ports contained a black soot-like substance. The interior surface of the vent ports was clean of any soot-like material. It should be noted that the petal vent system was designed to dissipate the exhaust gases over a larger area, thus eliminating the possibility of thermal issues (burns) to clothing and tissue. There was no trace evidence of exhaust gas residue to the headliner, sun visors, steering wheel, or the instrument panel **(Figure 12)**. It should be noted that the interior of the Focus was extremely dirty, due to poor maintenance.

Figure 12. Sun visor/headliner area over the driver's position.

Figure 13. Deployed front right passenger air bag.

The front right air bag module was mounted in the top aspect of the right instrument panel. The module was concealed by a single cover flap that measured 40.6 cm (16.0") at the leading edge tear seam and 44.5 cm (17.5") at the top hinge point. The cover flap was deformed (creased) laterally at the mid point from the deployment event. Although the windshield had been removed prior to the SCI investigation, the cover flap opened against the laminated windshield and fractured the glazing. **Figure 13** is a view of the deployed front right air bag.

The front right air bag was not tethered internally and was vented into the passenger compartment by two 2.9 cm (1.125") diameter vent ports located at the 3 and 9 o'clock sectors of the side panels. There was no damage or occupant contact noted to the deployed front right air bag membrane.

Driver Clothing/Thermal Burns

The 29-year old female driver of the Ford Focus was dressed in a washed-out pink 100 percent cotton pullover, long-sleeved sweatshirt and stretch pants. She stated that at impact, her hands were positioned on the steering wheel at the 3 and 9 o'clock sectors. The deployment of the frontal air bag system resulted in a discharge of hot exhaust gases that ignited the inboard aspect of her right sleeve at the cuff **(Figures 14 and 15)**. Immediately following the crash, the driver observed the flame on her sleeve. She wiped her sleeve against her right thigh to extinguish the flame. The driver subsequently noted that she sustained a thermal burn of the anterior aspect of her right forearm and wrist.

Based on the location of the burn to the driver's sweatshirt and forearm, the burn probably resulted from the hot exhaust gases and/or particulates that exhausted from the petal vents located on the backside of the front left air bag. A black soot-like substance was noted to the exterior surface of the inboard vents.

Figure 14. Burned left anterior sleeve of the driver's sweatshirt.

Figure 15. Close-up view of the burned sleeve.

Driver Demographics

Ford Focus

Age/Sex:	29-year old female
Height:	172.7 cm (68.0”)
Weight:	107.0 kg (236.0 lb)
Manual Restraint Usage:	3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Seat Track Position:	Mid-to-rear (moved prior to SCI inspection)
Mode of Transport From Scene:	Private vehicle
Type of Medical Treatment:	Telephone follow-up with private physician

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Thermal burn of the anterior aspect of the right wrist/forearm	Minor (792002.1,1)	Front left air bag exhaust gases

Source – Driver interview

Driver Kinematics

The driver of the Ford Focus stated that she was seated in an upright driving posture with the seat track adjusted to a mid-to-rear track position. Although the seat had been moved prior to the SCI investigation, the seat track was adjusted 7.6 cm (3.0”) forward of the full rear position with a measured seat back angle of 22 degrees aft of vertical. In this position, the horizontal distance between the seat back support and the center of the driver’s air bag module was 62.9 cm (24.75”). The driver was restrained by the manual 3-point lap and shoulder belt system. Belt usage was determined from a D-ring transfer on the shoulder belt webbing that was indicative of driver loading and firing of the retractor pretensioner.

The driver was dressed in a 100 percent cotton sweatshirt and stretch pants. She stated that her hands were positioned at the 3 and 9 o’clock positions on the steering wheel rim. At impact with the Ford E150, the frontal air bag system in the Ford Focus deployed. The driver stated that she heard a loud bang associated with the deployment of the frontal air bag system and noted a smoke-like substance within the vehicle. She immediately noted that the right sleeve of her sweatshirt was on fire. The driver immediately brushed the sleeve against her thigh to extinguish the flame. Without further concern of the fire, the driver unbuckled her restraint system and exited the vehicle.

At this point, the driver noted that the anterior aspect of her forearm was burned from the flame on her sweatshirt. The driver waited at the scene for police and exchanged information with the driver of the van. Following the on-scene police investigation, the driver and her child passenger were transported by a private vehicle to her residence.

Medical Treatment

The driver refused medical treatment at the scene of the crash. The following day, the driver called her private physician and reported the burn. The physician provided a medical cream to apply to the burn. The driver did not seek follow-up medical treatment as the burn began to heal.

Rear Right Child Passenger

Ford Focus

Age/Sex:	5-year old female
Height:	96.5 cm (38.0”)
Weight:	17.2 kg (38.0 lb)
Manual Restraint Usage:	3-point lap and shoulder belt system
Usage Source:	Driver interview
Mode of Transport From Scene:	Private vehicle
Type of Medical Treatment:	None, not injured

Rear Right Child Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Not injured	N/A	N/A

Rear Right Child Passenger Kinematics

The 5-year old child passenger was seated in the right rear position of the Ford Focus and was reported by the driver as restrained with the 3-point lap and shoulder belt system. A child safety seat was not available for the child. At impact, the child passenger probably initiated a forward trajectory and loaded the manual belt system. There were no occupant contact points in the rear seat area of the Focus or loading evidence on the belt system **(Figure 16)**. The child passenger was not injured in the crash.

Figure 16. Rear right seat position.

CRASH SCHEMATIC

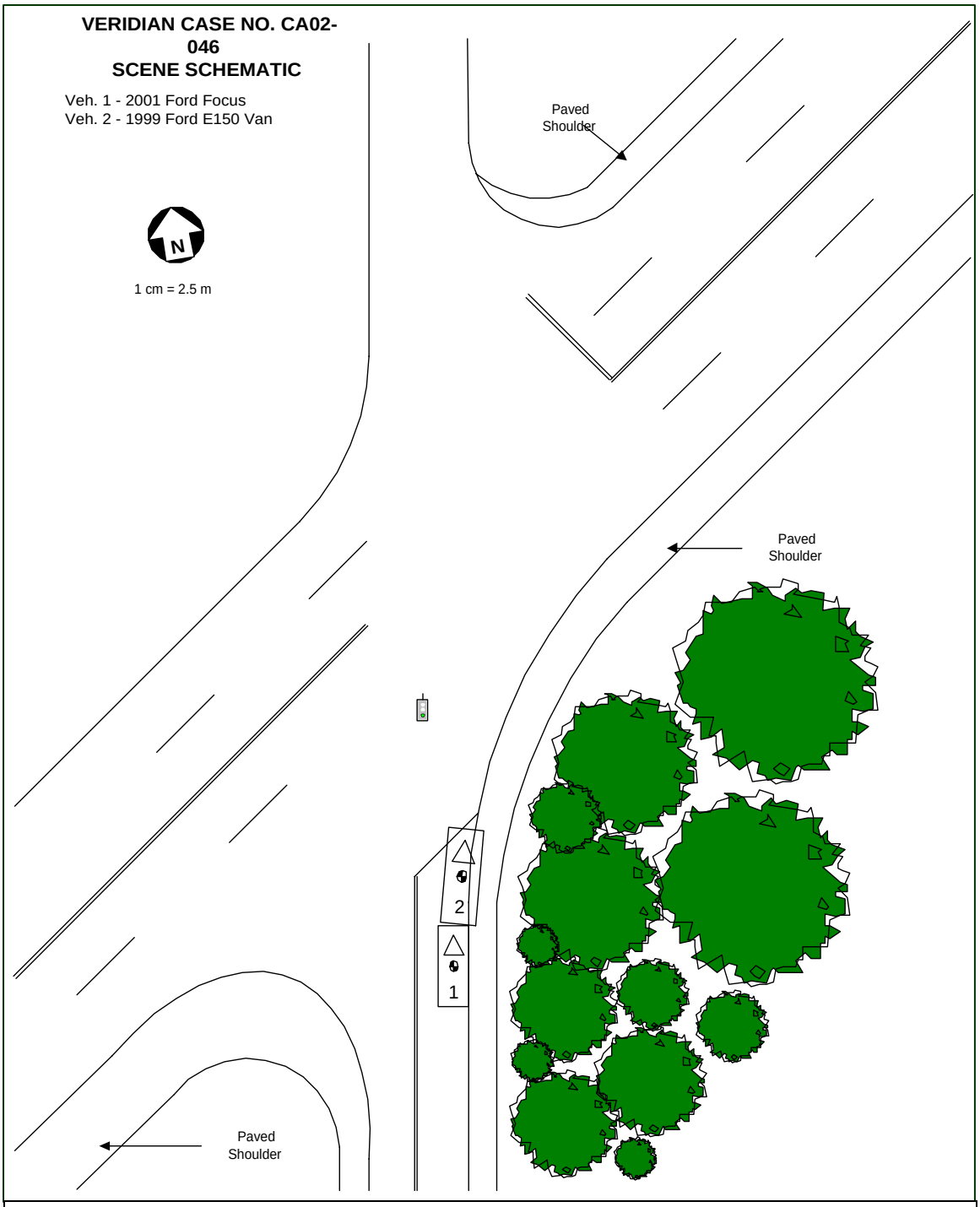

Figure 17. Crash schematic.