TRANSPORTATION SCIENCES
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ON-SITE ADVANCED OCCUPANT PROTECTION SYSTEM CRASH INVESTIGATION SCI TECHNICAL SUMMARY REPORT

VERIDIAN CASE NO. CA01-053

VEHICLE - 2002 FORD WINDSTAR

LOCATION - STATE OF NEW YORK

CRASH DATE - DECEMBER 2001

Contract No. DTNH22-01-C-17002

Prepared for:

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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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15. *Supplementary Notes* On-site investigation of a run-off-road crash with multiple impacts that resulted in the deployment of the driver's air bag (only) in a 2002 Ford Windstar. The Windstar was equipped with a seat weight sensor for the front right passenger position as part of the Advanced Occupant Protection System.			
16. *Abstract* This on-site investigation focused on the Advanced Occupant Protection System (AOPS) in a 2002 Ford Windstar. The Windstar was occupied by a 38-year-old female driver, a 12-year-old male front right passenger, an 8-year-old male second seat left passenger, and a 1-year-old female seated in an unspecified CSS. The driver and children were restrained by the manual 3-point lap and shoulder belts. The Windstar was involved in a run-off-road crash and struck a non-breakaway sign post, a telephone junction box, and a utility pole. The impact fractured the utility pole. Impact also resulted in the firing of the front seat belt pretensioners and the deployment of the driver's frontal air bag in the Windstar. A weight sensor was present in the front right seat of the Windstar, which appeared to have suppressed the front right passenger's air bag, most likely due to the weight of the 12-year-old occupant. The occupants initiated forward trajectories as a result of the pole impact and loaded the manual restraints. The driver contacted the deployed driver's air bag and the child loaded the CSS's harness system. None of the occupants sustained injuries, however, the 1-year-old female was transported by ambulance to a local hospital for evaluation and released. The remaining occupants did not receive medical treatment.			
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BACKGROUND

Figure 1. Damaged 2002 Ford Windstar

This on-site investigation focused on the Advanced Occupant Protection System (AOPS) in a 2002 Ford Windstar. The Windstar was occupied by a 38-year-old female driver, a 12-year-old male front right passenger, an 8-year-old male second seat left passenger, and a 1-year-old female seated in an unspecified CSS. The driver and children were restrained by the manual 3-point lap and shoulder belts. The Windstar was involved in a run-off-road crash and struck a non-breakaway sign post, a telephone junction box, and a utility pole **(Figure 1)**. The impact fractured the utility pole. Impact also resulted in the firing of the front seat belt pretensioners and the deployment of the driver's frontal air bag in the Windstar. A weight sensor was present in the front right seat of the Windstar, which appeared to have suppressed the front right passenger's air bag, most likely due to the weight of the 12-year-old occupant. The occupants initiated forward trajectories as a result of the pole impact and loaded the manual restraints. The driver contacted the deployed driver's air bag and the child loaded the CSS's harness system. None of the occupants sustained injuries, however, the 1-year-old female was transported by ambulance to a local hospital for evaluation and released. The remaining occupants did not receive medical treatment.

Notification of this crash was provided to the Veridian SCI team through a local fire department. The notification was forwarded to NHTSA and an on-site effort was assigned to the Veridian SCI team on Wednesday, December 12, 2001. The field activities were scheduled for December 13 and 14, 2001.

SUMMARY

Crash Site

This one-vehicle crash occurred during the daylight hours of December 2001 at a "T" intersection of a two-lane county roadway and a two-lane local roadway. At the time of the crash, the weather was clear and the asphalt roadway surface was dry. The north/south county roadway consisted of two travel lanes separated by a double-yellow centerline and was bordered by asphalt shoulders. The crash site was located near a sag in the roadway. The roadway exhibited a southbound downhill grade at the crash site, which was located approximately 59 m (195') south of a hillcrest. The roadside environment consisted of residential properties and fields. A utility pole that measured 30 cm (12") in diameter was located 2.4 m (8.0') west of the road edge. A square telephone box that measured 38 x 38 cm (15 x 15") and 91 cm

(36") in height was located on the west roadside 4.0 m (13.0') west of the road edge. The west roadside also had a negative slope. Traffic flow at the intersection was controlled by a stop sign for westbound traffic. A "Bump" sign and a "School Bus Stop Ahead" sign were located at the intersection on the west roadside for southbound traffic. A yellow sign with opposite arrows was located south of the other warning signs on the west roadside for westbound traffic at the intersection to identify the "T" intersection. The posted speed limit was 72 km/h (45 mph) for the north/south roadway. The scene schematic is included as **Figure 12.**

Pre-Crash

The 38-year-old female driver was operating the 2002 Ford Windstar southbound on the two-lane county roadway **(Figure 2)**. As the Windstar crested the hill, the driver detected a non-contact vehicle stopped at the mouth of the intersection waiting to initiate a left turn onto the local roadway. The driver of the Ford Windstar steered right in an attempt to avoid the collision with the non-contact vehicle. The Windstar departed the right roadside in a tracking mode.

Figure 2. Southbound approach for the Windstar

Crash

As the Windstar departed the right roadside, it struck the north non-breakaway sign post of the yellow arrow sign with the front right area. The sign was mounted on two U-channel posts that measured 8.3 cm (3.3") in width and 5.0 cm (2.0") in depth and were spaced 61.0 cm (24.0") apart. The Windstar continued through the sign and impacted the south post. Impact resulted in minor front right damage to the Windstar. The sign posts fractured and the sign was carried forward by the Windstar. The resultant impact force was in the 12 o'clock sector. The impact caused the posts to bend, and the sign deflected as the Windstar continued forward, which allowed the sign to impact the right rear aspect of the hood and the right aspect of the windshield. The Windstar traveled down the negative slope of the roadside and began a slight counterclockwise (CCW) yaw, evidenced by separation of the gouge marks from the right front and right rear wheels. The right side area of the Windstar impacted the square telephone box in a sideswipe configuration which resulted in minor right side damage. The entire right side of the Windstar contacted the telephone box and displaced it. The resultant direction of force for the second impact was in the 12 o'clock sector. The Windstar impacted a wood utility pole with the front left area. At impact, the yaw angle was approximately -10 degrees and the heading angle was approximately 175 degrees. The impact induced deceleration was sufficient to deploy the driver's air bag and fire the front seat belt retractor pretensioners. The impact fractured the pole, and the resultant direction of force was also in the 12 o'clock sector. The Windstar's CCW rotation increased as it traveled through the pole, and the vehicle came to rest on the roadside 12.9 m (42.4') south of the pole facing a southeast direction. The heading angle of the Windstar at rest was approximately 340 degrees. Due to the yielding nature of the struck objects, a delta-V could not be computed using the WinSMASH program. An estimated delta-V based on the visible damage was approximately 20-25 km/h (12-16 mph).

Post-Crash

The occupants of the vehicle exited the Windstar under their own power, although it was not known how the 1-year-old was removed from the vehicle. According to rescue personnel, all of the occupants were out of the vehicle and standing on the roadway when first responders arrived on-scene. Rescue personnel also reported that power lines from the utility poles had been displaced and were lying over the vehicle. The occupants of the Windstar did not sustain injuries, however emergency service personnel suggested that the 1-year-old be evaluated at a hospital as a precaution. The driver accompanied the 1-year-old to the hospital by ambulance, and the child was evaluated and released. The Windstar sustained disabling damage and was towed from the scene.

VEHICLE DATA - 2002 Ford Windstar

The 2002 Ford Windstar was identified by the Vehicle Identification Number (VIN): 2FMDA504X2B (production sequence omitted). The Windstar was a five-door minivan and was equipped with a 3.8 liter, V6 engine, four-speed automatic transmission, power front disc, rear drum brakes with anti-lock (ABS), power steering, tilt steering wheel, cruise control, power mirrors, dual sliding side doors, power windows, and power door locks with autolock (when vehicle is in motion). Safety features included driver and front right passenger dual stage air bags, driver's and front right passenger side impact air bags, front right passenger seat weight sensor, seat belt usage sensors, driver seat position sensor, front seat belt retractor pretensioners, energy management retractors and a low tire pressure warning system. The Windstar was equipped with an electronic odometer and the milage was not known. The Ford Windstar was configured with P215/70R15 tires. Each tire exhibited excellent tread. The front left tire was deflated and debeaded.

Figure 3. Displaced third seat

The Windstar was equipped with box-mounted captains chairs with integral head restraints for the driver and front right passenger positions. At the time of the vehicle inspection, the driver's seat track was adjusted to the full-forward position and the front right seat track was adjusted to the full-rear position. Both front seats traveled a total distance of 16.5 cm (6.5") fore and aft. The driver's seat back was reclined 30 degrees from vertical and the front right seat was reclined 10 degrees from vertical. The second row was configured with a two-person bench seat with adjustable head restraints. The left head restraint was adjusted 7.6 cm (3.0") above the seat back and the right head restraint was adjusted 6.4 cm (2.5") above the seat back. Plastic aftermarket mirror/cupholder accessories were affixed with single straps to each head restraint on the second seat. The adjustable seat back was reclined 25 degrees from vertical and the bench seat track was positioned at the full-rear position with a total travel distance of 10.2 cm (4.0"). The third row was configured with a three-person bench seat with adjustable head restraints on the outboard positions. At the time of the vehicle inspection, the forward anchors of the bench seat were disengaged from the floor anchor points and the seat was displaced rearward onto the floor resting on the seat back **(Figure 3)**. It was not known if the displacement was crash related.

VEHICLE DAMAGE

Exterior Damage - *2002 Ford Windstar*

Figure 4. Frontal view of damaged Windstar

The 2002 Ford Windstar sustained moderate damage as a result of the multiple impacts **(Figure 4)**. The vehicle exhibited minor front right damage as a result of the first impact with the non-breakaway sign. Narrow direct contact abrasions were located on the front right corner of the hood and measured 9.5 cm (3.8") in width and 10.2 cm (4.0") rearward from the forward aspect. The direct contact damage on the bumper fascia began 68.6 cm (27.0") right of the centerline and extended to the front right corner. The bumper fascia was fractured 74.3 cm (29.3") right of center and the corner of the fascia was separated. The right front fender sustained induced buckling and the head lamp assembly was displaced. The right side mirror was separated from the vehicle. The Collision Deformation Classification for the first impact with the sign was 12-FREN-1.

The displacement of the sign resulted in a second impact to the windshield which produced a small fracture at the base of the windshield on the right aspect, and a larger windshield fracture located 35.5 cm (14.0") inboard of the right edge and 40.6 cm (16.0") below the top aspect. The CDC for the second sign impact was 00-FRGW-6.

Figure 5. Right rear damage from the sideswipe impact

The impact with the telephone junction box resulted in minor sideswipe damage to the right side of the Windstar. Longitudinal abrasions were noted on the right front fender, lower right side sliding door, and on the right rear quarter panel. The lower plastic trim that extended forward from the rear bumper fascia on the right side was fractured from snagging on the telephone box **(Figure 5)**. The CDC for the sideswipe event was 12-FRES-1.

The impact with the utility pole resulted in moderate damage to the Windstar. The direct contact damage began 54.6 cm (21.5") to the left of center on the bumper fascia and extended to the front left corner and around the left side aspect of the fascia **(Figure 6)**. The front right aspect of the bumper fascia was fractured 82.6 cm (32.5") left of center at the left corner.

Figure 6. Damaged left aspect of front bumper fascia

The direct contact on the hood began 45.7 cm (18.0") left of center and extended laterally 38.1 cm (15.5") to the left front fender **(Figure 7)**. The combined direct and induced damage involved the entire frontal width of the Windstar. The multiple frontal impacts and overlapping nature of combined direct and induced frontal damage necessitated a single crush profile. The total combined direct and induced damage length measured 125.1 cm (49.3") along the bumper beam. Crush measurements were documented at the level of the bumper beam and at the upper radiator support. The residual maximum crush was located at the front left corner of the bumper beam at C1 and was approximately 13 cm (5"). The maximum crush at the same location on upper radiator support was approximately 27 cm (11"). The impact was primarily outboard of the left frame rail, and the outboard aspect of the left frame rail exhibited longitudinal abrasions from the pole on the forward aspect.

Figure 7. Direct damage from pole impact

The direct contact on the left corner of the bumper beam was minimal, however, the impact resulted in the induced displacement of the entire beam **(Figure 8)**. Direct contact abrasions were present on the left corner of the hood and the entire hood was buckled rearward. The pole impact also resulted in rearward and outward displacement of the left front fender. The aft edge of the left fender was displaced inboard of the leading edge of the partially restricted left front door. The crush resulted in incapacitating damage to the exterior fuse box, which resulted in complete power loss to the vehicle. The corner impact allowed the pole to penetrate rearward and contact the left front wheel assembly. The left front wheel was restricted against the rear aspect of the left front fender and rotated slightly CCW. The rearward left front wheel displacement reduced the left wheelbase by 42.7 cm (16.8"). The CDC for the pole impact was 12-FLEE-2. A crush profile was taken across the front bumper beam and on the upper radiator support. Based on approximate free space values, the estimated crush profile at the bumper beam was as follows: C1 = 13 cm (5"), C2 = 8 cm (3"), C3 = 5 cm (2"), C4 = 3 cm (1"), C5 = 3 cm (1"), C6 = 0.0 cm. The estimated crush profile along the upper radiator support was as follows: C1 = 27 cm (11"), C2 = 16 cm (6"), C3 = 10 cm (4"), C4 = 5 cm (2"), C5 = 3 cm (1"), C6 = 0.0 cm.

Figure 8. Lateral view of direct and induced frontal damage

Interior Damage - *2002 Ford Windstar*

Interior damage to the Windstar was minor and attributed to impact forces and passenger compartment intrusion. The windshield glazing was fractured at the bottom right aspect and 35.5 cm (14.0") inboard of the right edge and 40.6 cm (16.0") below the top aspect from the sign impact. The bottom left aspect of the windshield also exhibited a fracture from an direct contact, and linear fractures from impact forces were also present. The right front glazing disintegrated from impact forces. The remaining glazing was not damaged. The left toe pan intruded into the driver's area as a result of the pole impact.

MANUAL RESTRAINT SYSTEM - 2002 Ford Windstar

The front seat positions in the 2002 Ford Windstar were equipped with manual 3-point lap and shoulder belts and inertial lock/belt sensitive, load limiting retractors. The driver's manual restraint was configured with a sliding latch plate and the remaining manual restraints were configured with lightweight locking (cinching) latch plates. The front right lap and shoulder belt was also equipped with a switchable/automatic locking retractor (ALR). Both front manual restraints were configured with retractor pretensioners located in the lower B-pillars. Although both front seat restraints were restricted in the used position and it is highly likely that both front seat belt pretensioners fired, it could not be confirmed with certainty due to their position in the retractors. The driver's adjustable D-ring was in the full-down position and the front right D-ring was 2.5 cm (1.0") below the full-up position at the time of the vehicle inspection. The driver's D-ring and latch plate were abraded from occupant loading and pretensioner firing. and the front right passenger's D-ring and latch plate showed abrasions consistent with occupant loading and pretensioner firing. Both frontal seat belts exhibited distinct lateral fold patterns on the webbing which were not consistent with occupant positions and did not appear to be crash related. **(Figure 9)**.

Figure 9. View of front right manual restraint

The second seat positions were configured with manual 3-point lap and shoulder belts with sliding latch plates and inertial lock/belt sensitive, load limiting retractors **(Figure 10)**. Both lap and shoulder belts were equipped with switchable/ALR's. The second seat manual restraints were equipped with adjustable D-rings. The second seat left D-ring was in the full-down position and the second seat right D-ring was 2.5 cm (1.0") below the full-up position at the time of the vehicle inspection. There were no abrasions on either second seat D-ring or latch plate. The left position 3-point lap and shoulder belt was permanently anchored to the floor. The second seat right seat belt was anchored to the right rear side aspect of the seat with a latch plate and buckle mechanism. Multiple creases were noted on the webbing indicative of a child safety seat installation, and both second seat belts exhibited multiple lateral fold patterns on the webbing which were not consistent with occupant positions and did not appear to be crash related.

Figure 10. View of second seat restraints

The third seat was equipped with manual 3-point lap and shoulder belts for the outboard seat positions and a lap belt for the middle position.

FRONTAL AIR BAG SYSTEM - *2002 Ford Windstar*

The 2002 Ford Windstar was equipped with dual-stage frontal air bags for the driver and front right passenger positions. A seat track position sensor and seat belt usage sensor were present for the driver's seat to adjust the inflation rate and timing of the air bag deployment. A weight sensor and seat belt usage sensor were present in the front right passenger's seat to detect the occupancy and weight of a seated occupant in the seat and adjust the inflation rate, timing, or suppress the air bag.

The driver's air bag deployed as a result of the utility pole impact **(Figure 11)**. The air bag deployed from the center of the steering wheel from asymmetrical H-configuration module cover flaps. The top flap measured 15.2 cm (6.0") in width at the top aspect and 7.6 cm (3.0") in height. The width at the tear seam measured 16.8 cm (6.6"). The bottom flap measured 10.2 cm (4.0") in width at the bottom aspect and 4.4 cm (1.8") in height. The driver's air bag measured 53.3 cm (21.0") in diameter in its deflated state. The air bag was vented by two circular ports that measured 2.5 cm (1.0") in diameter and were located in the 12 o'clock sector 7.0 cm (2.8") from the seam. The air bag was tethered by two internal straps at the 12 and 6 o'clock positions that measured 11.4 cm (4.5") in width.

Figure 11. Deployed driver's air bag

The front right passenger's air bag did not deploy in the crash. The front right seat was occupied by a 12-year-old male child and the driver stated that the child weighed approximately 41-45 kg (90-100 lb). Based on seat belt usage, it appears that the restraint control module suppressed the air bag due to the weight of the child in the seat. The SCI investigator attempted to download the data from the restraint control module, however, the data collection software did not support the 2002 Ford Windstar at the time of the inspection. The raw data file was forwarded to Ford Motor Company for analysis, but could not be interpreted.

SIDE IMPACT AIR BAG SYSTEM - *2002 Ford Windstar*

The 2002 Ford Windstar was equipped with side impact head/torso air bags for the driver and front right positions. Both side impact air bags were located in the outboard aspects of the front seat backs and were designed to deploy forward from the seat backs. The side impact air bags did not deploy in this crash.

CHILD SAFETY SEAT

Cooperation could not be established with the family to facilitate the inspection of the CSS. The make/model information was unknown.

OCCUPANT DEMOGRAPHICS - 2002 Ford Windstar

Driver

Age/Sex:	38-year-old female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Full-forward
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Not injured and did not receive medical treatment

Driver Kinematics

The 38-year-old female driver was seated in a presumed upright posture and restrained by the manual 3-point lap and shoulder belt. The seat track was adjusted to the full-forward position during the vehicle inspection, but the pre-crash position could not be confirmed. As the Windstar departed the roadway the manual restraint helped the driver to maintain her position in the seat. At impact with the utility pole, the driver's air bag deployed and the seat belt pretensioner fired. She initiated a forward trajectory and loaded the manual restraint which resulted in abrasions on the D-ring and latch plate, and stretch marks on the webbing. The driver did not sustain injury and did not receive medical treatment.

Front Right Passenger

Age/Sex:	12-year-old male
Height:	Unknown
Weight:	41-45 kg (90-100 lb)
Seat Track Position:	Full-rear
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Not injured and did not receive medical treatment

Front Right Passenger Kinematics

The 12-year-old male front right passenger was presumed to be seated in an upright posture and restrained by the manual 3-point lap and shoulder belt. The seat track was adjusted to the full-rear position during the vehicle inspection, but the pre-crash position could not be confirmed. As the Windstar departed the roadway the manual restraint helped the front right passenger to maintain his position in the seat. The child reportedly weighed 41-45 kg (90-100 lb). Since the child was restrained by the 3-point belt, it appears that due to the child's weight, the data from the front right passenger's seat weight sensor caused the restraint control module to suppress the front right passenger's air bag. At impact with the utility pole, the 12-year-old initiated a forward trajectory and loaded the manual restraint. He did not sustain injury and did not receive medical treatment.

Second Seat Left Passenger

Age/Sex:	8-year-old male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Full-rear
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Not injured and did not receive medical treatment

Second Seat Left Passenger Kinematics

The 8-year-old male second seat left passenger was presumed to be seated in an upright posture and restrained by the manual 3-point lap and shoulder belt. The seat track was adjusted to the full-rear position. At impact with the pole, he initiated a forward trajectory and loaded the manual restraint. He did not sustain injuries, and did not receive medical treatment.

Second Seat Right Passenger

Age/Sex:	1-year-old female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Full-rear
Manual Restraint Use:	Unspecified CSS
Usage Source:	Police report
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a local hospital for evaluation and released

Second Seat Right Passenger Kinematics

The 1-year-old child was restrained in an unspecified CSS on the second seat right position. The orientation of the CSS was unknown. Based on the creases on the manual restraint webbing, the CSS was secured to the seat with the manual 3-point lap and shoulder belt. At impact with the pole, the CSS and the child initiated forward trajectories. The CSS loaded the manual restraint which resulted in stretch marks on the webbing. There were no distinct impressions in the seat cushion fabric indicative of a CSS, and there was no deformation to the fabric from longitudinal or lateral movement of the CSS. Due to the unknown orientation (forward-facing or rear-facing) of the CSS, it was not known how the child loaded the CSS. She did not sustain any visible injuries, but was transported by ambulance to a local hospital for evaluation as a precaution. She was evaluated and released.

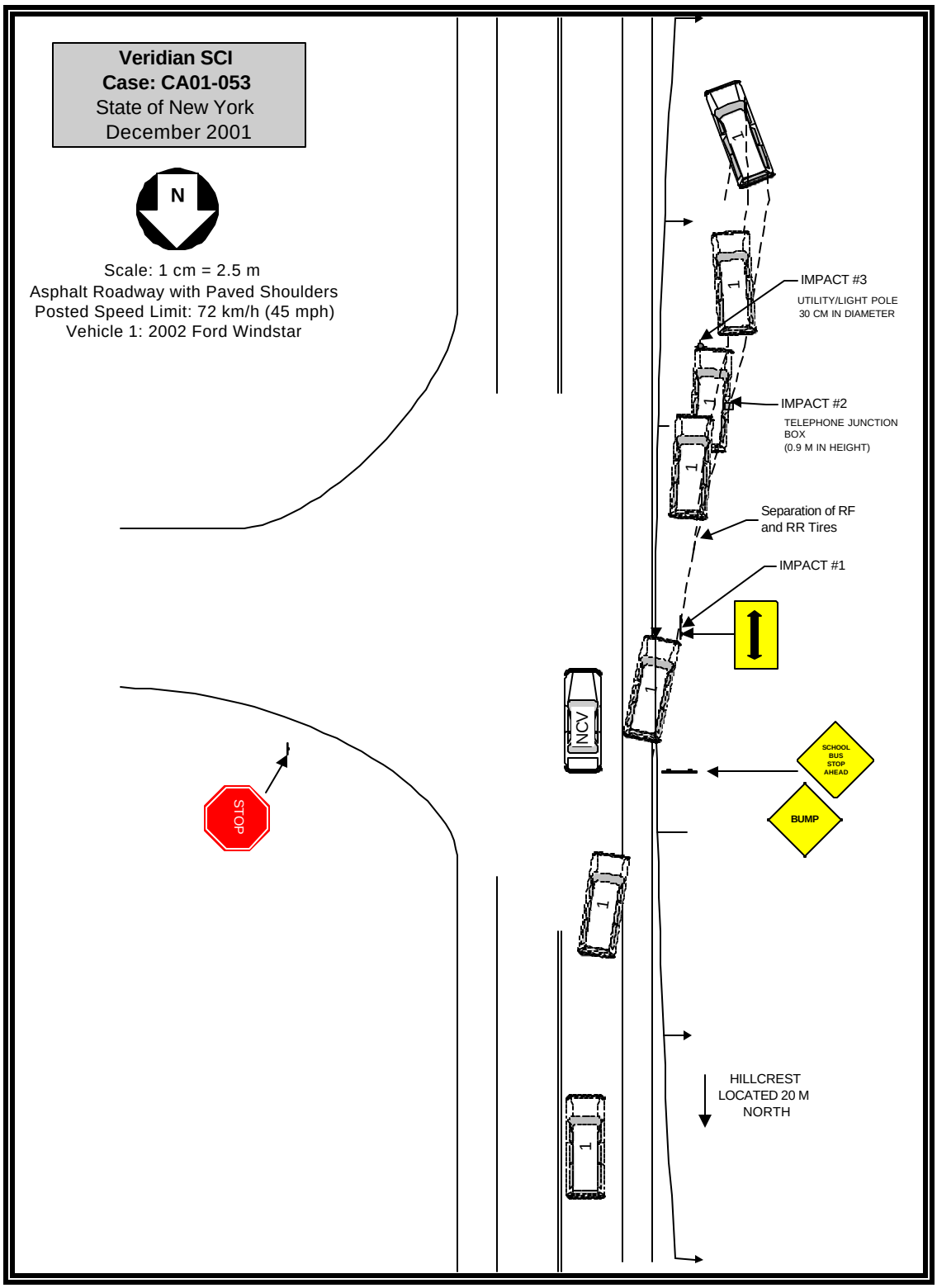

Figure 12. Scene schematic