TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

Veridian Engineering
Buffalo, NY 14225

ON-SITE AIR BAG RELATED ADULT DRIVER FATALITY INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

VERIDIAN CASE NO. CA99-048

VEHICLE - 1997 MERCURY SABLE

LOCATION - STATE OF KENTUCKY

CRASH DATE - JULY 1999

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation
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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.

TECHNICAL REPORT STANDARD TITLE PAGE

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16. *Abstract* This on-site investigative effort focused on the fatal injury mechanisms of a female driver of a 1997 Mercury Sable (Figure 1) that was equipped with frontal air bags. The 44-year-old driver was restrained by the manual 3-point lap and shoulder belt and the driver's seat was adjusted between the mid-track and full-forward positions. A pillow was also positioned behind the driver's lumbar region against the seat back, which resulted in the driver being positioned upright and in close proximity to the driver's air bag module. The driver of the Sable initiated a left turn into the path of a 1988 Ford Tempo which was traveling in the opposite direction. The frontal air bags in the Sable deployed as a result of the intersection crash with the Tempo. The driver was struck by the deploying driver's air bag and initiated a forward trajectory and loaded the manual restraint and knee bolster. Due to her close proximity to the driver's air bag module, the air bag expanded against her face and neck which resulted in "punch-out" type injuries to the head, neck and chest which included massive edema with obliterated basal cisterns, an intracerebral contusion, a left temporal subdural hemorrhage, bilateral pulmonary contusions, an arterial bleed of cranio-facial origin (likely internal carotid), intracranial pneumocephalus, a left temporal subarachnoid hemorrhage, a temporal/petrous bone fracture, bilateral pneumothorax, a pneumomediastinum, a tracheal/bronchial injury, an open mandibular symphysiseal fracture, an open fracture of the left superior lateral nose (maxilla), an occipital contusion, soft tissue injuries to the face, neck and chest, a right upper extremity ecchymosis, and skin abrasions. Her forward loading and impediment of the driver's air bag resulted in steering column compression. She rebounded rearward and reportedly came to rest in the driver's seat, slumped to the right. She was removed from the vehicle by rescue personnel and transported by ambulance to a regional trauma center where she expired six hours following the crash.			
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BACKGROUND

This on-site investigative effort focused on the fatal injury mechanisms of a female driver of a 1997 Mercury Sable **(Figure 1)** that was equipped with frontal air bags. The 44-year-old driver was restrained by the manual 3-point lap and shoulder belt and the driver's seat was adjusted between the mid-track and full-forward positions. A pillow was also positioned behind the driver's lumbar region against the seat back, which resulted in the driver being positioned upright and in close proximity to the driver's air bag module. The driver of the Sable initiated a left turn into the path of a 1988 Ford Tempo which was traveling in the opposite direction. The frontal air bags in the Sable deployed as a result of the intersection crash with the Tempo. The driver was struck by the deploying driver's air bag and initiated a forward trajectory and loaded the manual restraint and knee bolster. Due to her close proximity to the driver's air bag module, the air bag expanded against her face and neck which resulted in "punch-out" type injuries to the head, neck and chest which included massive edema with obliterated basal cisterns, an intracerebral contusion, a left temporal subdural hemorrhage, bilateral pulmonary contusions, an arterial bleed of cranio-facial origin (likely internal carotid), intracranial pneumocephalus, a left temporal subarachnoid hemorrhage, a temporal/petrous bone fracture, bilateral pneumothorax, a pneumomediastinum, a tracheal/bronchial injury, an open mandibular symphysiseal fracture, an open fracture of the left superior lateral nose (maxilla), an occipital contusion, soft tissue injuries to the face, neck and chest, a right upper extremity ecchymosis, and skin abrasions. Her forward loading and impediment of the driver's air bag resulted in steering column compression. She rebounded rearward and reportedly came to rest in the driver's seat, slumped to the right. She was removed from the vehicle by rescue personnel and transported by ambulance to a regional trauma center where she expired six hours following the crash.

Figure 1. Damaged 1997 Mercury Sable

This Crash Investigation Division of the National Highway Traffic Safety Administration was informed of this crash by the medical community, due to the fatality of a short-stature female in a low-speed frontal crash. The case was assigned to the Veridian SCI team and contact was made with the attorney who was handling the case. An on-site investigation was initiated in November 1999.

SUMMARY

Crash Site

This two-vehicle crash occurred during the daylight hours in July 1999. At the time of the crash, the weather was cloudy and the asphalt roadway surface was dry. The crash occurred at a three-leg T-intersection of two local roadways **(Figure 2)**. The east/west roadway comprised the top aspect of the "T"and was configured with one travel lane in each direction, separated by a dashed yellow centerline. The intersecting north/south roadway was configured with one travel lane in each direction but did not have a painted centerline. Both roadways were straight with level grades. Each roadway was bordered by concrete curbs. The roadside environment consisted of small grassy areas, sidewalks, trees, and commercial properties. Traffic control for the intersection consisted of a stop sign for northbound traffic entering the intersection. The posted speed limit for the east/west roadway was 56 km/h (35 mph). The scene schematic is included as **Figure 13** of this report.

Figure 2. Eastbound view of the crash site showing final rest of both vehicles

Pre-Crash

The 44-year-old female driver of the Mercury Sable was operating the vehicle westbound on approach to the T-intersection **(Figure 3)**. The 1988 Ford Tempo was traveling eastbound on approach to the intersection. The driver of the Sable apparently did not detect the approaching Tempo. The Sable reportedly slowed as she entered the intersection and initiated a left turn maneuver across the path of the Tempo. For unknown reasons, the driver of the Sable slowed and/or stopped the vehicle in the intersection while making the left turn. The driver of the Tempo detected the Sable turning across its path and applied the brakes in full lockup and steered right in an attempt to avoid the collision. Skid marks were present in the pre-crash trajectory of the Tempo. The skid marks were documented by police and measured 11.3 m (37.0') in length.

Figure 3. Pre-crash trajectory for the Mercury Sable

Crash

The front aspect of the Tempo impacted the front right corner of the Sable. Impact resulted in moderate damage to both vehicles. The principal direction of force was in the 12 o'clock sector for the Sable and in the 11 o'clock sector for the Tempo. The damage algorithm of the WinSMASH program computed a delta-V of 16.4 km/h (10.2 mph) for the Sable and 18.7 km/h (11.6 mph) for the Tempo. The impact was sufficient to deploy the frontal air bag system in the Sable. The longitudinal and lateral components for the Sable were -14.2 km/h (-8.9 mph) and -8.2 km/h (-5.1 mph), respectively. The longitudinal and lateral components for the Tempo were -16.2 km/h (-10.0 mph) and 9.3 km/h (5.8 mph), respectively. The Tempo came to rest in the intersection facing southeast **(Figure 4)**. The Sable traveled in a northeast direction across its original travel lane and struck the north curb after rotating approximately 250 degrees in a counterclockwise (CCW) direction. The Sable came to rest with the right front tire against the face of the curb on the north side of the roadway.

Figure 4. Trajectory of the 1988 Ford Tempo showing pre-crash skid marks, deflection point, and final rest

Post-Crash

The driver of the Sable came to rest in the vehicle. She was reportedly found in the driver's seat with her torso slumped to the right. Her final rest position was supported by a moderate amount of collected body fluid (blood) on the center console. Rescue personnel unbuckled the seatbelt and removed her from the vehicle. She was transported by ambulance to a regional trauma center where she expired six hours following the crash. The occupants of the Tempo were assisted from the vehicle by rescue personnel and were transported by ambulance to a local hospital for treatment.

VEHICLE DATA - 1997 Mercury Sable

The 1997 Mercury Sable was identified by the Vehicle Identification Number (VIN): 1MELM50U6VG (production sequence ommitted). The vehicle was a four-door sedan with the GS trim level. The Sable was equipped with a 3.0 liter, V6 engine, a four-speed automatic transmission, power brakes, power windows power steering, and a tilt steering column which was found in the center position. At the time of the vehicle inspection, the odometer read 95,967 km (59,465 miles).

The Mercury Sable was configured with front bucket seats with adjustable head restraints for the driver and front right passenger positions. Both adjustable head restraints were in the full-down position at the time of the vehicle inspection. A center seating position was available between the front bucket seats on the folding center console. The rear seating positions were configured with a bench seat.

The 44-year-old female driver was utilizing a contoured lumbar pillow/wing back support which was positioned between her back the forward aspect of the driver's seat back **(Figure 5)**. The pillow measured 34.9 cm (13.8") in width and 33.0 cm (13.0") in height. The forward aspect was contoured and measured 10.8 cm (4.2") in depth on the outboard aspects and 5.7 cm (2.3") in depth at the center aspect.

Figure 5. Close-up view of lumbar support pillow

The Office of Defects Investigation (ODI) had issued one recall notice for the 1997 Mercury Sable which was manufactured in March 1997 and was as follows:

NHTSA CAMPAIGN ID Number: 96V166000
Component: POWER TRAIN:TRANSMISSION:AUTOMATIC:INDICATOR:LEVER:GEAR
Manufacturer: FORD MOTOR COMPANY
Year: 1997 Make: MERCURY Model: SABLE Recall Date: 09/23/1996
Type of Report: Vehicle
Potential Number of Units Affected: 40000
Manufactured: 08/1996 - 08/1996
Defect Summary:
THE PARK PAWL ABUTMENT BRACKET HAS A SHARP EDGE WHICH CAN CAUSE THE PARKING PAWL TO HANG UP AND NOT ENGAGE THE PARK GEAR. THIS WOULD ALLOW THE VEHICLE TO MOVE EVEN THOUGH THE GEAR SHIFT INDICATOR SHOWS THAT THE VEHICLE IS IN PARK.
Consequence Summary:
UNINTENDED AND UNEXPECTED VEHICLE MOVEMENT CAN RESULT IN PERSONAL INJURY AND PROPERTY DAMAGE.
Corrective Summary:
DEALERS WILL INSPECT AND, IF NECESSARY, REPLACE THE PARK PAWL ABUTMENT BRACKET.

VEHICLE DAMAGE

Exterior Damage - *1997 Mercury Sable*

The 1997 Mercury Sable sustained moderate damage to the front right aspect as a result of the impact with the Ford Tempo **(Figure 6)**. The one-piece bumper/grille fascia was slightly displaced and direct contact abrasions were noted on the front bumper fascia. The direct damage was located 32.4 cm (12.8") to the left of center along the front bumper fascia and extended 104.1 cm (41.0") laterally to the right bumper corner. The combined direct and induced damage involved the entire frontal width of the Sable and measured 140.3 cm (55.3"). The hood was displaced slightly

Figure 6. Frontal damage to the 1997 Mercury Sable

upward and rearward. The left front fender was crushed rearward and laterally inward from direct contact. The left front fender was buckled outward slightly 76.2 cm (30.0") rear of the front right bumper corner from induced damage. The right front wheel cover was abraded from contact with the concrete curb. The Collision Deformation Classification (CDC) for the impact with the Ford Tempo was 01-FDEW-1. Six crush measurements were taken along the front bumper and were as follows: C1 = 0.0 cm, C2 - 0.0 cm, C3 = 0.5 cm (0.2"), C4 = 0.5 cm (0.2"), C5 = 3.1 cm (1.2"), C6 = 4.3 cm (1.7").

Interior Damage - *1997 Mercury Sable*

Interior damage to the 1997 Mercury Sable was moderate and attributed to occupant contact **(Figure 7)**. The steering wheel rim was deformed forward 1.3 cm (0.5") on the top half from occupant loading. The cruise control switch which was mounted on the left aspect of the steering wheel hub was separated. Two heavy tissue transfers were located on the knee bolster to the right and left of the steering column as a result of the loading of the driver's knees **(Figure 8)**. The left transfer was located 38.1 cm (15.0") left of the centerline and measured 7.0 cm (2.8") in width and 1.3 cm (0.5") in height. The right transfer was located 25.4 cm (10.0") left of the centerline and measured 5.1 cm (2.0") in width and 4.8 cm (1.9") in height. The steering column was compressed, evidenced by shear capsule displacement. The left shear capsule was displaced forward 2.5 cm (1.0") and the right shear capsule was displaced forward 2.0 cm (0.8"). Body fluid (blood) was present on the lower right quadrant of the driver's air bag, and driver's shoulder belt, inboard aspect of the driver's seat back and was collected on the center console. Multiple short black hair fibers were present on the head liner above the driver's seat over an area that measured 20.3 cm (8.0") in width and 17.8 cm (7.0") in length. A longitudinal abrasion was present along the head liner inboard of the hair deposit. It was unknown if the abrasion was crash related.

Figure 7. Interior view of the Mercury Sable

Figure 8. View of knee bolster and tissue transfers

The right aspect of the windshield was fractured as a result of the front right passenger's air bag and tethered cover flap. Based on interior damage patterns in the vehicle, it appeared that the front right passenger's sun visor was rotated downward with the vanity mirror exposed to the interior of the vehicle pre-crash. The front right passenger's air bag deployment most likely displaced it upward and rearward which resulted in the fracture of the inboard clip and the separation of the vanity mirror **(Figure 9)**. The right A-pillar plastic trim panel was fractured at the top aspect 1.9 cm

Figure 9. View of damaged front right sun visor

(0.8") below the windshield header. The fracture measured 17.8 cm (7.0") in length. The source of the fracture was unknown. There were no intrusions.

Exterior Damage - *1988 Ford Tempo*

Figure 10. Damaged 1988 Ford Tempo

The 1988 Ford Tempo sustained moderate frontal damage as a result of the impact with the Mercury Sable **(Figure 10)**. The direct damage was distributed across the entire frontal width of the vehicle. The front bumper and grille area were crushed rearward. The hood was displaced slightly upward and the leading edge was buckled rearward. The combined direct and induced damage measured 152.4 cm (60.0") from bumper corner to bumper corner. The outboard aspects of the bumper fascia were separated from the side aspects of the vehicle. The left and right front fenders sustained induced buckling from the frontal impact. The CDC for this impact was 11-FDEW-2. Six crush measurements were taken along the front bumper and were as follows: C1 = 7.6 cm (3.0"), C2 = 25.4 cm (10.0"), C3 = 40.6 cm (16.0"), C4 = 25.4 cm (10.0"), C5 = 7.6 cm (3.0"), C6 = 0.0 cm.

MANUAL RESTRAINT SYSTEMS - 1997 Mercury Sable

The 1997 Mercury Sable was equipped with manual 3-point lap and shoulder belts with sliding latch plates for the front outboard seat positions and all rear seat positions. The front outboard restraints were configured with adjustable D-rings. The front center position was equipped with a 2-point lap belt. The driver's seat belt was configured with continuous loop webbing and an emergency locking retractor (ELR). The adjustable D-ring was located in the full-down position. The driver's manual restraint showed signs of usage which included a 25.4 cm (10.0") area of body fluid (blood) deposits on the shoulder belt portion of the webbing. Minor stretch marks were also present on the shoulder belt webbing indicative of belt usage.

FRONTAL AIR BAG SYSTEM - 1997 Mercury Sable

Figure 11. View of driver's air bag in the Mercury Sable

The 1997 Mercury Sable was equipped with frontal air bags for the driver and front right passenger positions. The air bag system deployed as a result of the frontal impact with the Ford Tempo. The driver's air bag **(Figure 11)** was housed in the center of the steering wheel with asymmetrical H-configuration cover flaps which were constructed of 0.5 cm (0.2") thick vinyl. The top flap measured 7.6 cm (3.0") in height and14.0 cm (5.5") in width at the tear seam. The bottom flap measured 6.4 cm (2.5") in height and 14.0 cm (5.5") in width at the tear seam. The driver's air bag measured 67.3 cm (26.5") in diameter. The air bag was tethered by four internal straps and there were no vent ports. Two red lipstick transfers were located on the 3 o'clock aspect of the air bag which measured 5.4 cm (2.3") in

length, 0.6 cm (0.3") in thickness, and were spaced 3.8 cm (1.5") apart. The transfers began on the inboard aspect of the circular tether stitching and extended to the right in an upward diagonal fashion. A collection of body fluid (blood) which measured 15.2 cm (6.0") in width and 20.3 cm (8.0") in height was also present on lower right quadrant of the air bag.

The front right passenger's air bag deployed from a top-mount module configured with a tethered cover flap **(Figure 12)**. The cover flap measured 25.4 cm (10.0") in height on the left aspect, 17.8 cm (7.0") on the right aspect, and 43.2 cm (17.0") in width. The composition of the cover flap was 1.3 cm (0.5") metal backed vinyl. The cover flap was tethered by two straps that measured 24.1 cm (9.5") in length. The left and right tethers were attached to the underside of the cover flap 10.2 cm (4.0") and 7.6 cm (3.0") rear of the forward edge, respectively, and spaced 12.7 cm (5.0") apart. The edge of the cover flap sustained abrasions from contact with the windshield.

Figure 12. View of front right passenger's air bag and cover flap

The front right passenger's air bag measured 61.0 cm (24.0") and 48.3 cm (19.0") in height. The air bag was not vented by external ports. Minor body fluid (blood) spatter was present on the lower left aspect of the air bag.

OCCUPANT DEMOGRAPHICS - 1997 Mercury Sable

Driver

Age/Sex:	44-year-old female
Height:	165 cm (65")
Weight:	64 kg (140 lb)
Seat Track Position:	Between mid-track and full-forward
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection, injury data, police report
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a regional trauma center and expired six hours following the crash

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Massive edema with obliterated basal cisterns	Critical (140674.5,9)	Driver's air bag
Intracerebral contusion	Severe (140638.4,9)	Driver's air bag
Left temporal subdural hemorrhage	Severe (140650.4,2)	Driver's air bag

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Arterial bleed of cranio-facial origin (likely internal carotid)	Serious (121099.3,9)	Driver's air bag
Intracranial pneumocephalus	Serious (140682.3,9)	Driver's air bag
Left temporal subarachnoid hemorrhage	Serious (140684.3,2)	Driver's air bag
Temporal/petrous bone fracture	Serious (150204.3,8)	Indirect - driver's air bag, force transferred through skull from front to rear
Bilateral pneumothorax	Serious (442202.3,3)	Driver's air bag
Pneumomediastinum	Serious (442204.3,9)	Driver's air bag
Tracheal/bronchial injury	Serious (442699.3,9)	Driver's air bag
Open mandibular symphysiseal fracture	Moderate (250610.2,9)	Driver's air bag
Open fracture of the left superior lateral nose (maxilla)	Moderate (250800.2,2)	Driver's air bag
Occipital contusion	Minor (190402.1,6)	Probable contact with the driver's head restraint
Soft tissue injuries to the face, neck and chest (NFS)	Minor (290099.1,9) Minor (390099.1,9) Minor (490099.1,9)	Driver's air bag
Right upper extremity ecchymosis	Minor (790402.1,1)	Fling injury, possibly head liner or instrument panel
Skin abrasions, NFS	Minor (990200.1,0)	Driver's air bag

Injury source: Emergency room report, hospital records, no autopsy was performed

Driver Kinematics

The 44-year-old female driver of the 1997 Mercury Sable was attempting to initiate a left turn across the path of the oncoming Ford Tempo. The driver was restrained by the manual 3-point lap and shoulder belt and had the seat track adjusted to 15.9 cm (6.3") forward of the full-rear position and 9.2 cm (3.6") rear if the full forward position. The driver was utilizing an aftermarket contoured lumbar pillow/wing back

support which was positioned between her back the forward aspect of the driver's seat back. The pillow measured 34.9 cm (13.8") in width and 33.0 cm (13.0") in height. The forward aspect was contoured and measured 10.8 cm (4.2") in depth on the outboard aspects and 5.7 cm (2.3") in depth at the center aspect. Due to the combination of the forward seat track position and additional forward and upright positioning afforded by the lumbar pillow, the driver was well within the deployment zone of the driver's air bag at the time of the crash. The forward position most likely allowed the driver's arms to be bent approximately 90 degrees at the elbows and her knees to be positioned in close proximity to the knee bolster.

At impact with the Ford Tempo, the frontal air bag system deployed in the Mercury Sable. The expanding air bag struck the driver in the face and neck areas which resulted in "punch-out" type injuries to the head, neck and chest. The air bag contact resulted massive edema with obliterated basal cisterns, an intracerebral contusion, a left temporal subdural hemorrhage, bilateral pulmonary contusions, an arterial bleed of cranio-facial origin (likely internal carotid), an intracranial pneumocephalus, a left temporal subarachnoid hemorrhage, bilateral pneumothorax, a pneumomediastinum, a tracheal/bronchial injury, an open mandibular symphysiseal fracture, an open fracture of the left superior lateral nose (maxilla), and soft tissue injuries to the face, neck and chest. The force from the air bag deployment was transferred through the skull which caused a temporal/petrous bone fracture. She subsequently initiated a forward trajectory in response to the frontal impact force and loaded the knee bolster. The combination of air bag expansion against the driver and her forward trajectory resulted in compression of the steering column. Her knees struck the knee bolster, evidenced by two pronounced tissue transfers on either side of the steering column and she loaded the manual restraint. She rebounded rearward into the lumbar support pillow. Due to the space between her upper torso and the driver's seat back which resulted from the use of the lumbar pillow, her head probably continued to hyper-extend rearward which allowed the occipital region of her scalp to contact the driver's head restraint. She sustained an occipital contusion as a result of the probable head restraint contact. The driver's right arm was displaced as a result of the air bag deployment. She sustained a fling-type ecchymosis of the right upper extremity which may have resulted from the displacement of her right arm from the driver's air bag and contact with the head liner or instrument panel.

The driver came to rest in the driver's seat and slumped to the right, evidenced by a collection of body fluid (blood) on the center console. Reportedly, rescue personnel unbuckled and removed the seat belt from the driver and removed her from the vehicle on a long backboard. She was transported to a regional trauma center where she expired six hours following the crash.

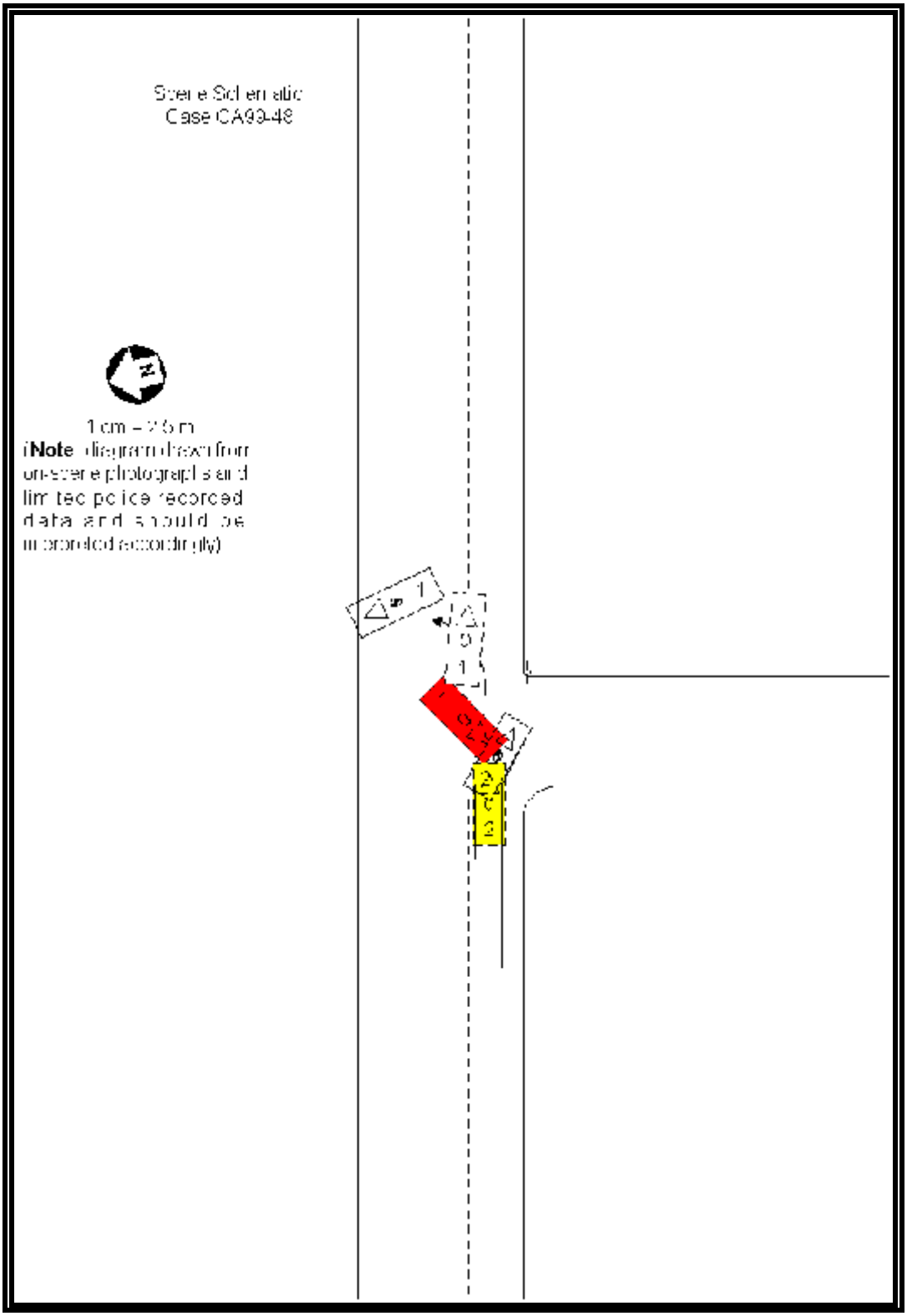

Figure 13. Scene schematic