TRANSPORTATION SCIENCES
Crash Data Research Center

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VERIDIAN ON-SITE SEAT BELT INVESTIGATION
VERIDIAN CASE NO. CA00-040
VEHICLE: 2000 FORD EXPLORER XLS SPORT
LOCATION: FLORIDA
CRASH DATE: SEPTEMBER 2000

Contract No.
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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 focused on the release of the front right 3-point lap and shoulder belt system in a 2000 Ford Explorer XLS Sport, 4-door sport utility vehicle. The Explorer was occupied by a 22 year old male driver and his 22 year old wife of approximately six hours, seated in the front right position. Both occupants were restrained by the manual 3-point lap and shoulder belt systems. The Ford Explorer was traveling on the inboard travel lane of a four lane divided U.S. Route at a driver estimated speed of 89 km/h (55 mph). A 1992 Jaguar XJS V-12 convertible was traveling behind the Explorer at a high rate of speed estimated by the investigating officer at 145-153 km/h (90-95 mph). The driver of the Jaguar was intoxicated and failed to detect the taillights of the Explorer during the nighttime hours. The full frontal area of the Jaguar impacted and underrode the rear of the Explorer resulting in a 12/06 o'clock impact configuration. The impact deflected the Explorer into a counterclockwise yaw as it departed the travel lane onto the sand median. The right side tires of the Explorer furrowed into the soft sand which tripped the vehicle into a lateral side-over-side rollover sequence. The driver of the Explorer, although restrained by the manual belt system, slid out of the restraint webbing and was ejected from the vehicle. His wife loaded the 3-point belt system at the on-set of the rollover. The inboard seat back bracket cut through the vinyl sleeve for the buckle assembly and cut the buckle tether which resulted in the release of the belt system. The front right passenger was partially ejected during the multiple rollover event and expired immediately due to a crushing injury of the head. The Ford Explorer came to rest in an upright attitude with the body of the front right passenger partially ejected through the right front door window opening. The driver of the Explorer sustained fractured ribs and multiple soft tissue injuries and was transported to a local hospital where he was admitted for three days for treatment of his injuries.

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BACKGROUND

Figure 1. Rollover damage to the 2000 Ford Explorer.

This on-site investigation focused on the release of the front right 3-point lap and shoulder belt system in a 2000 Ford Explorer XLS Sport, 4-door sport utility vehicle. The Explorer was occupied by a 22 year old male driver and his 22 year old wife of approximately six hours, seated in the front right position. Both occupants were restrained by the manual 3-point lap and shoulder belt systems. The Ford Explorer was traveling on the inboard travel lane of a four lane divided U.S. Route at a driver estimated speed of 89 km/h (55 mph). A 1992 Jaguar XJS V-12 convertible was traveling behind the Explorer at a high rate of speed estimated by the investigating officer at 145-153 km/h (90-95 mph). The driver of the Jaguar was intoxicated and failed to detect the taillights of the Explorer during the nighttime hours. The full frontal area of the Jaguar impacted and underrode the rear of the Explorer resulting in a 12/06 o'clock impact configuration. The impact deflected the Explorer into a counterclockwise yaw as it departed the travel lane onto the sand median. The right side tires of the Explorer furrowed into the soft sand which tripped the vehicle into a lateral side-over-side rollover sequence **(Figure 1)**. The driver of the Explorer, although restrained by the manual belt system, slid out of the restraint webbing and was ejected from the vehicle. His wife loaded the 3-point belt system at the on-set of the rollover. The inboard seat back bracket cut through the vinyl sleeve for the buckle assembly and cut the buckle tether which resulted in the release of the belt system. The front right passenger was partially ejected during the multiple rollover event and expired immediately due to a crushing injury of the head. The Ford Explorer came to rest in an upright attitude with the body of the front right passenger partially ejected through the right front door window opening. The driver of the Explorer sustained fractured ribs and multiple soft tissue injuries and was transported to a local hospital where he was admitted for three days for medical treatment.

The investigating police agency notified NHTSA SCI Headquarters on October 5, 2000 of the September crash. The notifying officer reported the case as a potential defect of the seat belt systems due to ejection of the driver and the separation of the front right buckle assembly. The notification was immediately forwarded to the Veridian SCI team as an on-site investigative effort. A local law firm was retained by the family of the driver and this firm immediately gained possession of the Explorer. The firm encouraged the SCI investigation and requested the presence of Ford Motor Company during the investigation process. A mutually agreed inspection date of October 17th was established by the legal representatives of both

parties. During this on-site effort, the Veridian SCI team member inspected the Ford Explorer and the involved Jaguar, documented the crash scene, and met with the investigating police personnel and the medical examiner.

SUMMARY

Crash Site

The crash occurred on a four lane divided U.S. Route that consisted of two lanes in each of the east and westbound travel directions. A shallow depressed 8.5 m (27.9') sand median with sparse grass coverage separated the travel lanes. The eastbound travel lanes were 3.6 m (11.8') in width and were bordered by a 1.4 m (4.6') paved south (outboard) shoulder and a 0.6 m (2.0') inboard paved shoulder. An additional 3.7 m (12.1') wide crushed stone shoulder bordered the outboard shoulder. A grass and sand area extended beyond the stabilized shoulders with a wire fence paralleling the roadway located 13.1 m (43.0') outboard of the stone shoulder. **Figure 2** is an overall view of the crash site at the initial point of impact.

Figure 2. Overall view of the crash site at the initial point of impact.

The westbound lanes were 3.5 and 3.6 m (11.5' and 11.8') in width and were bordered by a 0.6 m (2.0') paved inboard shoulder and a 1.3 m (4.3') paved outboard shoulder with a 2.9 m (9.5') crushed stone shoulder paralleling the outboard paved shoulder. Sand and scattered vegetation extended beyond the outboard shoulder of the westbound lanes. The travel lanes were surfaced with a coarse aggregate asphalt and were delineated with a broken white lane lines, white outboard edge lines and yellow inboard edge lines. This segment of roadway which paralleled the ocean and the intercostal waterway, was straight and level with a posted speed limit of 89 km/h (55 mph). There were no defects in the road surfaces. At the time of the crash, the conditions were clear and dark with no artificial lighting and the road surfaces were dry.

Vehicle Data

2000 Ford Explorer

The subject vehicle in this crash was a 2000 Ford Explorer XLS Sport, 4-door sport utility vehicle. The Explorer was manufactured on 11/99 at the St. Louis assembly plant and shipped via rail on November 3, 1999 to a Pensacola, FL area Ford dealership. The vehicle was purchased by the father of the front right passenger of the Explorer on November 30, 1999, through a program offered to the employees of his workplace. The Explorer was identified by vehicle identification number (VIN) 1FMZU62X7YZ (production number deleted). At the time of the crash, the odometer reading was 32,028 km (19, 902 miles). The front right passenger was the primary driver of the vehicle over the 10 months of ownership.

The Explorer was a two-wheel drive version built on a 284.5 cm (112.0") wheelbase. The drive train consisted of a 4.0 liter gasoline engine linked to a 5-speed automatic overdrive transmission with a console

mounted transmission selector lever. Braking was achieved through 4-wheel power assisted disc brakes with anti-lock (ABS).

Standard equipment included speed sensitive windshield wipers, a full-size spare tire mounted under the body aft of the rear axle, front cloth-covered high-back (integral head restraints) bucket seats with manual fore and aft adjusters with recline, air conditioning, redesigned frontal air bags for the driver and front right passenger positions, manual 3-point lap and shoulder belts for the four outboard seated positions with height adjusters, and a split/folding rear seat back. Optional factory equipment included speed control with a tilt steering wheel, remote keyless entry, a retractable cargo cover, deep tint privacy glass, step bars at the sill level, and fog lamps. It should be noted that an additional aftermarket dark window tint film was applied to the inside surfaces of the upper 22.9 cm (9.0") of the windshield, the rear door glazing, and the rear quarter window glazing.

The Ford Explorer was equipped with OEM steel wheels with a chrome insert and Firestone Wilderness AT P235/75R15 mud and snow rated tires. There was no tread separation to the tires, however, crash related damage did occur to the wheels and tires. This damage is addressed in the Vehicle Damage Section of this report. The following table identifies the recorded tire pressures and tread depths for the four tires and the separated spare tire at the time of the SCI inspection.

Tire/Wheel Position	Post-Crash Inflation kPa (PSI)	Tread Depth mm (/32")
Left Front	165.5 kPA (24 psi)	9.5 mm (12/32")
Right Front	(0 psi)	8.7 mm (11/32")
Left Rear	(0 psi)	9.5 mm (12/32")
Right Rear	(0 psi)	8.7 mm (11/32")
Spare	(0 psi)	9.5 mm (12/32")

1992 Jaguar

The striking vehicle in this crash was a 1992 Jaguar XJS convertible. The Jaguar was equipped with a longitudinally mounted V-12 engine linked to a 3-speed automatic transmission with a console mounted transmission selector lever. The vehicle was configured with rear wheel drive and four-wheel power-assisted disc brakes. The Jaguar was manufactured on 10/91 and was identified by vehicle identification number SAJNW4848NC (production number deleted). At the time of the crash, the vehicle's odometer reading was 81,094 km (50,391 miles). The driver had recently purchased the vehicle as a used car and was driving the Jaguar at the time of the crash with the convertible top in the down position.

The interior of the two passenger Jaguar was configured with bucket seats with adjustable head restraints. Both head restraints were in the full down position at the time of the crash. Occupant protection systems

consisted of 3-point lap and shoulder belt systems for the two seated positions and a Breed driver air bag system which deployed during the crash with the Ford Explorer. It should be noted that the driver and front right passenger of the Jaguar were not wearing the manual belt systems.

The Jaguar was equipped with OEM alloy-type wheels and Bridgestone Potenza RE 490 P215/65ZR15 tires. All four tires were in new condition and inflated to near normal pressures (pressures not recorded).

Crash Sequence

Pre-Crash

The driver and his bride of approximately six hours had departed their wedding reception and were traveling in an easterly direction on the inboard travel lane of the U.S. Route at a driver estimated speed of 89 km/h (55 mph). The couple had been traveling for approximately one hour and were within 15 minutes of their destination when the crash occurred.

The 45 year old female driver of the 1992 Jaguar and her 51 year old male passenger had departed a local restaurant/lounge and were traveling in an easterly direction on the inboard lane of the U.S. Route. The driver accelerated the vehicle to a high rate of speed that was estimated by the investigating officer at 145-157 km/h (90-95 mph) and traveled a distance of approximately 1.6 km (1.0 mile). The driver of the Jaguar was under the influence of alcohol with a police reported BAC of 0.225. She failed to detect the taillights of the Ford Explorer and continued forward to impact. There was no evidence of pre-crash braking at the scene from the driver of the Jaguar. The crash schematic is attached as **Figure 24**.

Crash

The frontal area of the Jaguar impacted the rear of the Ford Explorer in a slight offset configuration. Based on analysis of the resultant damage patterns, the lateral offset was approximately 30.5 cm (12.0") to the right of the striking Jaguar. Resultant directions of force were 12 o'clock for the Jaguar and 06 o'clock for the struck Explorer. The damage algorithm of the WinSMASH reconstruction program computed total velocity changes of 32 km/h (20 mph) for the Jaguar and 33 km/h (20.5 mph) for the Explorer. The longitudinal components were -32 km/h (-20 mph) for the Jaguar and 33.0 km/h (20.5 mph) for the struck Explorer. The longitudinal component of the Jaguar's deceleration was sufficient to deploy the vehicle's driver air bag system.

As the vehicles crushed to maximum engagement, the Ford Explorer was accelerated by the Jaguar and initiated a counterclockwise (CCW) yaw. The right front and right rear tires began to mark on the asphalt road surface as it initiated the yaw. Although the scene was documented approximately three weeks post-crash, 22.2 m (72.8') of right rear and 7 m (23') of right front tire yaw marks remained visible on the asphalt road surface. The Explorer subsequently departed the inboard edge of the eastbound travel lane and crossed the asphalt shoulder onto the depressed sand median. An additional 18.5 m

Figure 3. Right tire furrows in the sand median.

(60.7') of right front and 9.8 m (32.2') of right rear tire yaw marks extended east of the edgeline departure points.

The Ford Explorer yawed approximately 57 degrees in a CCW direction onto the sand median. The right side tires furrowed into the soft surface **(Figure 3)** which tripped the vehicle into a lateral side-over-side rollover event, leading with its right side. At the time of the SCI scene inspection, six pronounced gouge marks remained present in the sand median that were located over a 13 m (43') longitudinal area. Inclusive to these gouge marks was the left rear quarter window trim of the Ford Explorer. From the on-set of the lateral rollover, the Explorer traveled approximately 26 m (85') before entering the westbound travel lanes. During this trajectory, the Explorer appears to have completed seven (7) quarter rolls, ejecting the driver onto the westbound travel lanes. He came to rest in a face down attitude with his head positioned near the centerline of the westbound travel lanes.

Figure 4. Rollover trajectory of the Ford Explorer.

The Explorer continued to roll in a lateral mode across the westbound lanes as its center-of-gravity continued in a northeasterly direction **(Figure 4)**. Two distinct gouge marks were present in the inboard westbound lane. The eastern most gouge mark was a semi-circular gouge indicative of a wheel impact to the pavement surface. The Explorer continued to roll across the westbound lanes and shoulders, coming to rest in an upright attitude 64.5 m (211.6') east of the trip point which initiated the rollover. It should be noted that the front right female passenger of the Ford Explorer was restrained by the 3-point lap and shoulder belt system, however, due to a belt system failure, she was partially ejected through the right front door window opening which resulted in a fatal crushing injury of her head. Due to the severity of the injury and the lack of sand within the injured area, it was determined the injury occurred as the vehicle was overturning on the hard asphalt road surface or shoulder.

Following the impact with the Ford Explorer, the front right tire of the 1992 Jaguar locked due to rearward displacement of the right front fender. This, in combination with a possible clockwise (CW) steering input by the driver, initiated a CW yaw to the vehicle's eastbound trajectory. The Jaguar traveled approximately 56.5 m (185.4') across the eastbound travel lanes before departing the right (south) edgeline onto the stabilized shoulders **(Figure 5)**. At the point of departure, the Jaguar had rotated approximately 50 degrees CW. The vehicle continued to rotate to a broadside trajectory on the sand and grass covered surface adjacent to the eastbound travel lanes. As the Jaguar yawed to 90 degrees CW of its initial trajectory, the yaw marks in the sandy surface hooked in a counterclockwise direction with respect to the vehicle's continued CW yaw. The Jaguar continued to yaw CW as evidence by the pronounced left side (leading side) tire marks **(Figure 6)**. The reverse hook of the yaw marks was possibly due to the unequal weight distribution of the predominately front heavy vehicle. The Jaguar rotated approximately 171 degrees CW of its initial trajectory, coming to rest against a wire fence that was located 17.4 m (57.1') outboard

of the south edgeline of the eastbound travel lanes. The total yaw travel distance for the vehicle was documented by the SCI investigator at 104.6 m (343.2').

Figure 5. Off-road trajectory of the Jaguar.

Figure 6. Clockwise yaw trajectory of the Jaguar with reverse hook of the yaw marks.

Post-Crash

The Ford Explorer came to rest in an upright attitude on the sandy surface adjacent to the stone shoulder of the northbound travel lane. At rest, the vehicle was facing in a northwesterly direction with its center of gravity located approximately 64.4 m (211.3') east of the trip point of the rollover, or 101.8 m (334.0') east of the initial point of impact with the Jaguar. The Jaguar came to rest against the wire fence approximately 104.6 m (343.2') east of its initial impact location with the Ford Explorer. At rest, the Jaguar was facing in a westerly direction.

A westbound motorist noted a large amount of debris in the westbound lanes and the ejected driver of the Ford Explorer lying near the centerline of the roadway. She brought her vehicle to a controlled stop on or near the median of the roadway. As she exited her vehicle, another westbound vehicle that contained two adult male occupants, stopped on the north roadedge. The woman of the first vehicle walked to the Explorer and observed the front right passenger in a partially ejected state with her upper body extending out of the right front door window area. She further observed the seat belt system draped over the lower extremities of this occupant and noted the fatal injury to the passenger's head. At this point, she reported to the investigating police agency that the two male passing motorists heard a clicking sound from the Explorer and were concerned the vehicle would burst into flames. As they approached the Explorer, the male motorists noted the female passenger was deceased. They immediately pulled her body from the Explorer and dragged it to a point of rest that was approximately 1.5 m (6.0') east of the vehicle. These witnesses returned to their vehicle and departed the scene prior to police arrival.

Vehicle Damage

Ford Explorer - Exterior

The initial impact to the rear of the Ford Explorer resulted in moderately severe damage. The direct contact damage to the rear bumper extended the full width of the vehicle and was measured at 147.3 cm

(58.0") along the damaged profile. The impact deflected the bumper downward, rotating the face of the bumper to a near 90 degree attitude. The crush profile, by protocol, was measured at the mid plane of the bumper face and was as follows: C1 = 33.7 cm (13.25"), C2 = 32.0 cm (12.6"), C3 = 33.8 cm (13.3"), C4 = 34.5 cm (13..6"), C5 = 21.0 cm (8.25"), C6 = 6.1 cm (2.4"). **Figures 7 and 8** depict the damage to the rear of the Explorer.

Figure 7. Rear impact damage to the Ford Explorer.

Figure 8. Right three-quarter view of the rear damage.

The 6 o'clock direction of force impact displaced the rear structure forward, compressing the rear leaf springs and the spare tire against the rear axle. The main leafs of the rear springs were bent in a U-configuration and the top mount of the left rear shock absorber was fractured by the damage. The spare tire separated from the undercarriage carrier during the crash. The OEM steel rim of the spare tire was deformed and the tire was fully deflated with the bead separated from the wheel. The Collision Deformation Classification (CDC) for this event was 06-BDEW-3.

Components damaged by the rear impact included the rear bumper, both frame rails, the liftgate, rear cargo floor, rear leaf springs, spare tire, and both quarter panels.

The secondary event to the Ford Explorer was a multiple rollover event. The vehicle yawed counterclockwise into the depressed sand median. The right side tires furrowed into the soft sand which tripped the vehicle into a lateral side-over-side rollover, leading with its right side. Based on contact evidence in the sand median, the asphalt road surface, the area outboard the westbound travel lanes, and the total distance traveled, the Explorer completed three, possibly four complete overturns prior to coming to rest on its wheels.

The direct contact damage, which consisted of abrasions to the painted surfaces, extended the full length and width of the Explorer. The left roof side rail area of the roof structure sustained the most severe damage. The junction of the left upper A-pillar, windshield header, and side rail was displaced 29.8 cm (11.75") vertically into the driver's compartment. The roof side rail at the mid aspect of the left rear door was crushed 24.1 cm (9.5") while the side rail at the mid point of the rear quarter window was displaced 27.9 cm (11.0") downward. The backlight header was crushed 29.2 cm (11.5") into the cargo area. It should be noted that the severe deformation to the driver's compartment occurred after his ejection from

the vehicle. **Figures 9 and 10** are side views of the Explorer documenting the severity of the rollover damage.

Figure 9. Left side rollover damage to the Explorer.

Figure 10. Right side rollover damage.

The front right and rear right occupant positions were minimally intruded by deformation of the roof structure **(Figure 11)**. The vertical displacement of the right roof side rail was approximately 2.5 cm (1.0") while the roof panel was deflected upward as a result of lateral displacement of the left upper A-pillar. The right corner of the front bumper contacted the ground during the rollover event. The damage began 39.4 cm (15.5") right of center and extended 36.8 cm (14.5") to the right corner. This damage was the only direct contact damage to the frontal plane of the vehicle.

Figure 11. Front right passenger compartment.

The multiple event rollover fractured the laminated windshield with separation of the laminant occurring along the header and both A-pillars. An aftermarket dark window tint film was applied to the interior surface at the top 22.9 cm (9.0") of the windshield, the rear side glazing, and the backlight. All side glazing and the backlight shattered during the rollover with the exception of the fixed quarter window on the right rear door. The right front door remained closed during the crash and was operational post-crash. The remaining side doors were jammed closed due to damage. The hood and rear liftgate latches released during the crash. The Explorer was not equipped with a sunroof. The CDC for the rollover event was 00-TDDO-4.

1992 Jaguar - Exterior

The 1992 Jaguar sustained moderate frontal damage **(Figure 12)** as a result of the front-to-rear impact sequence with the 2000 Ford Explorer. The initial contact involved the front bumper of the Jaguar against the rear bumper of the Explorer, however, as the vehicles crushed, the Jaguar underrode the rear of the Explorer. Maximum crush was approximately 47.2 cm (18.6") located at the leading edge of the hood, 20.3 cm (8.0") right of the centerline. The bumper was crushed to a maximum depth of 22.2 cm (8.75") located inboard of the right corner. The direct contact damage extended across the full width of the bumper resulting in a combined direct and induced damage length of 147.3 cm (58.0"). The underride resulted in vertical displacement of the Jaguar's frontal structure. The left frame rail was displaced 22.9

cm (9.0") upward while the right was displaced 11.4 cm (4.5"). The bumper energy absorbing devices (EADs) compressed and returned to the original pre-crash positions. Due to the vertical displacement of the rails, these units bound, thus limiting the stroke of the EADs. The left compressed 1.0 cm (0.4") while the right compressed 3.8 cm (1.5"). **Figure 13** is a profile view of the right front area of the Jaguar documenting the extent of frontal crash. The CDC for the frontal impact event was 32-FDEW-2. The 12 o'clock direction of force was incremented by a value of 20 for the vertical displacement.

Figure 12. Frontal damage to the Jaguar XJS.

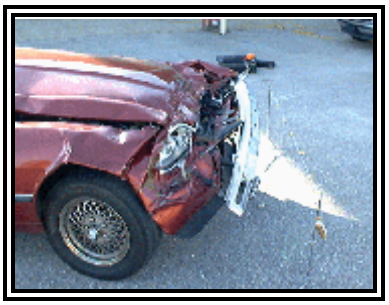

Figure 13. Profile view documenting the extent of frontal crush.

Crush profiles were documented at the level of the bumper and the hood face due to the underride and averaged for the WinSMASH reconstruction program. The bumper profile was as follows: C1 = 13.7 cm (5.4"), C2 = 17.8 cm (7.0"), C3 = 21.0 cm (8.25"), C4 = 22.2 cm (8.75"), C5 = 22.2 cm (8.75), C6 = 20.8 cm (8.2"). The profile at the leading edge of the hood was as follows: C1 = 1.0 cm (0.4"), C2 = 37.8 cm (14.9") , C3 = 46.5 cm (18.3") , C4 = 47.2 cm (18.6"), C5 = 43.4 cm (17.1"), C6 = 45.7 cm (18.0") .

The Jaguar's hood was hinged at the forward aspect and opened from the rear. During the crash, the hood latches released and the rear edge of the hood was displaced into the windshield and upper A-pillars. In addition to the windshield, components damaged by the crash included the front bumper fascia and reinforcement bar, both EADs and frame rails, grille, hood, both front fenders, windshield, and both upper A-pillars.

The left front side area of the Jaguar sustained minor damage from the secondary impact with the wire fence as it came to rest. The superficial damage was restricted to the left front fender and left door. The CDC for this event was 06-LYES-1.

Manual Restraint Systems - Ford Explorer

The Explorer was equipped with manual seat belt systems for the five designated seated positions. The front outboard positions consisted of 3-point continuous loop webbings, sliding latchplates, that retracted onto a dual mode locking retractor incorporated into the lower aspect of the B-pillar, and adjustable height adjustors (D-rings). The outboard anchorage of the lap belt was bolted to the floor adjacent to the B-pillar.

The buckle assemblies consisted of a mechanical latching unit with a top mounted release button. The buckle unit was tethered in a vinyl sleeve attached to the lower anchorage bracket. This bracket was bolted through the sleeve to a mounting bracket located on the inboard aspect of the seat frame. The driver side belt buckle was equipped with a switch for the instrument panel warning light. The buckle unit was identified by the following nomenclature:

TRW
434991
34
36412B

The webbing tether consisted of conventional belt webbing that was routed through a 3.5 cm (1.375") steel loop at the bottom of the buckle. The lower anchor bracket was 6.7 cm (2.625") in length and 2.5 cm (1.0") in width. The attachment bolt was fastened through a 8.0 mm (5/16") diameter hole that was centered 1.6 cm (0.625") from the bottom of the bracket. The mid point of the bracket was formed with a slight angle which extended across the width of the bracket. The belt attachment slot was a D-shaped hole. This was 1.6 cm (0.625") in width and 3.0 cm (1 3/16") in length. The flat aspect of the D-shaped hole was located 0.6 cm (0.25") from the upper end of the bracket. The upper end of the bracket was dipped in a plastic-type coating to protect the webbing from the edges of the D-shaped hole. Both edges of the upper (flat) end of the anchor hole were beveled, thus removing a sharp edge from riding against the webbing. This anchorage bracket was identified by the stamped designation Y-L, TC-210. There was no damage to this anchor bracket.

The buckle tether was 4.4 cm (1.75") in width and was gathered to route through the loop at the bottom of the buckle. The downstream end of this webbing was gathered to fit through the 1.6 cm (0.625") wide D-shaped hole in the anchor bracket. The ends of the webbing were returned to the midpoint of the tether and stitched with nine (9) rows of stitching. The total length of the buckle tether was 10.8 cm (4.25").

The vinyl sleeves were 19.1 cm (7.5") in length and 4.6 cm (1 13/16") in width. The sleeve had two elongated slots at the lower end adjacent to the anchorage hole. The slots were 0.6 cm (0.25") in width and 3.7 cm (1 7/16") in length. This sleeve completely concealed the buckle tether. The sleeves were identified by a molded part/model number as follows:

364065B
REGENCY 1
LDPE

This identifier was located on the outboard aspect of the sleeve, adjacent to the inboard aspect of the seat cushion. The upper end of this sleeve was formed in a rectangular shape to receive the buckle assembly. The sleeve provided a rigid mount of the buckle between the upper and lower anchorage points. The total length of the sleeve, inclusive of the buckle assembly, was 26.0 cm (10.25").

The lower anchorage of this buckle assembly was bolted to a bracket affixed to the seat frames. The front right seat frame bracket was identified by Model/Part Nos. P1268 BFL192608.

The outboard aspect of the buckle sleeve extended vertically from the attachment point at a forward angle along the inboard aspect of the seat cushion/seat back support. The seat back was attached to the cushion frame by a stamped U-channel bracket **(Figure 14)**. This bracket was 3.2 cm (1.25") in width. The edges of the U-channel protruded outward from the body of the bracket by approximately 0.6 cm (0.25"). These edges were exposed (unprotected) to the outboard aspect of the vinyl sleeve of the buckle. When not in use, the sleeve was positioned away from the edges of the U-channel, however, when loaded, the sleeve engaged against the edges of the bracket.

Figure 14. Driver's side inboard seat back support bracket.

Manual Belt System Damage

The driver of the Ford Explorer was restrained by the 3-point lap and shoulder belt system. Belt usage was supported by severe loading of the webbing evidence at the D-ring, latchplate, and from abdominal injury sustained by the driver. At the on-set of the initial rear impact crash, the inertia activated locking retractor would have locked as the driver moved rearward into this seat back support. Following this engagement, the Explorer was accelerated forward. During this time frame, the inertia activated retractor could have momentarily released from its locked position. As the driver initiated a forward rebound trajectory, he loaded the belt in its probable released state which spooled webbing from the retractor.

During the yaw and at the on-set of the rollover, the retractor would have locked again. It was probable that the retractor remained locked during the rollover event and remained locked throughout the entire sequence. As the driver loaded the manual belt system during the rollover event, he tensioned the webbing against the buckle, D-ring, retractor, and the floor anchorage points. The inboard aspect of the webbing against the D-ring was heavily loaded (longitudinal striations). These striations extended 10.2 cm (4.0") below the D-ring toward the retractor and an additional 10.2 cm (4.0") beyond the D-ring onto the shoulder aspect of the webbing. In addition, the webbing was captured in the rear aspect of the D-ring. The plastic coating of the D-ring was heavily abraded from the frictional interaction with the webbing.

The lap belt webbing was loaded in a similar pattern from interaction against the latchplate. The inboard aspect of the webbing was loaded over a 34.5 cm (13.6") length with 19.3 cm (7.6") of the loading evidence extending above the latchplate and the remained extending below the latchplate on the lap belt. The crossbar of the latchplate was abraded across the full width from the frictional interaction of the webbing.

The outboard aspect of the buckle sleeve was tensioned across the inboard U-channel bracket of the seat back support. The exposed edge of the U-channel gouged the vinyl sleeve. Two diagonally oriented narrow gouge marks were present on the sleeve, originating 8.9 cm (3.5") above the bottom of the sleeve.

The lower of the two gouge marks was 1.6 cm (0.625") in length while the upper mark was 1.9 cm (0.75") in length. A third narrow scratch type mark was present parallel to and located immediately above these distinct gouges. The edge of the seat back support bracket did not cut through the vinyl sleeve.

The front right passenger's belt system was configured the same as the driver's belt system. The adjustable D-ring was found adjusted to the top position during the SCI inspection of the Ford Explorer. The buckle sleeve was present and attached to the inboard aspect of the front right seat track **(Figures 15 and 16)**. The buckle and tether webbing had separated from the sleeve and was retrieve by the legal team's investigators and placed in a sealed in plastic bag. It should be noted that the front right passenger's seat back rest was reclined to a measured angle of 40 degrees aft of vertical.

Figure 15. Sleeve/buckle attachment viewed from rear aspect of passenger's seat.

Figure 16. Passenger's buckle sleeve at inboard aspect of seat cushion.

The SCI inspection of the buckle assembly found the buckle unit intact with the top mounted release button spring loaded and operational. The webbing tether had separated from the lower anchorage bracket which remained bolted to the seat frame bracket. The webbing tether was cut in an irregular pattern above the lower anchorage bracket. That is, removed from the vehicle, the outboard aspect side of the webbing tether (side exposed to the inboard aspect of the seat cushion) was shorter in length than the opposing aspect. The outboard aspect of the webbing tether measured 9.0-10.0 cm (3 9/16 - 3 15/16") in length from the base of the buckle unit to the frayed cut points. The opposing length ranged from 11.1-11.7 cm (4 3/8-4 5/8"). All stitching remained intact and was located above the cut location. **Figure 17** is a view of the partially retracted passenger's belt system.

The vinyl sleeve was removed from the vehicle by removing the #50 TORX head bolt from the seat frame bracket. This allowed for the removal of the lower anchor bracket, which the webbing tether had separated from, and the sleeve. Inspection of the sleeve revealed a narrow, curved cut line that extended through the thickness of the sleeve. The cut was located on the outboard aspect of the sleeve, the aspect exposed to the inboard seat back support bracket **(Figure 18)**. The diagonally orientated cut was 3.7 cm (1 7/16") in length and originated 7.9 cm (3 1/8") above the bottom of the sleeve. In addition, the cut

extended laterally across the sleeve from a point that began 0.6 cm (0.25") above the lower side of the sleeve to 0.3 cm (0.125") beyond the midpoint of the sleeve.

Figure 17. Post-crash position of the retracted right front belt system.

Figure 18. Inboard passenger's seat back rest support bracket.

During the early phase the rollover crash sequence, the driver loaded his belt system which engaged the buckle sleeve against the seat back support bracket. Two to three separate load pulses were transmitted into the buckle sleeve as evidence by the gouge marks in the vinyl **(Figure 20)**. He was subsequently ejected from the vehicle with the belt system remaining buckled and intact.

The front right passenger loaded the belt system during the early phase of the rollover event. Her initial tensioning of the belt webbing resulted in the buckle sleeve engagement against the edge of the back support bracket. The edge of the bracket cut through the sleeve **(Figure 21)** and cut the gathered webbing tether for the buckle **(Figure 22)**. Although the edge of the bracket did not cut clean through the webbing, the tension placed on the system by the occupant allowed the webbing to tear at the cut line. As a result, the webbing separated from the lower anchor bracket, thus releasing the buckle from the sleeve. At this point, the front right passenger was no longer restrained by the manual belt system. The spring tensioned retractor partially retracted the belt webbing. Post-crash, the occupant was found partially ejected from the vehicle with the belt webbing extended over her lower extremities. **Figure 19** is a side-by-side comparison of the driver and passenger buckle assemblies.

It is unknown if the latchplate and the buckle remained latched following the separation of the buckle tether. It is believed that passing motorists probably unlatched the system as they pulled the deceased passenger from the vehicle. The buckle assembly was found by a family member in the back seat area of the vehicle

several days following the crash. During the SCI inspection of the vehicle, the front right latchplate was engaged into the buckle assembly and the components locked and released manually as designed.

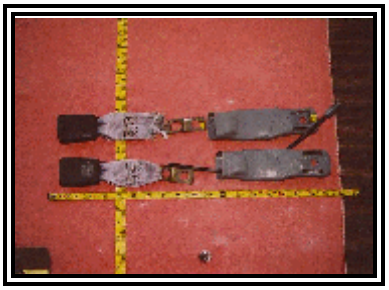

Figure 19. Removed buckle assemblies; top - passenger; bottom - driver.

Figure 20. Gouges on the driver's side buckle sleeve.

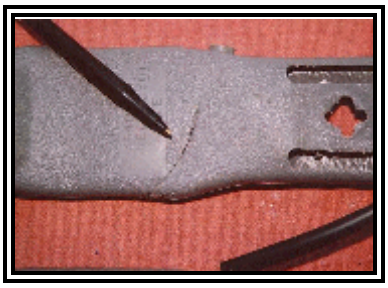

Figure 21. Cut line on the passenger's buckle sleeve.

Figure 22. Cut passenger's side buckle tether.

Supplemental Restraint System - Ford Explorer

The 2000 Ford Explorer was equipped with redesigned frontal air bags for the driver and front right positions. The air bag system deployed during the multiple event rollover sequence. The driver air bag deployed from a conventional mount within the steering assembly. The driver was probably ejected prior to the deployment of the air bag system. There was no visible evidence of driver involvement with the air bag. Additionally, the air bag may have prevented ejection of the driver if deployment occurred early in the rollover event.

The front right passenger air bag deployed from a mid mount module in the right instrument panel. A single, top hinged cover flap concealed the bag within the module assembly. The front right air bag was not tethered or vented directly into the passenger compartment. The overall dimensions of the air bag were 55.9 cm (22.0") horizontally and 48.3 cm (19.0") vertically.

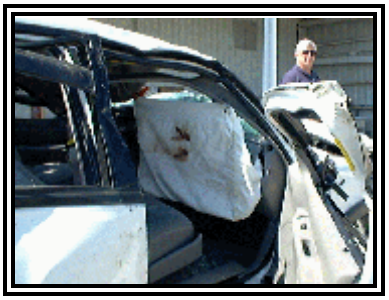

Figure 23. Blood stain on the front right passenger air bag.

A large blood stain was noted to the center face of the passenger bag **(Figure 23)**. The stain probably occurred following the partial ejection of the front right occupant. This event resulted in massive destruction of the head. There was no damage to the instrument panel forward of the air bag, indicative of occupant loading through the air bag. The system was equipped with a single point air bag control module. This module did not have event data recording capabilities.

Driver Demographics - Ford Explorer

Age/Sex:	22 year old male
Height:	188 cm (74")
Weight:	109 kg (240 lb)
Eyeware:	Not reported
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection, driver injury patterns
Mode of Transport From Scene:	Ambulance to a local hospital
Type of Medical Treatment:	Admitted for three days and released

Driver Injuries - Ford Explorer

Injury	Severity (AIS 90/Update 98)	Injury Mechanisms
Multiple right rib fractures (NFS) with 10 percent right pneumothorax (ribs 1-2 were not fractured)	Serious (450211.3,1)	Road surface
Small contusion right apex of lung	Serious (441406.3,1)	Road surface
15 mm distracted right mid clavicle fracture	Moderate (752200.2,1)	Road surface
Cervical strain	Minor (640278.1,6)	Initial impact force
Left index finger sprain	Minor (750402.1,2)	Road surface
Seat belt abrasion across lower abdomen and groin area	Minor (590202.1,0)	Lap belt webbing
3 cm full thickness laceration of the right index finger	Minor (790602.1,1)	Road surface

Injury	Severity (AIS 90/Update 98)	Injury Mechanisms
6 cm full thickness laceration of the posterior left shoulder with dirt and gravel embedded into tissue	Minor (790602.1,2)	Road surface
Abrasion of the dorsal right wrist	Minor (790202.1,1)	Road surface
Abrasions over the knuckles of the 1st and 2nd digits of the right hand	Minor (790202.1,1)	Road surface
Abrasion of the right chest wall	Minor (490202.1,1)	Road surface
Forehead abrasion	Minor (290202.1,7)	Road surface
Left knee contusion with abrasion	Minor (890402.1,2; 890202.1,2)	Road surface
Left lateral lower leg abrasion	Minor (890202.1,2)	Road surface
Left lateral foot and toe abrasions	Minor (890202.1,2)	Road surface
Right knee abrasion	Minor (890202.1,1)	Road surface
Right lateral lower leg abrasion	Minor (890202.1,1)	Road surface
Right lateral malleous abrasion	Minor (890202.1,1)	Road surface
Right lateral foot and toe abrasions	Minor (890202.1,1)	Road surface

Driver Kinematics - Ford Explorer

The driver of the Ford Explorer was seated in a presumed upright attitude at the on-set of this crash sequence. The front left seat track was adjusted to a full rear track position and the seat back support was reclined approximately 18 degrees. The driver was restrained by the manual 3-point lap and shoulder belt system. Belt usage was supported by loading evidence on the webbing at the D-ring and latchplate areas. In addition, these components were abraded by the frictional interaction of the webbing against the plastic surfaces.

The initial impact by the Jaguar against the rear of the Ford Explorer resulted in a 6 o'clock impact force to the Explorer. The driver responded to this impact force by moving rearward into the seat back support.

This trajectory and contact sequence did not result in injury. At the initiation of this event, the seat belt inertia locking retractor would have locked. As the vehicle's separated and the driver rebounded forward from this event, the locking retractor could have released momentarily during his forward rebound trajectory. This brief pause in the locking phase of the retractor could have resulted in spool-out of shoulder belt webbing, producing slack at this location. During the CW yaw and subsequent rollover, the locking retractor locked and remained locked during the event. This was evidenced by the load induced damage to the webbing and hardware components.

The driver loaded the lap belt aspect of the 3-point system during the rollover event. The webbing abraded his lower abdomen, producing a narrow band abrasion that extended across the full width of his abdomen, proximal to the umbilicus. This loading routed the slack shoulder belt webbing through the sliding latchplate, causing slack at both the shoulder and lap belt regions of the restraint.

During the rollover event, the tension applied to the belt system was transferred to the three (3) anchor points; the outboard lap belt anchorage, the D-ring, the inboard buckle attachment point, and the latchplate. This tension deflected the vinyl sleeve for the belt buckle tether against the inboard aspect of the seat assembly. The exposed edge of the U-channel seat back bracket compressed into the vinyl sleeve of the buckle assembly. This was evidenced by two distinct gouge marks in the lower aspect of the vinyl sleeve. These two marks indicated the driver twice loaded the belt system during the rollover sequence.

As the vehicle traversed the depressed sand median and entered the westbound travel lanes in the rollover mode, the driver slid out of the slacked belt system and was ejected through the front door window area. During this ejection sequence, his lower abdominal area engaged against the lap belt webbing that resulted in an abrasion of the lower abdominal area that extended onto the anterior groin area at the level of the pubic hair. It should be noted that this ejection was a non-violent ejection. That is, the driver was not thrown from the vehicle, but deposited on the road surface as the vehicle completed seven quarter turns with its left side exposed to the road surface. He tumbled a short distance on the coarse aggregate road surface before coming to rest perpendicular to the travel lanes with his head resting near the centerline of the center line of the westbound lanes. The driver sustained multiple right rib fractures and multiple soft tissue injuries from contact with the asphalt road surface during the ejection phases of this event.

Front Right Passenger Demographics - Ford Explorer

Age/Sex:	22 year old female
Height:	166.4 cm (65.5")
Weight:	75.8 kg (167.0 lb)
Manual Restraint Usage:	3-point lap and shoulder belt
Usage Source:	Vehicle inspection, system damage, occupant injury patterns
Type of Medical Treatment:	N/A, expired at scene

Front Right Passenger Injuries - Ford Explorer

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Internal Crushing injury of the head and face that included the following: - *multiple bilateral mandibular fractures* - *maxilla fracture* - *cranial fractures with brain matter exuding from fracture sites* - *residual brain was crushed and pulverized* - *fracture lines into the foramen magnum* - *innumerable basilar skull fractures* - *obvious transection of the upper portion of the pons within the brainstem* - *pituitary fossa was destroyed*	Maximum (113000.6,0)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail
Bilateral flail chest with lung contusions (right posterior rib fractures 1-7 with posterio-lateral fractures of 8-10; left 2nd rib fractured anteriorly, multiple fractures of the left 3rd rib laterally, left 4-10 fractured laterally	Critical (450266.5,3)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail
Associated with rib fractures are multiple lacerations to the upper, mid, and lower lungs	Severe (441450.4,3)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Multiple sternal fractures	Moderate (450804.2,4)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail
Multiple pleural punctures associated with the rib fractures	Moderate (441800.2,1)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail
Single midline superficial parenchymal laceration of the liver	Moderate (541822.2,1)	Lap belt webbing
Palpable long bone fractures of the upper extremities (NFS)	Moderate (751800.2,1; 751800.2,2)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail
Palpable closed fracture of the mid shaft of the right femur	Serious (851814,3.1)	Probable right door panel
External Full thickness laceration through the superior portion of the left ear pinna	Minor (290602.1,2)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail
Extensive contusions/abrasions of the mid face	Minor (290402.1,4; 290202.1,4)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail
Horizontally oriented deep linear abrasion of the right cheek and nasal areas	Minor (290202.1,1)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
15 cm (6") full thickness laceration of the left fronto-parietal scalp	Moderate (190604.2,2)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail
Full thickness scalp laceration of the right temporal-parietal region	Minor (190602.1,1)	Partial ejection/crushing injury between the environmental surfaces and the right roof side rail
Irregular deep abrasion of the mid back	Minor (690202.1,4)	Right roof side rail/right front door window frame
Superficial abrasion over the left scapula	Minor (690202.1,2)	Right roof side rail/right front door window frame
Horizontally oriented deep abrasion with accentuation over the lateral sides of the lower abdomen with scattered abrasions at the level of the umbilicus	Minor (590402.1,0)	Lap belt webbing
Deep brush abrasions of the entire lateral and anterior aspect of the right arm, extending from shoulder to dorsal hand	Minor (790202.1,1)	Road surface/ environmental surfaces
Contusion of the medial left upper arm	Minor (790402.1,2)	Right roof side rail/right front door window frame
Irregular deep abraded contusion of the mid aspect of the right thigh	Minor (890202.1,1; 890402.1,1)	Probable right door panel
5 cm (2") laceration over the right knee	Minor (890602.1,1)	Lower right instrument panel

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Multiple superficial and deep abrasions with punctata contusions of the right knee and distal lower extremities	Minor (890202.1,1; 890202.1,2; 890402.1,1; 890402.1,2)	Probable multiple sources that include the lower right instrument panel, console mounted shifter, and right door panel

** Source of Injury Data - Medical Examiner's Autopsy Report*

Front Right Passenger Kinematics - Ford Explorer

The front right female passenger of the Ford Explorer was seated in a normal seated position with the manual seat track adjusted to the full rear position and the seat back reclined to a measured 40 degree angle aft of vertical. She was wearing the manual 3-point lap and shoulder belt system with the D-ring adjusted to the top position. Belt usage was verified by loading evidence on the latchplate, D-ring, and the load induced cut to the vinyl buckle sleeve and webbing tether that resulted in complete separation of the buckle assembly. The passenger was dressed in a T-shirt, shorts, and sandals.

The front right passenger responded to the initial 6 o'clock impact force by initiating a rearward trajectory and loading the partially reclined seat back support. There was no deformation noted to the seat assembly from this initial trajectory. Her head was probably supported by the integral head restraint of the seat back. It was doubtful that injury occurred as a result of this kinematic response.

The passenger rebounded from the initial rearward trajectory and traveled forward into the manual belt webbing. This rebound trajectory occurred as the vehicles separated and the Explorer yawed in a counterclockwise direction. She subsequently loaded the manual restraint system at the on-set of the rollover event. The inertia activated belt retractor locked during the rollover sequence. Her loading force against the belt system was evidenced at the D-ring and latchplate components. Frictional belt webbing abrasion patterns were visible to the full length of the plastic coated D-ring and latchplate crossbar. There was no remaining abrasion patterns visible on the webbing at the time of the SCI inspection. (The investigating officer did observe an abrasion to the belt webbing from interaction against the latchplate.) The passenger's loading of the lap belt webbing resulted in abrasions across both sides of the abdomen with scattered abrasions at the level of the umbilicus.

The violent force of the rollover event was transmitted into the front right passenger. Her loading of the belt webbing tensioned all anchorage points which resulted in the abrasion patterns noted above. As a result of belt loading, the passenger sustained a laceration of the liver. The vinyl sleeve which concealed the buckle tether webbing at the seat frame anchorage point was pulled taut against the exposed seat back support bracket. The formed metal edge of this U-channel bracket cut through the vinyl sleeve and partially through the buckle webbing tether while the webbing was under tension due to the loading of the passenger. The webbing frayed at the cut point and completely separated from the lower anchor bracket. The buckle and webbing tether pulled out of the vinyl sleeve as the buckle/latchplate presumably remained fastened.

At this point, the female passenger was now unrestrained during the continuation of this multiple rollover event.

The redesigned frontal air bag system deployed during the rollover event. As the vehicle rolled onto its right side on the asphalt road surface, the female passenger's head was partially ejected through the right front window opening. Her head was crushed between the asphalt surface and the door window frame/roof side rail. This crushing injury fragmented the skull, facial bones, and brain. Tissue and blood from the injury location was disbursed in a high-velocity spatter pattern onto the right front door panel and into the air. As the vehicle continued to roll though the airborne spatter pattern, matter was transferred onto all surfaces of the vehicle, inclusive of the left side and rear areas. It should be noted that the transfer patterns were diagonally oriented from front to back which mirrors the vehicle's rollover heading angle and travel path of its center of gravity.

During the rollover, the passenger's torso was partially ejected through the window opening. Her back was struck by the door window frame and the side rail, compressing her torso against the road surface. As a result, she sustained multiple bilateral rib fractures (flail chest) with pulmonary contusions and lacerations. Following the above contact sequence, the unrestrained front right passenger rebounded into the passenger compartment and contacted the deployed front right air bag. This was evidenced by a large blood transfer on the center face of the bag membrane. There was no deformation to the instrument panel forward of the bag, suggesting the bag may have been partially inflated during this contact sequence.

The female passenger sustained multiple soft tissue injures (i.e., abrasions, lacerations, and avulsions) and a fracture of the right mid shaft femur from contact within the vehicle. She sustained multiple soft tissue abrasions and lacerations from contact with the environmental surfaces during the rollover sequence.

The vehicle came to rest in an upright attitude north of the westbound travel lanes. At rest, the front right passenger's torso was extended through the right door window frame with her head pointing downward toward the ground. A passing motorist confirmed this rest position and further noted that the belt system appeared to be positioned over her lower extremities.

Two male passing motorists also stopped at the scene of the crash to lend assistance. These men approached the vehicle and noted the deceased condition of the passenger. They proceeded to pull the female passenger from the vehicle and dragged her body along the ground for approximately 1.5-2.0 m (4.9'-6.6') where they laid her on her left side with her head facing away from the final rest position of the Ford Explorer. This is the position the police and medical examiner first observed the body at the scene. These males subsequently departed the scene prior to police arrival.

It should be noted that the front right passenger compartment remained intact with minimal intrusion. Furthermore, the right front door remained closed during the rollover event. The front right passenger was afforded a potentially survivable space for the passenger of the Ford Explorer had the manual seat belt system remained intact during the rollover event, thus preventing her partial ejection.

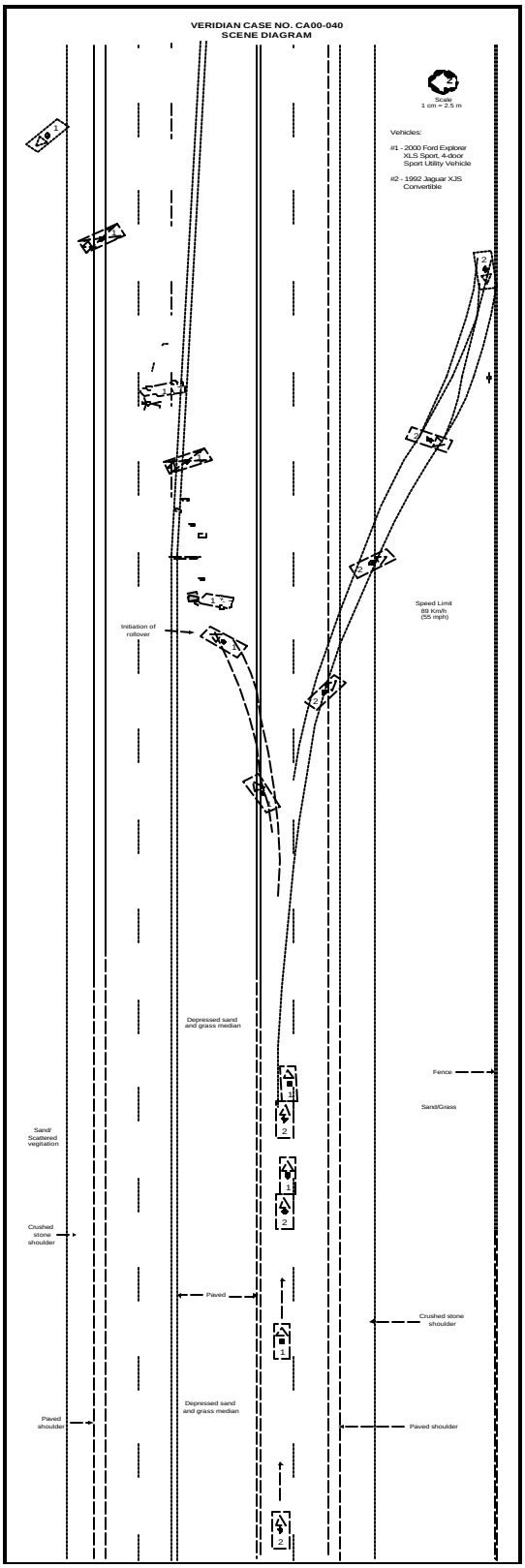

Figure 24. Scene Schematic