TRANSPORTATION SCIENCES
Crash Data Research Center

Veridian Engineering
Buffalo, NY 14225

VERIDIAN ON-SITE REAR IMPACT CRASH/FIRE INVESTIGATION

VERIDIAN CASE NO. CA03-025

VEHICLE: 2000 FORD CROWN VICTORIA POLICE INTERCEPTOR

LOCATION: DISTRICT OF COLUMBIA

CRASH DATE: MAY 2003

Contract No.
DTNH22-01-C-17002

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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

1. Report No. CA03-025	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle Veridian On-Site Rear Impact Crash/Fire Investigation Vehicle: 2000 Ford Crown Victoria Police Interceptor Location: District of Columbia		*5. Report Date*: July 2003 *6. Performing Organization Code*	
7. Author(s) Crash Data Research Center		*8. Performing Organization Report No.*	
9. Performing Organization Name and Address Transportation Sciences Crash Data Research Center Veridian Engineering P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* C00410.0000.0122 *11. Contract or Grant No.* DTNH22-01-C-17002	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		*13. Type of Report and Period Covered* Technical Report Crash Date: May 2003 *14. Sponsoring Agency Code*	
15. Supplementary Note This investigation focused on the severity of the crash and the cause of the fire that engulfed the trunk area and passenger compartment areas of a 2000 Ford Crown Victoria Police Interceptor.			
16. Abstract This on-site investigation focused on the severity of the crash and the cause of the fire that engulfed the trunk area and passenger compartment areas of a 2000 Ford Crown Victoria Police Interceptor. The vehicle was parked behind an ambulance and was unoccupied, reportedly with the engine running and the overhead emergency light bar activated. A 32-year old female driver of a 1990 Ford Taurus station wagon lost control of her vehicle as she approached a three-leg Y-intersection. She sideswiped a 1997 Chevrolet Cavalier prior to entering the intersection against a regulatory stop sign. The front center and left areas of the Taurus struck the center and right rear areas of the Crown Victoria, resulting in severe damage to the police vehicle. The steel fuel tank of the Crown Victoria was punctured and a fire ensued which consumed the vehicle. The Crown Victoria was displaced forward by the crash. Two police officers who were standing in the roadway forward of the Police Interceptor were struck by the front of the Crown Victoria. One of the officers sustained bilateral leg fractures while the other sustained minor severity injuries. The Taurus subsequently struck the rear of the ambulance. The impact with the Crown Victoria deployed the Taurus' frontal air bag system. The unrestrained female driver of the Taurus was reportedly under the influence of a controlled substance at the time of the crash. She sustained police reported incapacitating injuries and was transported to a local hospital where she was admitted for treatment.			
17. Key Words Ford Crown Victoria Police Interceptor Severe rear impact Fuel tank puncture Fire		*18. Distribution Statement* General Public	
19. Security Classif. (of this report) Unclassified	*20. Security Classif. (of this page)* Unclassified	*21. No. of Pages* 20	*22. Price*

TABLE OF CONTENTS

BACKGROUND *1*

SUMMARY *2*

CRASH SITE 2
2000 Ford Crown Victoria Police Interceptor *2*
1990 Ford Taurus *3*
2002 Ford E-450 Ambulance *3*
CRASH SEQUENCE 3
Pre-Crash *3*
Crash *4*
Post-Crash *5*

VEHICLE DAMAGE *6*

EXTERIOR DAMAGE – 2000 FORD CROWN VICTORIA 6
INTERIOR DAMAGE – 2000 CROWN VICTORIA 8
EXTERIOR DAMAGE – 1990 FORD TAURUS 9
EXTERIOR DAMAGE – 2002 FORD E-450 TYPE III AMBULANCE 10
FUEL SYSTEM – 2000 FORD CROWN VICTORIA 11
FUEL SYSTEM INSPECTION 12
TRUNK CONTENTS 16
TANK PUNCTURE 18
CONCLUSIONS 18

FIGURE 28. SCENE SCHEMATIC *20*

VERIDIAN ON-SITE REAR IMPACT CRASH/FIRE INVESTIGATION
VERIDIAN CASE NO. CA03-025
VEHICLE: 2000 FORD CROWN VICTORIA POLICE INTERCEPTOR
LOCATION: DISTRICT OF COLUMBIA
CRASH DATE: MAY 2003

BACKGROUND

This on-site investigation focused on the severity of the crash and the events that lead up to a fire that engulfed the trunk area and passenger compartment areas of a 2000 Ford Crown Victoria Police Interceptor. The vehicle was parked behind an ambulance and was unoccupied, reportedly with the engine running and the overhead emergency light bar activated. A 32-year old female driver of a 1990 Ford Taurus station wagon lost control of her vehicle as she approached a three-leg Y-intersection. She sideswiped a 1997 Chevrolet Cavalier prior to entering the intersection against a regulatory stop sign. The front center and left areas of the Taurus struck the center and right rear areas of the Crown Victoria, resulting in severe damage to the police vehicle. The steel fuel tank of the Crown Victoria was punctured and a fire ensued which consumed the vehicle **(Figure 1)**. The Crown Victoria was displaced forward by the crash. Two police officers who were standing in the roadway forward of the Police Interceptor were struck by the front of the Crown Victoria. One of the officers sustained bilateral leg fractures while the other sustained minor severity injuries. The Taurus subsequently struck the rear of the ambulance. The impact with the Crown Victoria deployed the Taurus' frontal air bag system. The unrestrained female driver of the Taurus was reportedly under the influence of a controlled substance at the time of the crash. She sustained police reported incapacitating injuries and was transported to a local hospital where she was admitted for treatment.

Figure 1. Right rear view of the crush pattern and resultant fire damage to the 2000 Ford Crown Victoria.

NHTSA was notified of the crash on Monday, May 5, 2003. The notification was immediately forwarded to the Veridian SCI team and assigned as an on-site investigative effort. Cooperation was established with the police department and the on-site investigation was initiated on Tuesday, May 6. During this investigation, inspections of the police vehicle, the striking Ford Taurus, and the ambulance were performed. A vehicle autopsy of the Crown Victoria was performed which involved the careful removal of the fuel tank, and the removal and documentation of the contents of the trunk. In addition, the operator of the involved Crown Victoria was interviewed and the crash site was inspected and documented.

SUMMARY

Crash Site

Figure 2. Overall view of the crash site.

This crash occurred during the daytime hours of May 2003, in the District of Columbia. At the time of the crash, the weather was clear and the asphalt roadway surface was dry. The crash occurred at a three-leg, Y-intersection of two urban roadways **(Figure 2)**. The north/south roadway was configured with two travel lanes in each direction, separated by a double-yellow centerline, and bordered by asphalt curbs. This roadway had a negative two percent northbound grade on the approach to the intersection. The north/south roadway terminated at the intersection. The east/west roadway was configured with one travel lane in each direction, separated by a double-yellow centerline and bordered by asphalt shoulders and 13 cm (5") asphalt curbs. The north/south roadway intersected the east/west roadway at a 57 degree angle. The travel lanes curved to the right in a westbound direction as the roadway continued past the intersection. A painted-flush gore at the southwest quadrant of the intersection directed eastbound traffic through the intersection or onto a designated right turn lane onto the southbound roadway. Northbound traffic flow entering the intersection was controlled by a stop sign. A marked crosswalk was present on the east leg of the intersection. The general roadside environment consisted of residential and wooded areas. The north roadside consisted of a hillside with numerous trees. Debris (firewood-sized logs) from previously cut trees was present on the roadside in addition to fragments of the fractured asphalt curb. It was not known if the curb was damaged during this crash. The posted speed limit for the north/south roadway was 48 km/h (30 mph) and the posted speed limit for the east/west roadway was 40 km/h (25 mph). The scene schematic is included as **Figure 28,** Page 20 of this narrative report.

VEHICLE DATA

2000 Ford Crown Victoria Police Interceptor

The struck 2000 Ford Crown Victoria was a four-door sedan, marked police unit that was identified by Vehicle Identification Number (VIN) 2FAFP71WXY (production number deleted). The last recorded odometer reading for this vehicle was 120,408 km (74,820 miles). The vehicle was equipped with the Ford Police Interceptor package. The Crown Victoria was powered by a 4.6 liter, V-8 engine linked to an automatic 4-speed overdrive transmission with rear wheel drive. The braking system consisted of four-wheel disc brakes with anti-lock. The exterior consisted of the police department paint scheme, a light bar mounted to the roof of the vehicle, centered over the B-pillar area, and a left A-pillar mounted spotlight. The Goodyear Eagle RS-A P225/60R16 all-season tires were mounted on OEM steel wheels.

The interior of the Crown Victoria was configured as a five-passenger vehicle with front bucket seats and a fixed rear bench seat. A police safety cage was bolted to the structure of the vehicle, aft of the B-pillars that provided a physical barrier for police use between the front and rear seats. The vehicle safety systems consisted of three-point lap and shoulder belts for the four outboard seated positions and a center rear lap belt. Supplemental protection was provided by frontal air bags for the driver and right passenger positions. The air bags did not deploy during the crash events or as a result of the ensuing fire.

1990 Ford Taurus

The striking vehicle in this crash was a 1990 Ford Taurus station wagon. The vehicle was equipped with a 3.0-liter gasoline engine linked to a four-speed automatic overdrive transmission with a column mounted shifter. The braking system consisted of power-assisted front disc/rear drum and no anti-lock. The Taurus' safety systems consisted of three-point lap and shoulder belts for the four outboard seated positions and center lap belts. The Taurus was also equipped with a frontal air bag system for the driver's position that deployed as a result of the crash with the Crown Victoria. The Taurus was identified by VIN 1FACP55U0LA (production number deleted). The odometer reading at the time of the crash was 47,706 km (29,644 miles). Although the five digit odometer indicated low mileage, the condition of the vehicle was consistent with an additional 161,000 kilometers (100,000 miles).

2002 Ford E-450 Ambulance

The Ford ambulance was parked adjacent to the shoulder at the crash scene and was struck by the Ford Taurus following its impact with the Crown Victoria. The ambulance consisted of a heavy-duty E-450 chassis and a Type III Wheeled Coach ambulance body. The chassis was equipped with a 7.2-liter diesel engine linked to a four-speed automatic overdrive transmission. The Gross Vehicle Weight Rating (GVWR) for this unit was 6,372 kg (14,050 lb). The ambulance was built on a (158.0") wheelbase. The Ford E-450 was manufactured on March 2002 and was identified by VIN 1FDXE45F22H (production number deleted).

Crash Sequence

Pre-Crash

The crash events were preceded by an emergency call of an assault in progress. The call resulted in the response of several marked police vehicles and an ambulance to the three-leg Y-intersection intersection. Although there was no assault, there was an on-scene report of a custody issue. The ambulance approached the scene from an easterly travel direction and parked at the north curb line of the westbound travel lane of the through street. The on-duty firefighter/emergency medical technicians (EMTs) were providing treatment to a child patient in the patient compartment of the ambulance. The on-duty police officer of the involved 2000 Ford Crown Victoria parked the vehicle behind the ambulance, facing in a northeasterly direction. In these parked positions, the heading angle of the ambulance was 102 degrees (oriented from North) with the parked Crown Victoria facing at a heading angle of approximately 57 degrees. The driver of the Crown

Victoria reported that the overhead light bar was activated and the engine was running to maintain electrical power to support the light bar. He exited the Crown Victoria to attend to his duties as a police officer at the scene of the event.

A 79-year old male driver of a 1997 Chevrolet Cavalier was traveling in a northeasterly direction on the left (inboard) lane of the intersecting roadway, on approach to the three-leg intersection. The driver was probably slowing for the stop sign posted at the southeast corner of the intersection.

The 32-year old female driver of the Ford Taurus was reportedly under the influence of a controlled substance. She was traveling in a northeasterly direction on inboard lane of the three-lane city street. On her approach to the three-leg Y intersection, the driver of the Taurus attempted to overtake a slower moving vehicle on the left. She attempted to steer into the oncoming lane and sideswiped the left rear quarter panel of the Cavalier with the front right area of the Taurus. This impact produced minor damage to both vehicles. The driver of the Taurus continued to travel toward the intersection and maintained speed as she failed to stop for the stop sign. A police officer, who was assisting at the scene of the call, observed the Taurus traveling on the wrong side of the roadway as it approached the intersection. He continued to track the vehicle as it proceeded through the intersection and noted that the driver of the Taurus did not attempt avoidance actions (i.e., braking/steering).

Crash

The front center and left areas of the Taurus impacted the center and right rear areas of the Ford Crown Victoria. Resultant directions of force were within the 12 o'clock sector for the Taurus and 6 o'clock for the struck Crown Victoria. The damage algorithm of the WinSMASH program computed total velocity changes of 45.1 km/h (28.0 mph) for the struck Crown Victoria and 52.9 km/h (32.9 mph) for the Ford Taurus. The specific longitudinal and lateral components for the Crown Victoria were 44.3 km/h (27.5 mph) and 12.4 km/h (4.9 mph) respectively. It should be noted that the computed velocity change for the Ford Taurus was high. This was based on the rigid frontal structure of the Taurus and the compliant rear structure of the Crown Victoria. The impact accelerated the Crown Victoria in a forward direction.

The driver, who was outside the Crown Victoria at the time of the crash, stated that the vehicle burst into flames immediately following the rear impact with the Taurus. As the vehicle was accelerated forward, the frontal area of the Crown Victoria impacted a police officer who was standing in front of the vehicle and rearward of the ambulance. This officer sustained two lower extremity fractures and was deflected away from the Crown Victoria's forward trajectory. The Crown Victoria reportedly struck a second female police officer as it was displaced forward. Her injuries were minor. It should be noted that due to fire suppression efforts and a covering of soot on the vehicle, the pedestrian contact points could not be identified.

The Crown Victoria overrode a decrepit asphalt barrier curb as it departed the road surface. The vehicle rode-up an earth embankment where it came to rest. The center

aspect of the lower radiator support panel and air conditioning condenser impacted an object on the embankment. The embankment was littered with numerous firewood-size logs and several small diameter tree trunks. The specific environmental object could not be identified due to the fire and the subsequent removal of the vehicle from the scene. The grass and tree branches surrounding the final rest position of the vehicle were charred and scorched by the fire and heat. **Figure 3** is impact and final rest areas of the Crown Victoria.

Figure 3. Impact and final rest area of the Ford Crown Victoria.

The Ford Taurus continued forward and struck the rear of the parked ambulance in an endswipe-type configuration. The impact initially involved the front right corner of the Taurus against the rear folding step and rear left bumper of the ambulance. This contact crushed the corner of the ambulance and displaced the corner post of the box laterally left. The Taurus subsequently side-slapped against the rear right area of the ambulance prior to coming to rest.

Post-Crash

An officer at the scene of the crash notified the police and fire departments immediately via police radio. Police, fire, and ambulance personnel were dispatched to the scene of the crash. The driver of the Crown Victoria approached the left front door of the Ford Taurus and instructed the driver to exit the vehicle. She slumped onto the front right seat cushion. The police officer broke the left front door window to gain access to the Taurus. He opened the left front door and pulled the female driver from the vehicle. This police officer sustained a laceration of his left thumb (five sutures) from the tempered side glazing. Ambulance personnel attended to the driver of the Taurus. The officers then proceeded west of the crash scene to direct traffic and secure the crash site from eastbound traffic flow.

The injured police officers were transported to a local hospital where they received treatment for their injuries. The driver of the involved Crown Victoria and the female pedestrian officer who was struck by the Crown Victoria were treated and released. The officer, who was struck by the frontal area of the Crown Victoria, sustained fractures of his lower extremities. He was admitted for treatment of those fractures. The driver of the Taurus was transported to a local hospital where she was admitted for treatment.

Fire department personnel used water to control the fire of the Crown Victoria and chemical agents to suppress the gasoline fueled fire. Following the police investigation, the Crown Victoria was towed to the police maintenance facility where it was secured for this SCI investigation. The Ford Taurus was towed to a private tow facility and impounded by the police. The ambulance was driven from the scene to a fire station where it was held pending damage appraisal. The Taurus and the ambulance were

inspected at these facilities. The struck Cavalier was driven from the scene and was not inspected for this investigation.

VEHICLE DAMAGE

Exterior Damage – 2000 Ford Crown Victoria

The 2000 Ford Crown Victoria sustained severe rear damage **(Figure 4)** as a result of the impact with the Ford Taurus. The direct contact damage began 8.6 cm (3.4") left of the center of the face of the trunk lid and extended 94.6 cm (37.2") to the rear right corner. The impact deformed the entire end width resulting in a combined direct and induced damage length that measured 89.2 cm (35.1"). The bumper beam was crushed forward and rotated upward 90 degrees. The maximum crush on the bumper beam measured 127.0 cm (50.0") and was located 34.3 cm (13.5") right of center. (The rear bumper fascia was consumed by the ensuing fire). The trunk lid was buckled and displaced upward, and the entire trunk was crushed forward. The left frame rail was displaced laterally inward. The right frame rail was crushed forward and laterally over the rear axle and was bent at the apex of the axle. The frame rail crush measured 34.6 cm (13.6") on the left rail and 104.8 cm (41.3") on the right frame rail. The forward displacement of the rear axle resulted in the reduction of the right wheelbase by 33.3 cm (13.1") and the elongation of the left wheelbase by 4.8 cm (1.9"). The alloy driveshaft was fractured forward of the differential yoke as a result of the forward displacement of the rear axle. Both rear quarter panels were crushed forward and the left quarter panel was pulled inward at the rear aspect due to the offset impact configuration. The longitudinal displacement at the left quarter panel measured 12.4 cm (4.9") and the longitudinal crush on the right quarter panel measured 114.0 cm (44.9"). The forward displacement of the right rear quarter panel resulted in the restriction of the right rear wheel and tears in the sidewall of the right rear tire. The right rear quarter panel damage also resulted in the forward displacement of the bottom aspect of the right C-pillar and the separation of spot welds from the right rear inner fender to the right C-pillar. The total length of the weld separation measured 105.1 cm (41.4") vertically from the sill. Six crush measurements were documented along the center aspect of the bumper beam and were as follows: C1 = 41.0 cm (16.1"), C2 = 66.0 cm (26.0"), C3 = 91.6 cm (36.1"), C4 = 118.1 cm (46.5"), C5 = 121.0 cm (47.6"), C6 = 112.9 cm (44.4"). Six additional crush measurements were documented along the bottom of the trunk lip. The Field-L along the trunk lip measured 134.9 (53.1") and the crush measurements were as follows: C1 = 29.2 cm (11.5"), C2 = 61.9 cm (24.4"), C3 = 84.8 cm (33.4"), C4 = 120.7 cm (47.5"), C5 = 129.5 cm (51.0"), C6 = 130.8 cm (51.5"). The Collision Deformation Classification (CDC) for the rear impact was 06-BZEW-6. **Figures 5 and 6** document the rear damage pattern.

Figure 4. Rear view of the Crown Victoria.

Figure 5. Right rear three-quarter view of the Crown Victoria.

Figure 6. Lateral view documenting the extent of crush to the back plane.

The Crown Victoria struck two police officers as it was deflected forward by the rear impact sequence with the Taurus. There was no discernable vehicle damage associated with these impacts. Based on the nature and location of the first officer's injuries, it was presumed that the front bumper **(Figure 7)** of the Crown Victoria struck the police officer. The CDC for the frontal impact to the first police officer was 12-F999 with an unknown extent zone. The impact location for the second officer was unknown.

Figure 7. Frontal view of the Crown Victoria.

Figure 8. Lower radiator support impact damage.

The Crown Victoria also sustained frontal damage, possibly the result of an impact with a tree stump or log on the roadside. The bumper fascia exhibited abrasions and minor deformation along the entire width and the front left corner of the fascia was crushed rearward and fractured on the bottom aspect. The frontal damage was concentrated on the lower radiator support that was crushed rearward **(Figure 8)**. The direct damage on the lower radiator support began at the centerline and extended 14.0 cm (5.5") to the right. The combined direct and induced damage measured 83.8 cm (33.0") across the lower radiator support. Both the lower radiator support and lower aspect of the radiator core

were crushed and abraded. Transfers that appeared to be from tree bark were present on the lower radiator support in the area of the direct damage. Four crush measurements were documented along the lower radiator support and were as follows: C1 = 8.3 cm (3.3”), C2 = 11.4 cm (4.5”), C3 = 23.5 cm (9.3”), C4 = 12.1 cm (4.8”). The CDC for this frontal impact was 12-FCLN-1.

The Crown Victoria sustained additional damage from the fire after the crash. The entire trunk area was completely scorched. The left side aspect of the vehicle was burned to the sheet metal from the C-pillar rearward. The left rear door was burned and soot-covered. The left front door was burned, although the lettering and paint scheme was still visible. The right rear quarter panel and aft aspect of the right rear door were scorched. The right rear door paint was still visible on the forward half of the door and the right front door was not burned. The roof was burned, most severely on the rear aspect. The light bar on the roof was completely melted.

Additional undercarriage damage to the transmission oil pan, transmission cross-member, and the bottom of the drive shaft resulted from post-crash removal of the vehicle.

The CDC summary for the Crown Victoria is as follows:

Event No.	Object Contacted	CDC
2	1990 Ford Taurus	06-BZEW-6
3	Pedestrian	12-F999-Unknown
4	Pedestrian	Unknown
7	Possible tree stump or log on the roadside	12-FCLN-1

Interior Damage – 2000 Crown Victoria

The interior damage to the 2000 Crown Victoria was attributed to passenger compartment intrusion and the crash-induced fire. The entire passenger compartment was charred. The ignition switch was positioned in a vertical orientation relative to the steering column, and appeared to be in the “off” position during the vehicle inspection, although the driver of the vehicle stated that the vehicle was running at the time of the crash. As a result of the rear impact, the rear seat and rear parcel shelf intruded longitudinally into the passenger compartment, most severely on the right aspect. The specific intrusions are as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
LR	Rear parcel shelf	11.1 cm (4.4”)	Longitudinal
LR	Rear seat back	3.5 cm (1.4”)	Longitudinal
CR	Rear parcel shelf	45.1 cm (17.8”)	Longitudinal
CR	Rear seat back	22.2 cm (8.8”)	Longitudinal
RR	Rear parcel shelf	59.7 cm (23.5”)	Longitudinal
RR	Rear seat back	38.1 cm (15.1”)	Longitudinal
RR	Right C-pillar	17.1 cm (6.8”)	Longitudinal

Exterior Damage – 1990 Ford Taurus

The 1990 Ford Taurus sustained moderate right side damage as a result of multiple impacts with the Cavalier (initial impact event) and the ambulance resulting in overlapping damage patterns **(Figure 9)**. The direct damage began 92.1 cm (36.3") forward of the right rear axle and extended forward 257.8 cm (101.5") along the right side plane to the leading edge of the right front fender. Isolated dents were present on the front and rear right doors. A vertical dent and related abrasion was present on the roof side rail on above the forward aspect of the right rear door from direct contact with the right rear corner of the ambulance patient compartment. The right rear door glazing also disintegrated. The right front fender was abraded and deformed inward from direct contact. Due to masking damage from the multiple events, the specific crush profiles could not be separated, therefore a common profile was documented along the right side plane and was as follows: C1 = 0.0 cm, C2 = 0.0 cm, C3 = 0.0 cm, C4 = 7.0 cm (2.8"), C5 = 20.6 cm (8.1"), C6 = 13.0 cm (5.1").

Figure 9. Right side damage to the Ford Taurus.

The 1990 Ford Taurus sustained moderate frontal damage as a result of the impact with the Ford Crown Victoria **(Figure 10)**. The direct damage on the hood began 13.0 cm (5.1") to the right of the centerline and extended across the hood to the front left corner. The direct damage on the bumper began 18.1 cm (7.1") to the right of the centerline and extended 81.3 cm (32.0") to the left corner. The fiberglass/plastic bumper beam was fractured near the left bumper mount/EAD. The left aspect of the bumper was fractured and separated. The combined direct and induced damage involved the entire frontal width of the Taurus and measured 130.8 cm (51.5") across the bumper. The hood and front fenders were buckled rearward. The frontal damage resulted in the reduction of the right wheelbase by 10.5 cm (4.2"). Six crush measurements were documented across the front bumper and were as follows: C1 = 27.0 cm (10.6"), C2 = 29.2 cm (11.5"), C3 = 25.1 cm (9.9"), C4 = 16.8 cm (6.6"), C5 = 5.7 cm (2.3"), C6 = 7.3 cm (2.9"). **Figure 11** is a lateral view of the left side documenting the extent of frontal crush.

The lower radiator support also sustained direct contact damage from the frontal impact. The maximum crush on the lower radiator support measured 29.8 cm (11.8"). The Field-L on the lower radiator support measured 71.1 cm (28.0") across its width. Four crush measurements were documented along the lower radiator support and were as follows: C1 = 19.7 cm (7.8"), C2 = 26.0 cm (10.3"), C3 = 20.3 cm (8.0"), C4 = 4.4 cm (1.8"). The Taurus CDC's for the impact events are identified in the following table.

Event No.	Object Contacted	CDC
1	Chevrolet Cavalier	12-RYES-1
2	2000 Ford Crown Victoria Police Interceptor	12-FYEW-2
5	2002 Ford E-450 Type III Ambulance	12-FREE-9
6	2002 Ford E-450 Type III Ambulance	03-RYEW-3

Figure 10. Frontal view of the resultant damage from the Crown Victoria impact.

Figure 11. Lateral view documenting the extent of the frontal crush.

Exterior Damage – 2002 Ford E-450 Type III Ambulance

The 2002 Ford E-450 Type III Ambulance sustained minor damage to the rear aspect of the patient compartment **(Figure 12)** as a result of the impact by the Taurus. The Taurus initially impacted the left aspect of the step bumper and left corner area prior to side-slapping the full end width of the patient compartment. The overlapping impacts resulted in direct contact that measured 245.1 cm (96.5”). The left rear corner post of the patient compartment was deflected outward 9.3 cm (3.8”) at the base and separated to 124.5 cm (49.0”) above the rear step. The rear wall of the patient compartment was crushed 8.9 cm (3.5”) and the left rear step was deflected inward at the rear left corner. The lower window glazing on the left rear door disintegrated. The aluminum rear-folding step was rotated upward and crushed against the rear aspect of the patient compartment. The license plate was crushed 10.8 cm (4.3”) laterally to the left. Both door-keepers were deformed on the left aspect of the rear of the patient compartment. A dark scuff was present on the right rear corner of the patient compartment 142.2 cm (56.0”) above the ground that extended 5.7 cm (2.3”) vertically from the right rear door and roof side rail of the Taurus. Fractured tempered glazing was also present on the right rear side gutter over

Figure 12. Damage to the back of the parked ambulance.

the compartment door. The CDC for the initial impact was 03-BYEW-1 with a sideslap CDC of 06-BZEW-1.

Fuel System – 2000 Ford Crown Victoria

The Ford Crown Victoria was equipped with an OEM 72 liter (19 gallon) steel fuel tank that was mounted vertically to the undercarriage of the vehicle, aft of the rear axle. The tank was positioned between the forward wall of the trunk and the rear axle. The dual exhaust tailpipes wrapped over the axle forward of the fuel tank. The filler tube was positioned on the left side of the vehicle, aft of the axle position. The tube entered the left side area of the tank at the upper aspect. The tube was secured to the tank with a large rubber grommet/gasket. The electric fuel pump was positioned in the tank and was located at the mid/upper aspect on the forward wall of the tank. Three valves were positioned on the top surface of the tank and were concealed by the mounted position of the fuel tank. The tank was secured to the vehicle by two conventional straps, hinged at the lower end and bolted to the body at the top forward surface of the tank.

This 2000 Ford Crown Victoria was updated to meet Ford's Technical Safety Bulletin (TSB) that was issued in October, 2001 for the model year 2000 Ford Crown Victoria. This safety bulletin recommended the removal (grinding) of the tabs on the sway-bar mounting brackets positioned on the rear axle. This procedure was performed on this vehicle at the police maintenance facility on June 14, 2002.

A Field Service Campaign (02B02) was announced by Ford in September 2002, to install a retrofit shield kit to the rear axle and fuel tank straps. The kit included two fiberglass reinforced shields that cover the shock and sway-bar mounting brackets, a rubberized shield that protects the differential cover, rubber boot-type shields that protect the bottom attachment point of the fuel tank straps, and the installation of three rivets to the leading edge of the rear mounted vapor recovery system mounting bracket. **Figure 13** is a view of an exemplar vehicle with the retrofit kit installed. An authorized Ford technician demonstrated and supervised the installation of these kits to the police maintenance technicians. The kits were subsequently installed by the police maintenance technicians on all vehicles within this police fleet. The kit was installed on the crash-involved Crown Victoria on March 15, 2003. Following the crash and fire, the kit remained intact, with moderate fire-related damage **(Figure 14)**, and appeared to have been installed properly to Ford's specifications.

Figure 13. Shield kit installed on an exemplar Crown Victoria.

Figure 14. Shield kit of the Subject Crown Victoria.

The driver reported that he filled the Crown Victoria's fuel tank prior to the crash. He estimated that he drove the vehicle 24 kms (15 miles) prior to the crash; therefore the tank was full. Based on tank volume and the estimated mileage driven, the tank contained approximately 64-68 liters (17-18 gallons) of gasoline at the time of the crash.

Fuel System Inspection

The Crown Victoria was inspected in a service bay at the police maintenance facility. The vehicle was positioned on an electric/hydraulic side stanchion lift that provided a full, unimpeded view of the undercarriage components. The following narrative documents the inspection process and identifies the source of the vehicle fire.

The rear crush to the Crown Victoria displaced the fuel tank forward. The forward aspect of the fuel tank was minimally deformed by the tank straps and its engagement against the tailpipes. The fuel tank did not engage the rear axle components or the differential cover. The retrofit kit outlined above was not contacted by the tank.

The fuel system was inspected in its post-crash state. All fuel supply, vent, and recovery lines were basically intact, allowing the investigators to trace the lines for signs of suspected ruptures/failures. The right frame rail was displaced laterally left (inboard) approximately 20.0 cm (8.0") at the location of the right C-pillar. The fuel filter was attached to the frame at this location. The fuel supply pressure line was burned at the aft segment of the filter; however, the manufactured loop in the supply line aft of the filter provided sufficient flex in the line to prevent line separation at this point **(Figure 15)**. This area did not exhibit signs of intense heat commonly attributed to the origin of

Figure 15. Displaced right frame rail and the fuel filter/pressure lines.

the fire. The fuel lines extending from the tank's internal fuel pump remained intact. There was evidence of heat and fire to the exterior surfaces of these lines.

The vapor recovery system was mounted to the undercarriage surface of the trunk floor. This system was severely damaged by the crush and subsequently separated from the Crown Victoria as the vehicle was winched from its final rest position. The ensuing fire burned the vapor recovery lines leading to this system.

The forward and side surfaces of the fuel tank were visually inspected for signs of penetration and/or ruptures. These surfaces appeared to be free of punctures **(Figure 16)**. With the approval of Fleet Management, the decision was made to remove the tank from the vehicle to allow for inspection of the top and aft surfaces of the tank. Several police automotive technicians conducted the tank removal process with assistance provided by the SCI investigators.

Figure 16. Deformed fuel tank prior to removal

The upper end filler tube was partially fused to the inner left quarter panel due to melting of the fuel cap around the internal mounting hardware. The filler tube was intact and securely held to the tank by the rubber grommet/gasket. The upper end of the tube was cut with a hacksaw and removed from the tank. The rollover valve in the filler tube was intact and appeared to be operational.

The fuel lines were secured to the fuel pump/sending unit by an external metallic clip and an internal plastic clip. The external clips were intact and were removed by the technician. A special tool was inserted into the fuel line couplers, however, the plastic clips would not release, therefore the steel lines at the sending unit were cut with a pair of diagonal shears (side-cutters). This process did not damage the fuel lines.

The fuel tank straps were intact. The upper end of the left tank was unbolted using a 13 mm socket on an impact wrench. The right strap bolt was partially restricted by the body deformation. At the mid point of the strap, the tank was bowed inward which created a void between the strap and the tank surface. Using a pneumatic rotary cutter, this strap was cut without damaging the tank.

At this point, all lines and fasteners had been removed from the tank. Attempts were made to remove the tank from between the frame rails. Due to the lateral displacement of the right rail, the tank was captured against the left rail. The left seam of the tank was bent at a 90 degree angle using a crescent wrench; however, the flange could not be deformed sufficiently to remove the tank.

At this point, a probe was inserted into the tank (at the filler tube location) which measured a significant amount of liquid in the tank. The liquid had the odor of gasoline. A remote electric fuel pump with pickup and discharge lines was used to drain the liquid from the tank. A calibrated liquid measuring container was used to measure the amount of fluid in the fuel tank. The tank contained 25.5 liters (6.75 gallons) of clean gasoline that was transferred to a holding tank for proper disposal.

Attempts to remove the tank from between the frame rails were unsuccessful. At this point, two alternatives were addressed for the removal of the fuel tank without inflicting damage to the tank. The first method was to cut the left frame rail from the vehicle. The second method was to position a hydraulic ram between the frame rails in an attempt to spread the rails sufficiently to remove the tank. Since the latter method was less invasive to the vehicle, a local body shop was called to supply the hydraulic tool. The rear body mounts were disconnected and the ram was positioned between the frame rails. After several attempts, the frame rails were spread sufficiently and the tank was removed from the vehicle. **Figures 17 and 18** are views of the removed fuel tank.

Figure 17. Forward aspect of the removed fuel tank.

Figure 18. Rear aspect of the fuel tank with puncture outline with calibrated tape.

As the tank was removed from the Crown Victoria, a large puncture **(Figure 19)** was noted to the back-side of the tank (side adjacent to the trunk), near the top surface. The puncture was located 12.7-15.2 cm (5.0-6.0”) right of the tank’s vertical centerline and extended 5.7-9.9 cm (2.25-3.9”) below the top surface of the tank. The puncture measured 6.4 mm (0.25”) in maximum width. A burn pattern, which indicated extreme heat, extended from the puncture site, oriented up and to the right of the puncture location. This pattern was white in color against the blackened fuel tank and extended 5.1 cm (2.0”) outward from the puncture. The triangular shaped pattern was 2.5 cm (1.0”) wide at the site of the puncture. As viewed from the rear of the tank, the burn pattern extended in a clock direction of 2-2:30.

Several gallons of water were poured into the tank prior to its removal and this water remained in the tank following its removal and subsequent inspection. As the tank was rotated and repositioned for inspection and photographic documentation, there were no leaks from the tank surface. There were no additional punctures or ruptures of the steel fuel tank detected visually or by this water test.

Figure 19. Puncture to the upper aspect of the fuel tank with adjacent burn.

The investigation continued to determine the source of the puncture. Since the puncture was located adjacent to the trunk wall, it was suspected that an object within the trunk was crushed against the trunk wall, thus penetrating the wall and fuel tank. This inspection process involved the documentation, removal, and inspection of the contents of the trunk. To facilitate this procedure, the trunk deck was removed from the hinges. It should be noted that the driver of the Crown Victoria stated that there were no road flares in the trunk of the vehicle.

The spare tire was positioned in its designated position on the top shelf of the trunk, lying horizontally, right of center and fully forward against the rear seat area. The wheel was positioned in a face-up attitude with the outside surface of the tire and wheel facing upward. In this position, approximately 25 percent of the tire and wheel protruded over the rear edge of the shelf. The tire was charred with minimal burn-through which resulted in the loss of tire pressure. A pry bar was used to separate the tire from the steel floor of the trunk. As the tire was slid rearward, the spare tire hold-down bracket and washer fell to the floor of the trunk. This hold-down bracket was lying loose under the wheel toward the center point of the vehicle. The bracket and washer **(Figure 20)** were retrieved as the tire was removed from the trunk. It should be noted that the tire contained a significant amount of water that was used by the firefighters to cool the vehicle following the suppression of the fire.

Figure 20. Spare tire hold-down bracket and anchor loop.

As the tire was removed from the vehicle, a similar (fuel tank) puncture was noted to the forward (with respect to the vehicle) wall of the trunk. The puncture was 5.1 cm (2.0”) in height and 6.4 mm (0.25”) in width. The puncture began 1.6 cm (0.625”) below the top shelf (spare tire location) and was located left of the spare tire hold-down bracket anchor loop. At the top of the puncture, its lateral location was 3.8 cm (1.5”) left of the anchor

loop and the bottom aspect of the puncture was located 1.9 cm (0.75") left of the referenced loop.

The spare tire hold-down bracket and retainer washer were examined and compared to an exemplar unit **(Figure 21)**. The hook aspect of the treaded rod was elongated, or opened to the extent of 3.5 cm (1.375"). This indicated a stress load was placed on this bracket as it was engaged with the floor mounted anchor loop. The loop was closely examined and it was noted to be loaded in a rearward direction, with deflection from left to right. It appeared that the hold-down bracket was engaged with the anchor loop and inserted into the loop from the right side.

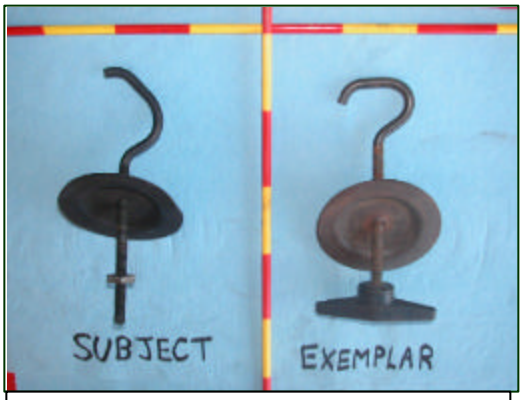

Figure 21. Subject vehicle hold-down bracket compared to an exemplar

The retainer washer was inspected and was slightly deformed. The 8.4 cm (3 5/16") diameter washer was formed with a 6.4 mm (0.25") reinforcement ridge located 1.3-1.9 cm (0.5-0.75") inboard of the perimeter. This ridge provided stiffness to the washer and acted as a positioning locator into the axle hub bore of the steel wheel.

This washer, with minimal circumferential deformation, was positioned in the puncture of the trunk wall and the fuel tank puncture site. As the washer was rotated in the puncture sites, the deflection of the washer surface aligned near perfectly with the slight vertical contour of the punctures. An inspection mirror was utilized to examine the intruding back wall of the trunk. At maximum engagement, the dynamic crush displaced the rear wall of the trunk fully forward against the forward wall at the spare tire location. A superficial, vertically oriented crease **(Figure 22)** was present in the rear wall of the trunk, nearly directly opposite of the trunk wall puncture site. This evidence verified that the fuel tank was punctured by an object within the trunk, apparently the spare tire hold-down bracket washer.

Figure 22. Crease to the back wall of the trunk from washer engagement.

Trunk Contents

Prior to drawing a conclusion for the penetration of the trunk wall and fuel tank, the contents of the trunk needed to be identified and removed for inspection. The left aspect of the trunk sustained the least amount of crush. The contents at this location were removed using a pry bar to separate melted components from the trunk floor. A collection of rain jackets and safety vests were first removed from the trunk. The OEM

scissors jack was lying loose in the trunk, laterally oriented on the left side. Adjacent to the jack was a roll of plastic crime scene tape. Located near the center aspect of the trunk was a plastic milk carton that was used to store loose objects in the trunk. This carton was melted and found to be empty. The OEM lug wrench was loose and positioned against the forward wall of the trunk. Two composite police Batons were laterally oriented in the trunk. Located on the floor of the trunk at the back left corner was a paper Police Manual.

Additional contents were located in the right side of the trunk; however, due to the crush deformation of the rear wall of the trunk, these contents could not be removed. The Fleet Maintenance Manager authorized the altering of the crush profile. This was accomplished by cutting the deformed right frame rail from the Crown Victoria. A roll-back tow truck was backed-up to the rear of the Crown Victoria and the flatbed was positioned against the left frame rail of the vehicle. The winch cable was hooked onto the rear wall of the trunk and the sheet metal was pulled rearward to gain access to the trunk.

With the trunk stretched back to it near original position, a plastic first aid kit was removed from the vehicle; melted but intact. A fabric sac or jacket-like item was found burned and had been removed from the vehicle. Lying loose under this melted fabric, were a pair of jumper cables, a 2.3 kg (5.0 lb) ABC dry chemical fire extinguisher, a 76 cm (30") crowbar positioned laterally across the trunk, and a conventional tire iron that was not OEM.

Figure 23. Outward dents on the forward wall of the trunk toward fuel tank from trunk contents.

It should be noted that none of these items recovered from the trunk, had the characteristics, shape, or location of the puncture to the trunk wall and fuel tank. The pry-end of the crowbar did penetrate the deformed trunk floor left of center at the aft aspect of the trunk. Three distinct outward dents **(Figure 23)** were noted to the forward wall of the trunk, adjacent to the location of the fuel tank. The OEM jack dented the left side of the trunk wall, 8.3-10.8 cm (3.25-4.25") inboard of the left tank strap and 8.9-11.4 cm (3.5-4.5") above the trunk floor. On the center aspect of the wall, a small round shaped dent was noted 29.2 cm (11.5") inboard of the right tank strap and 8.9 cm (3.5") above the floor of the trunk. This dent probably resulted from the OEM lug wrench. The third outward dent (two clustered) was located 7.6-10.2 cm (3.0-4.0") inboard of the right tank strap and 15.2-19.7 cm (6.0-7.75") above the trunk floor. These dents probably resulted from the hook portion of the crowbar.

Tank Puncture

Based on a thorough inspection of the 2000 Ford Crown Victoria's fuel system and related components, and the documentation of the vehicle damage pattern in conjunction with the contents of the trunk, the following conclusion was derived from the vehicle evidence.

1. The steel OEM fuel tank was punctured on the back wall of the tank, opposite of the rear axle and differential.
2. A burn pattern demonstrating extreme heat was present at the location of the puncture, supporting the theory that the fire was fuel related.
3. A mating puncture of the forward wall of the trunk was located in the exact area of the tank puncture and was of the same size and shape as the fuel tank puncture.
4. All components of the trunk were removed and inspected as potential sources of the puncture.
5. All trunk items were ruled out as potential sources of the puncture with the exception of the hold-down bracket washer for the spare tire.

Conclusions

The spare tire was loosely positioned in the designated area of the trunk, placed in a face-up attitude, horizontal to the vehicle. The hook aspect of the spare tire hold-down bracket was engaged into the right side of the floor mounted anchor hook. The hold-down bracket was positioned under the tire, lying rearward to the vehicle with the retainer washer positioned rearward of the anchor hook. The washer was laterally oriented to the vehicle.

As the 1990 Ford Taurus impacted the rear of the parked Ford Crown Victoria, the rear aspect of the Crown Victoria began to crush. During this event, the Crown Victoria was accelerated forward. The spare tire essentially remained in position in space as the vehicle was displaced forward. (The spare tire was displaced rearward with respect to the vehicle). The forward aspect of the wheel rim of the spare engaged the retainer washer of the hold-down bracket. This was evident by the load induced bending of the hook aspect of the hold-down bracket. During this loading event, the hook aspect of the hold-down bracket deformed the floor mounted anchor bracket. As the 6.4 mm (0.25") diameter hold-down bracket deformed under load by the spare tire, the hook aspect disengaged from the anchor bracket. During the loading and disengagement, the retainer washer rotated approximately 90 degrees in a clockwise direction with respect to the vehicle. The hold-down bracket was free-floating as it was contacted and compressed against the forward wall of the trunk by the intruding back wall of the trunk. This compression resulted in the edge of the retainer washer penetrating, in a knife-like manner, the back wall of the trunk and the adjacent fuel tank. The tank puncture was 5.1 cm (2.0") vertically and 6.4 mm (0.25") in width. As the vehicle continued to crush, the hold-down bracket was displaced vertically, coming to rest on the shelf under the spare tire.

The fuel tank was full at the time of the crash with an estimated 64-68 liters (17-18 gallons) of gasoline present in the tank. The tank was compressed against the tank straps and the tailpipes that reduced its volume. Fuel was forced from the puncture and subsequently ignited immediately, resulting in the vehicle fire. The source of ignition could not be determined. There were no distinct impacts to the undercarriage (i.e., curb, pavement) in the area of the fuel leakage. **Figures 24-27** are simulated images of the spare tire hold down bracket engagement by the spare tire, the subsequent separation and rotation of the unit, and the puncture of the trunk and fuel tank.

Figure 24. Initial position and engagement of the spare tire hold-down bracket.

Figure 25. Loading, elongation, and separation of the bracket from the anchor loop.

Figure 26. CW rotation of the bracket and engagement against the trunk wall.

Figure 27. Penetration of the bracket washer through the trunk wall and into the back of the fuel tank.

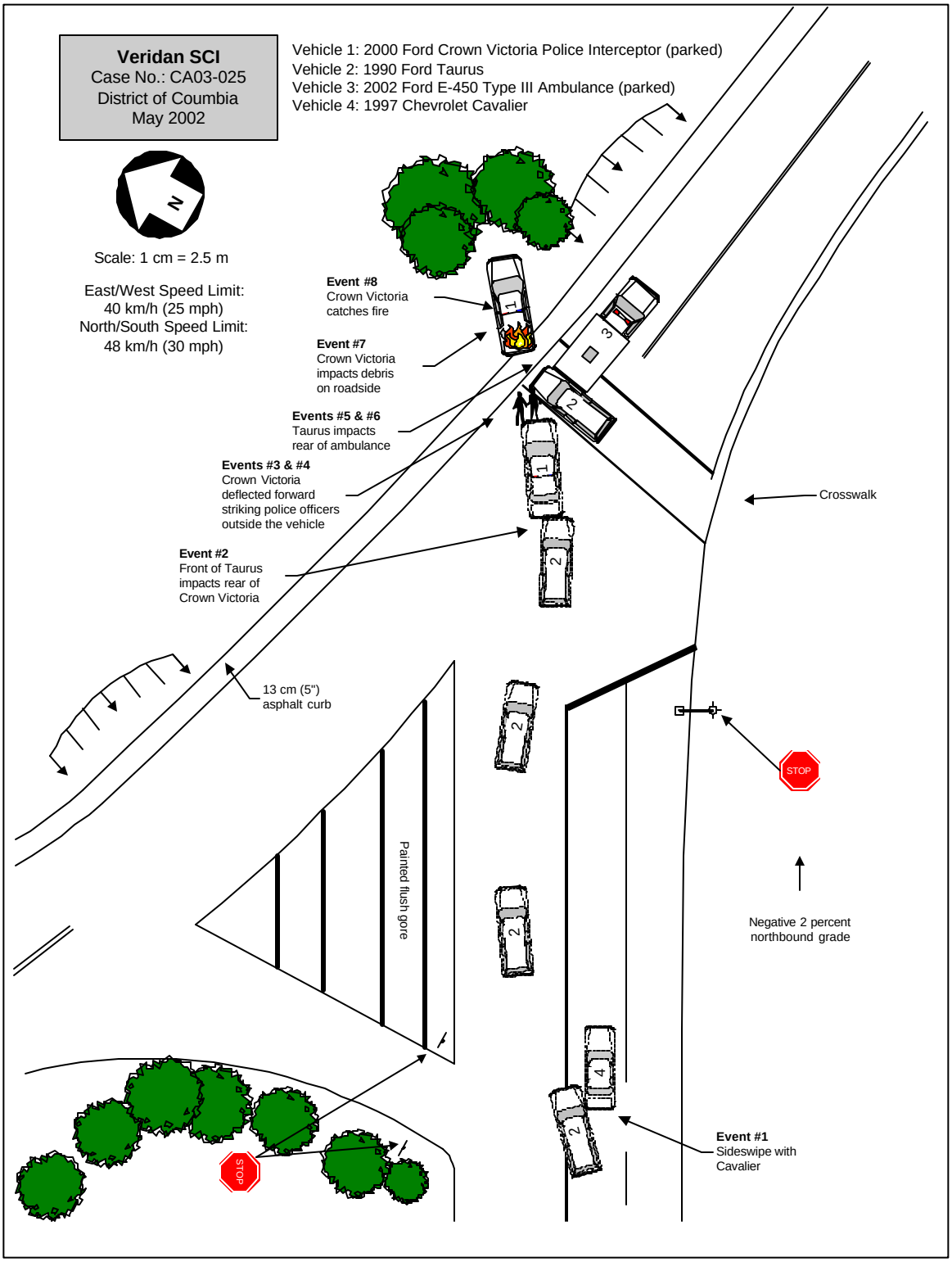

Figure 28. Scene schematic