TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

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GENERAL DYNAMICS ON-SITE REAR IMPACT CRASH/FIRE INVESTIGATION
SCI 1 CASE NO: CA03-028
VEHICLE: 2003 FORD CROWN VICTORIA POLICE INTERCEPTOR
LOCATION: MISSOURI
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

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. CA03-028	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle General Dynamics On-Site Rear Impact Crash/Fire Investigation Vehicle: 2003 Ford Crown Victoria Police Interceptor Location: Missouri		*5. Report Date*: Jnauary 2004 *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 General Dynamics P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* C00410.0000.0125 *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 On-site investigation that focused on the performance of the fuel system in a 2003 Ford Crown Victoria.			
16. Abstract This on-site investigation focused on the crash severity, integrity of the fuel system, fire source, and the cause of death of a 25-year old male on-duty police officer. The officer was the driver of a 2003 Ford Crown Victoria Police Interceptor (CVPI) that was parked on the right shoulder of an interstate roadway. He was conducting official police business following a routine traffic stop. A 1999 Lincoln Town Car was parked forward of the CVPI. The 48-year old male driver of the Lincoln was seated in the front right position of the CVPI. Due to the circumstances of the traffic stop, it was suspected that both occupants of the CVPI were unrestrained. A 2001 Ford F-350 was traveling in the outboard lane in a westerly direction on the interstate roadway. In the vicinity of the impending crash site, the police reported a site distance of approximately 1.6 km (1.0 mile) for westbound traffic. The driver of the F-350 was reportedly distracted as he attempted to reach for his sunglasses that were on the right instrument panel. As he reached for the glasses, he applied an inadvertent steering input that directed the F-350 onto the right shoulder. The frontal area of the truck impacted the rear of the parked CVPI that resulted in severe damage to the CVPI. As a result of the crush, the CVPI's fuel tank filler tube was severed which resulted in fuel leakage and a subsequent fire.			
17. Key Words 2003 Ford Crown Victoria Police Interceptor Severe rear impact Fuel leakage		*18. Distribution Statement* General Public	
19. Security Classif. (of this report) Unclassified	*20. Security Classif. (of this page)* Unclassified	*21. No. of Pages* 26	*22. Price*

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BACKGROUND

This on-site investigation focused on the crash severity, integrity of the fuel system, fire source, and the cause of death of a 25-year old male on-duty police officer. The officer was the driver of a 2003 Ford Crown Victoria Police Interceptor (CVPI) that was parked on the right shoulder of an interstate roadway. He was conducting official police business following a routine traffic stop. A 1999 Lincoln Town Car was parked forward of the CVPI. The 48-year old male driver of the Lincoln was seated in the front right position of the CVPI. Due to the circumstances of the traffic stop, it was suspected that both occupants of the CVPI were unrestrained. A 2001 Ford F-350 was traveling in the outboard lane in a easterly direction on the interstate roadway. In the vicinity of the impending crash site, the police reported a site distance of approximately 1.6 km (1.0 mile) for eastbound traffic. The driver of the F-350 was reportedly distracted as he attempted to reach for his sunglasses that were on the right instrument panel. As he reached for the glasses, he applied an inadvertent steering input that directed the F-350 onto the right shoulder. The frontal area of the truck impacted the rear of the parked CVPI that resulted in severe damage to the CVPI. As a result of the crush, the CVPI's fuel tank filler tube was severed which resulted in fuel leakage and a subsequent fire **(Figure 1)**.

Figure 1. Left rear view of the CVPI at final rest at the crash site.

The CVPI was displaced forward into the rear of the parked Lincoln Town Car. This secondary impact resulted in severe damage to the rear of the Lincoln and minor damage to the front of the CVPI. The F-350 was deflected to the left as a result of the initial crash, and an evasive steering input by the driver. The right front tire/wheel separated which redirected the F-350 in a clockwise direction. The F-350 impacted a W-beam guardrail and rode the guardrail for a police reported length of 85.3 m (280.1') prior to coming to rest. The CVPI and the Lincoln were deflected off-road onto a grassy area where they came to rest. The CVPI was fully engulfed in flames as passing motorists stopped and removed the passenger from the vehicle. Due to the severity of the fire, they were unable to provide assistance to the driver. The driver of the CVPI expired due to the crash-induced fire. The passenger sustained burns over 40 percent of his body and was transported to a regional trauma center where he was admitted for treatment. The driver of the F-350 sustained minor severity injures.

The General Dynamics SCI team identified this crash following an Internet news search of potential crashes of interest on May 23, 2003. The notification was forwarded to NHTSA's Crash Investigation Division on the day of identification and was immediately assigned as on-site investigative effort. Cooperation was established with the MSHP's Director of Fleet Management, who in conjunction with state representatives coordinated a combined investigative effort that was scheduled for July 1-2 that included Ford's technical representatives, litigation attorneys, consultants, and the SCI team. All three vehicles were towed to a Missouri Highway Patrol repair facility for the inspection/investigation process.

SUMMARY

Crash Site

The crash occurred on a four lane divided interstate roadway during daylight hours. The east/westbound travel lanes were separated by a depressed grass median. The crash occurred on the outboard shoulder of the eastbound travel lanes. The eastbound lanes consisted of two lanes that were 3.6 m (12.0') in width and delineated by a broken white centerline. The outboard edge line was a solid white line and the inboard edge was marked with a solid yellow edge line. The lanes were bordered by asphalt shoulders. The inboard shoulder width was 1.4 m (4.5') while the outboard shoulder width was 2.9 m (9.5'). Adjacent to the outboard shoulder was an earth and grass surface that sloped downward from the shoulder. The weather was police reported as clear and dry. In the vicinity of the crash site, the roadway was straight with a positive 1.1 percent grade to the east with an approximate 1.6 km (1.0 mile) line of sight afforded to eastbound traffic. The posted speed limit was 113 km/h (70 mph). The police measured a coefficient of friction for the outboard shoulder of the eastbound lane at 0.67. **Figure 2** is an overall eastbound view of the crash site.

Figure 2. Overall eastbound view of the crash site on approach to impact.

Vehicle Data

2003 Ford Crown Victoria Police Interceptor (CVPI)

The struck 2003 Ford CVPI was a four-door sedan, marked police unit, that was identified by Vehicle Identification Number (VIN) 2FAFP71WX3 (production number deleted). The vehicle was equipped with the MSHP required police equipment and placed into service on 4/7/03. The vehicle was assigned exclusively to the police officer driver. 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 white MSHP paint scheme, a light bar mounted to the roof of the vehicle, centered over the B-pillar area, and a left A-pillamounted spotlight. The Goodyear Eagle RS-A P225/60R16 all-season tires were

mounted on OEM steel wheels. The estimated weight of the equipped MSHP patrol car was 2,334 kg (5,145 lb).

The interior of the Crown Victoria was configured as a five-passenger vehicle with front bucket seats and a fixed rear bench seat. This CVPI was not equipped with a police safety cage. The vehicle safety systems consisted of three-point lap and shoulder belts for the four outboard-seated positions and a center rear lap belt. An Advanced Occupant Protection System (AOPS) that included dual stage frontal air bags for the driver and right passenger positions, front seat belt retractor pretensioners, a driver's seat track-positioning sensor, and an Event Data Recorder (EDR), provided supplemental protection. The frontal air bags probably deployed during the secondary crash event with the rear of the Lincoln Town Car.

Design changes incorporated into the 2003 model year vehicle included rack and pinion steering, an alloy radiator support panel, an enhanced performance-oriented front suspension redesign, and a redesigned frame for improved crash rigidity and performance. The rear aspect of the frame was widened to accommodate the redesigned rear suspension that positioned the rear shock absorber mounting brackets away from the fuel tank, outboard of the frame rails. The 2003 model was also equipped with the OEM shields covering the sway bar brackets and the tank straps, a molded rubber grommet that recessed the bolt heads on the lower aspect of the rear differential cover, and a redesigned vapor canister mounted to the lower surface of the trunk **(Figure 12)**.

A fellow MSHP Trooper borrowed this CVPI on the day prior to this crash. This Trooper returned the CVPI to the assigned driver's residence at 1450 hours and reported that he filled the vehicle's fuel tank prior to returning the vehicle. At the time of the refueling, the CVPI's odometer reading was 5,573 km (3,463 miles).

2001 Ford F-350 Truck

The 2001 Ford F-350 truck was identified by the Vehicle Identification Number (VIN) 1FDWF36F01E (production sequence deleted). The vehicle was a regular cab, 1 ton, chassis-cab 4x2 model manufactured on a 418.6 cm (164.8 in) wheelbase. The Gross Vehicle Weight Rating (GVWR) was 5,669 kg (12,500 lb). The power train consisted of a 7.3 liter, V-8 diesel engine linked to a 4-speed automatic transmission. The truck was manufactured as an incomplete vehicle in June 2001. Post-manufacture modification included the addition of a 2.4 m x 3.4 m (8.0 ft x 11.0 ft) flatbed to the truck. A 5.7 cm (2.25 in) fifth-wheel hitch ball was mounted in a recessed area of the flat bed at the rear axle location. The vehicle was towing a double axle 9.7 m (32.0 ft) Kiefer gooseneck flatbed trailer at the time of the crash. (The trailer was not inspected during this on-site SCI investigation). The service brakes consisted of front and rear hydraulic disc brakes with 4-wheel anti-lock. The manual restraint system consisted of 3-point lap and shoulder belts with retractor pretensioners for the outboard positions. The center position was equipped with a lap belt. The F-350 was equipped with redesigned driver and front right passenger air bags that deployed as a result of the crash with the CVPI. The pretensioners also fired as a result of the crash. The odometer had registered 116,307 km

(72,272 miles) at the time of the crash. The MSHP weighed the vehicle and trailer post-crash; recording a combined measured weight (less occupant) of 5,788 kg (12,760 lb).

1999 Lincoln Town Car

The 1999 Lincoln Town Car was identified by the Vehicle Identification Number (VIN): 1LNHM82W9XY (production sequence deleted). The 4-door, rear-wheel drive, body-on-frame, sedan was manufactured on the same platform as a 1999 Ford Crown Victoria. The Lincoln's power train consisted of a 4.6 liter/V8 engine linked to a four-speed automatic transmission. The service brakes were four-wheel disc with ABS. The manual restraint system consisted of 3-point lap and shoulder belts for the four outboard and center rear positions. The center front was equipped with a lap belt. The Lincoln was also equipped with redesigned frontal air bags for the driver and right passenger positions.

Crash Sequence

Pre-Crash

The 25-year old Missouri State Highway Patrol Trooper was operating the subject 2003 Ford CVPI on his assigned work shift. Reportedly, he had been on-duty for approximately one hour. During the course of his interstate patrol, the Trooper stopped an eastbound 1999 Lincoln Town Car that was driven by a 48-year old male driver for an apparent traffic law violation. The driver of the Lincoln stopped his vehicle on the outboard (south) shoulder of the interstate and the MSHP Trooper stopped the CVPI approximately one car length behind the Lincoln. The emergency lights on the CVPI were activated. The evidence and scene reconstruction conducted by the MSHP indicated the Trooper positioned the CVPI at an estimated five-degree angle with respect to the roadway. In this position, the rear of the vehicle was angled away from the traffic lane (angled toward the south). The Trooper walked up to the Lincoln and approached the left side of the vehicle to inform the driver of the traffic violation. The officer apparently requested that the driver of the Lincoln sit in the front right position of the CVPI as he conducted the official business of writing the violation. The Trooper and the driver of the Lincoln were seated in the front positions of the CVPI.

Figure 3. Eastbound view of the approach to the crash site.

Coincident to the above events, the 2001 Ford F-350 truck/towed trailer combination was eastbound on the outboard (right) lane driven by a 30-year old male. The Ford was towing an empty 9.7 m (32.0') 2000 Kiefer flatbed gooseneck trailer. Several motorists trailing the Ford indicated that traffic was light and that it was traveling approximately the posted speed limit of 113 km/h (70 mph). One of these motorists reported that his cruise control was set to the speed limit and he indicated the Ford F-350 was slowly pulling away from his vehicle. He estimated the Ford was traveling approximately 116

km/h (72 mph). This motorist further indicated they encountered no visibility problems and that he detected the overhead lights of the stopped patrol vehicle from approximately 1.6 km (1.0 mile) west of its parked position.

As the driver of the Ford F-350 continued his eastbound trajectory, he reported that the glare from the morning sun was bothering his eyes. He reportedly reached to his right across the instrument panel to retrieve his sunglasses. This reaching movement resulted in an inadvertent right steering maneuver that redirected the pickup truck onto the outboard shoulder of the road. The MSHP investigation documented two pre-crash counterclockwise arcing tire marks attributed to the right front and right rear tires of the truck. The marks measured approximately 14.6 m (48.0 ft) in length. The characteristics of the marks indicated the driver of the truck was steering to the left and braking prior to the impact. These inputs followed his detection of the parked CVPI and the impending crash. **Figure 3** is an eastbound view of the approach to the crash site.

Crash

The front right aspect of the F-350 impacted the back left aspect of the CVPI in an offset 12/6 o'clock impact configuration. An estimate of the Ford F-350's impact speed was approximately 105 km/h (65 mph) based on the Conservation of Momentum. **Figure 4** is an eastbound trajectory view of the point of impact. The position of the CVPI was evidenced by a scuffmark attributed to the left rear tire. The total Delta V for the CVPI was calculated by the Damage Algorithm of the WinSMASH model at 41.0 km/h (25.4 mph). The longitudinal and lateral components were +41.0 km/h (+25.4 mph) and 0 km/h, respectively. This analysis underestimated the crash severity due to the offset crash configuration, the use of the overlapping damage pattern of the striking F-350 truck, and the model's limitation of the 4,536 kg (10,000 lb) vehicle weight limit. The Ford F-350 exceeded this weight at the time of the crash. A WinSMASH analysis using the Missing Vehicle Algorithm estimated the CVPI's delta V to be 45 km/h (28.0 mph). The Missing Vehicle analysis was more consistent with the vehicle's damage.

Figure 4: Eastbound trajectory view at the POI.

The impact of the F-350 displaced the CVPI forward and the offset configuration caused the vehicle to begin to rotate clockwise (CW). During this translation and rotation, the full frontal plane of the CVPI engaged and then overrode the back plane of the Lincoln. A scuff mark attributed to the right front tire of the Lincoln evidenced its impact position. The front-to-rear impact configuration of these vehicles arrested the rotation of the CVPI. It should be noted that the F-350 was still engaged with the CVPI at the time of the secondary event. The Damage Algorithm of the WinSMASH program computed velocity changes of 19.0 km/h (11.8 mph) for the CVPI and 24.0 km/h (15.0 mph) for the struck Lincoln Town Car.

The eastbound momentum of the Ford accelerated both vehicles to the southeast as it drove-through the impact. The CVPI and Lincoln initiated counterclockwise (CCW) rotations. The F-350's right front axle fractured during its engagement with the CVPI. The tire, wheel rim, and brake rotor separated from the F-350. This tire/wheel separation redirected the F-350 in a CW direction as the truck continued in a general eastbound trajectory. The front right area of the F-350 impacted the W-beam guardrail that was located on the south road edge several times. The F-350 eventually came to rest against the guardrail approximately 134 m (440') east of the point of impact. Its trajectory was evidenced by left tire marks, gouge marks from the right front suspension, and impacts to the guardrail. The final rest of the F-350 is depicted in the background of **Figure 4**.

The CVPI disengaged from the Lincoln and rotated approximately 100 degrees counterclockwise during its spinout to final rest. The CVPI came to rest off the south edge of the pavement facing northward, approximately 15 m (50 ft) southeast of the initial point of impact. The vehicle was engulfed in flames at this time. Witnesses reported the fire started nearly instantaneously upon impact with the F-350. In summary, the fire ignited when the fuel tank filler tube that was located in the left rear quarter panel area of the CVPI was severed, allowing gasoline to escape under hydraulic pressure as the tank was crushed during the rear impact. It should be noted that at the time of the crash, the fuel tank on the CVPI was nearly full. Details regarding the cause and origin of the fire are detailed in various sections of this report that follow. **Figure 5** is a southeasterly view of the final rest positions of the CVPI and the Lincoln.

Figure 5. Final rest positions of the CVPI and the Lincoln Town Car.

The unoccupied Lincoln came to rest off the south edge of the pavement approximately 20 m (67 ft) southeast of the impact. The vehicle rotated approximately 152 degrees CCW, facing in a northwesterly direction. Schematics of the crash developed by the MSHP using a total station (electronic survey) are attached as **Figures 24 and 25**.

Post-Crash

Passing motorists stopped immediately at the crash site to render aid to the involved occupants. These individuals ran to the right side of the CVPI, opened the front right door, and removed the Lincoln driver who was seated in the front right of the CVPI. He sustained burns to 25 percent of his body, predominantly to his lower extremities. These motorists reported that the smoke and fire became too intense to return to the vehicle to assist the Trooper seated in the driver's position. Fire department personnel responded to the scene and extinguished the fire. The body of the Trooper was found in the driver's seat in a normal posture.

Vehicle Damage

Exterior - 2003 Ford CVPI

Figure 6. Rear view of the CVPI.

The CVPI sustained severe damage to the back and left side that was associated with the initial impact sequence with the Ford F-350. **Figures 6-8** are the rear, left lateral and right lateral views of the damaged CVPI, respectively. The back plane of the vehicle sustained severe direct and induced impact damage that extended across its entire 152 cm (60") end-width. The rear bumper reinforcement bar separated from the Energy Absorbing Device (EAD's) brackets and was found at the crash site essentially undamaged. The longitudinal displacement (crush) of the left and right EAD's measured 111.8 cm (44.0") and 50.5 cm (19.9"), respectively. The left EAD compressed its entire 3.5 cm (1.375") length and was jammed. There was no compression of the right EAD. The rear damage profile of the CVPI was documented along the rear wall of the trunk and was as follows: C1 = 120.0 cm (47.2"), C2 = 92.0 cm (36.2"), C3 = 82.0 cm (32.3"), C4 = 73.0 cm (28.7"), C5 = 57.0 cm (22.4"), C6 = 53.0 cm (20.9"). The trunk latch released during the impact and the trunk lid was displaced forward through the backlight and into contact with the roof and backlight header. The displacement of the upper left and right corners of the roof measured 19.6 cm (7.7") and 8.6 cm (3.4"), respectively. The left wheelbase was reduced in length by 59.9 cm (23.6"). The right wheelbase was elongated 8.6 cm (3.4 in) due to displacement of the rear axle. The Collision Deformation Classification (CDC) was 06-BYEW-6.

The direct contact damage was biased to the left side indicative of the offset impact configuration. The force of the offset impact separated the exterior sheet metal of the left rear quarter panel and C-pillar from the inner fender and side rail. The deformed sheet metal was attached to the deformed left rear door by the latch/striker post engagement. The separation then continued forward approximately 151.1 cm (59.5") along the left floor pan to the left A-pillar location. The left doors of the vehicle became a free-floating section, attached to the vehicle at the A-pillar door hinge and by the upper B-pillar connection to the left roof rail. During this deformation and separation, the fuel tank filler tube was cut 15.2 cm (6.0") outboard of the fuel tank. The upper end of the filler neck became entrapped in the deformed left rear quarter panel sheet metal. The in-tank end of the filler tube remained in the tank. Refer to the *Filler Tube Damage - CVPI* section of this report for greater detail on the filler tube separation. The left side separation created a direct path for the fire to enter the occupant compartment.

The left front door was jammed closed by the exterior deformation. The left rear door remained engaged to the C-pillar; however, the pillar was separated by the damage resulting in integrity loss due to structural failure. The right front door remained closed during the impact and was initially operational. The passing motorist opened this door in

order to remove the front right occupant. Presumably, it closed after his removal and was then rendered inoperative by the fire. As depicted in **Figure 8**, both right doors and the right B-pillar were removed by rescue personnel in order to extricate the body of the Trooper.

Figure 7. Left view of the CVPI

Figure 8. Right view of the CVPI.

As a result of the rear impact with the F-350, the CVPI was displaced forward with a large percentage of its weight transferred to its rear axle as the F-350 overrode the rear of the CVPI and drove the vehicle forward as they remained momentarily engaged. This resulted in an override impact between the full frontal plane of the CVPI and the back plane of the Lincoln. The engagement resulted in minimal damage to the front of the CVPI as it overrode the Lincoln's rear bumper and penetrated into the soft structure of its trunk. Maximum crush was 8.3 cm (3.25") located at the left corner of the bumper reinforcement beam. The measured crush profile at this level was as follows: C1 = 8.3 cm (3.25"), C2 = 5.3 cm (2.1"), C3 = 4.8 cm (1.9"), C4 = 4.3 cm (1.7"), C5 = 3.8 cm (1.5"), C6 = 3.2 cm (1.25"). The impact involved the bumper, grille, and hood face levels of the CVPI. The CDC of this impact was 12-FDEW-1. The F-350 was still in contact with the CVPI during this event and the majority of the Lincoln's damage should be attributed to the momentum of the pickup.

Interior – 2003 Ford CVPI

Figure 9 is a right interior view of the CVPI. The interior compartment was completely burned by the crash-induced fire. During the process of extricating the driver, fire department personnel removed the right doors and cut the right B-pillar from the CVPI to gain access to the compartment. In order to access the driver, the front right seat back, center console and driver seat back were cut. There was no deformation of the seat backs upon examination. The adjustable front seats were estimated to be in a full rear track position. The CVPI was not equipped with a

Figure 9. Right interior view of the CVPI.

safety cage separating the front and rear seats. The residual longitudinal intrusion of the rear seat was measured along the package shelf and is listed in the table below:

Position	Intruding Component	Direction	Magnitude
Rear Left	Rear parcel shelf	Longitudinal	66.0 cm (26.0")
Rear Center	Rear parcel shelf	Longitudinal	39.1 cm (15.4")
Rear Right	Rear parcel shelf	Longitudinal	17.0 cm (6.7")

It should be noted that under the dynamic conditions of the impact, the rear intrusion would have been greater than documented. As such, the dynamic rear left intrusion was probably in-close proximity to the driver's seat back.

The 2003 Ford CVPI was equipped with a Restraint Control Module (RCM) with Event Data Recorder (EDR) capabilities. The RCM controlled and monitored the deployment of the vehicle's safety systems (pretensioners and air bags). Although the RCM was designed to capture data related to a frontal crash, the potential existed that data regarding this multi-sequence event may have been captured. The RCM was located under the center instrument panel on the vehicle's center tunnel and was removed by the SCI team. Although the exterior case of the RCM remained intact, the plastic electrical connectors were melted and fused by the heat of the fire. Due to this damage, it was not possible to download the RCM with the Vetronix Crash Data Retrieval Tool.

Exterior – 2003 Ford F-350

The overall exterior damage to the Ford F-350 was a combination of overlapping impacts with the CVPI, the CVPI's interaction with the Lincoln, and the F-350's direct contact to the W-beam guardrail during its roll out to final rest. **Figure 10** is a right front view of the damaged vehicle. The direct damage width began 11.4 cm (4.5") right of center and extended 82.6 cm (32.5") to the front right corner. The front plane of the Ford sustained a combined width of direct and induced damage that extended across its entire 188 cm (74") undeformed end width. The frontal deformation measured along the bumper was as follows: C1 = 0 cm, C2 = 1.0 cm (0.4"), C3 = 7.0 cm (2.8"), C4 = 11.0 cm (4.3"), C5 = 16.0 cm (6.3"), C6 = 32.0 cm (12.6"). The CDC for the impact with the CVPI was 12-FZEW-2. The total Delta V calculated by the Damage Algorithm of the WINSMASH model was 22.0 km/h (13.7 mph). This calculation should be used as a point of reference only, due to the limitations of the analysis previously discussed.

Figure 10. Right front view of the Ford F350.

The frontal damage pattern wrapped around the front right corner and extended along the right side of the cab to the leading edge of the cargo body and integrated tool box. This contact pattern occurred as the pickup drove through the impact sequence, remaining

momentarily engaged with the deformed left rear side area of the CVPI, and subsequently contacting the left side of the Lincoln in a sideswipe configuration. Additionally, the F-350 impacted the guardrail system that paralleled the right shoulder. Based on these multiple overlapping impacts, the damage could not be isolated for each event; therefore the CDC's for these events were 12-F999-9.

The exterior sheet metal of the right fender was deflected rearward to the right A-pillar. The lower right aspect of the windshield was fractured from direct contact. The leading edge of the flat bed body protruded 13.5 cm (5.3") outboard of the cab and exhibited direct contact damage. The flat bed was shifted approximately 2.5 cm (1.0") rearward on the right side. The right door remained closed during the cash and was jammed closed post-crash. The right front axle spindle fractured across its threaded end and the right front tire and wheel assembly separated which fractured the brake rotor. The right front tire was debeaded and the sidewall was cut. The rim was deformed over a 20x5 cm (8x2") region. The right wheelbase was reduced in length by 17.5 cm (6.9"). There was no measurable change in the left wheelbase dimension.

Interior – 2003 Ford F-350

The interior damage to the Ford F-350 was consistent with the deployment of the vehicle's redesigned frontal air bag system. The driver and front right passenger air bags deployed as a result of the crash. The OEM cut-off switch for the front right passenger air bag was in the "Air Bag On" position. The 61 cm (24") diameter, tethered, driver air bag did not exhibit signs of occupant contact. There was no intrusion or interior damage attributed to the exterior forces of the crash.

The driver seat was located in a rear track position that measured 0.6 cm (0.25") forward of the full rear position. There was no deformation of the steering wheel rim and there was no shear capsule displacement. MSHP personnel removed the driver knee bolster panel from the vehicle during their post-crash inspection of the vehicle. There was no direct contact evidence to the panel. They also removed the Restraints Control Module (RCM); however this module was not compatible for download by the Vetronix software. The webbing of the driver's 3-point manual restraint system was extended from the retractor and lying on the seat. The pretensioner in the driver's retractor fired which locked the retractor in its crash position. The latch plate exhibited indicators of historical use. Examination of the webbing revealed crash related evidence on two areas of the restraint indicative of use by the driver at the time of the crash. An 8 cm (3") wide latch plate transfer was located 119 cm (47") above the outboard floor anchor and a 5 cm (2") D-ring transfer was located 229 cm (90") above the anchor. The adjustable D-ring was in its lowest adjusted position. The length of the extended webbing was consistent with the stature of the driver. The investigating officer estimated the driver's height and weight at 178 cm (70") and 150 kg (330 lb).

Exterior – 1999 Lincoln Town Car

Figure 11 is a left lateral view of the Lincoln. The frontal area of the CVPI initially impacted the rear bumper of the Lincoln and overrode the bumper, engaging the sheet metal area of the trunk. The rear bumper fascia was torn and partially separated from the vehicle, exposing the bumper beam. The direct contact extended across the vehicle's full 156.2 cm (61.5") end width. The residual deformation of the Lincoln was measured along the bumper reinforcement beam and at the rear wall of the trunk. Maximum crush was 69.8 cm (27.1") located at the rear left corner of the trunk wall. The crush depth at the left corner of the rear bumper beam was 13.0 cm (5.1"). The documented crush profile at the level of the trunk wall was as follows: C1 = 69.8 cm (27.1"), C2 = 68.3 cm (26.9"), C3 = 55.6 cm (21.9"), C4 = 47.2 cm (18.6"), C5 = 35.8 cm (14.1"), C6 = 22.2 cm (8.75"). The averaged residual crush profile, based on bumper and trunk wall crush was as follows: C1 = 40.9 cm (16.1 in), C2 = 45.0 cm (17.7"), C3 = 38.0 cm (15.0"), C4 = 30.0 cm (11.8"), C5 = 24.0 cm (9.4"), C6 = 13.0 cm (5.1"). The CDC for this impact was 06-BDEW-4.

Figure 11. Left lateral view of the Lincoln's crush profile.

The F-350 contacted the left side of the Lincoln resulting in sideswipe-type damage to the Town Car. The direct contact damage began 15.9 cm (6.25") aft of the left rear axle position and extended 405.1 cm (159.5") forward, terminating at the front bumper corner. Maximum crush was 13.3 cm (5.25") and was located on the fender opening, 34.3 cm (13.5") aft of the front axle. The damage consisted of abrasions and isolated dents. The CDC for this event was 06-LDES-1.

Interior – 1999 Lincoln Town Car

There was no interior damage to the Lincoln as a result of the impact. The frontal and side impact air bags did not deploy. The vehicle was not occupied at the time of the crash. The 48-year old male driver was seated in the front right position of subject CVPI.

Fuel System – 2003 Ford CVPI

The fuel system of the 2003 Ford Crown Victoria consisted of a 72 liter (19 gallon) steel fuel tank that was mounted vertically to the undercarriage, aft of the rear axle and forward of the trunk. The tank was fastened to the vehicle by two steel tank straps that were hinged at the lower aspect of the tank and bolted to the top surface of the undercarriage. An internal electric fuel pump was mounted to the sending unit that was positioned on the upper forward surface of the tank. This sending unit was fastened to the tank with six bolts and sealed with a gasket. A single steel braded fuel supply line was attached to the sending unit output. This fuel line extended the length of the right frame rail to the engine compartment. **Figure 12** is an undercarriage view of an exemplar 2003 Ford CVPI.

The top surface of the tank was equipped with three valves that were affixed to the tank with rubberized grommets. The left and center mounted valves were completely consumed by the fire. The fire melted the top, right mounted valve; however, the valve concealed the formed tank opening at this location.

Figure 12. Undercarriage view of an exemplar 2003 CVPI depicting the fuel system and shield kit.

The fuel tank filler tube extended from the left upper side surface of the tank and was formed to fit within the contour of the left inner fender of the quarter panel. The tube was fastened to the quarter panel and was concealed by a door with an interior mounted release mechanism. The filler tube was constructed of a single length of formed steel and was sealed to the tank by a rubber/composite grommet. A plastic spacer extended outboard of the grommet. Located at this position was a riveted bracket that attached and positioned the filler tube to the outboard seam flange of the tank.

The steel filler tube extended approximately 17.1 cm (6.75") into the steel fuel tank. A plastic spring loaded check valve was affixed to the inboard end of the tube and was 7.9 cm (3.125") in length. This valve opened during the refueling process and closed to prevent back flow of fuel through the tube. The filler tube was capped with a plastic ratcheting filler cap.

A fellow MSHP Trooper borrowed this 2003 Ford CVPI on the day preceding the crash. The CVPI was returned to the assigned Trooper's residence following the completion of fellow Trooper's work shift. The vehicle was returned with a full tank of fuel and the recorded odometer reading at the time of the refueling was 5,573 km (3,463 miles).

The Trooper involved in the crash began his assigned work shift at 0600 hours and had been on-duty for approximately one hour prior to the crash. Assuming the fuel tank was full to the maximum 72 liter (19 gallon) capacity, in this one hour on-duty time frame, the Trooper could have used a maximum amount of 13.2 liter (3.5 gallons) of fuel. This was based on a constant speed of 113 km (70 mph) at an average consumption rate of 8.45 km/liter (20 mpg). Therefore, at the time of the crash, the fuel tank of the CVPI contained a minimum of 58.7 liters (15.5 gallons) of gasoline.

Fuel System Damage – 2003 Ford CVPI

In-Vehicle Observations

This assessment of the fuel system damage was documented with the vehicle intact in its post-crash state while supported by its frame on a hydraulic two-post service lift. **Figure 13** is an overall view of the undercarriage and fuel system in the CVPI.

The left rear quarter panel and C-pillar were severely crushed and completely separated from the body of the vehicle. Both components remained attached to the left rear door solely by the engagement of the door latch to the striker post. The sheet metal surrounding the spot-welds fractured due to stress overload during the crash which resulted in the component separation.

Figure 13. Rear undercarriage view of the CVPI.

The fuel filler tube on the 2003 Ford CVPI was located in the left quarter panel, aft of the axle position and concealed by a door with an interior mounted release mechanism. Post-crash, the filler tube was noted to be completely separated with the upper segment engaged to the deformed sheet metal of the quarter panel. The sheet metal screws that attached the upper flange of the filler tube to the quarter panel pulled through the flange resulting in the separation of the mounting system. The separation of the filler tube was located 38.1 cm (15.0”) downstream of the retaining flange.

The tank end of the separated filler tube was found in the tank at the time of the SCI inspection, in its approximate mounted position. The grommet seal was completely consumed by the fire. This segment of the tube was marked for position and removed from the tank. The overall length of this section was 26.7 cm (10.5”) with 11.1 cm (4.375”) inserted into the tank. Upon removal of this tube section, the forward aspect of the tank end of the tube was deformed (flatted) over a 1.9 cm (0.75”) vertical area. The plastic check valve that was mounted within the fuel tank at the end of the filler tube was missing from the tube. The check valve probably fractured during the crash as a result of tank deformation and tube rotation. The check valve separated or partially separated from the tube, then was consumed by the ensuing fire.

The vertically mounted fuel tank was compressed between the forward wall of the trunk, the tailpipes, and the ring gear protrusion of the differential cover. The fuel tank did not engage against the rear axle components that were protected by the Ford shield kit. At maximum engagement, the fuel tank was compressed against the left tail pipe of the CVPI. This contact resulted in a vertically oriented dent to the forward wall of the tank. At the time of the inspection, there was 6.4 cm (2.5”) of clearance between the tailpipe and the upper aspect of the tank and 17.8 cm (7.0”) at the lower aspect. The mid aspect of the fuel tank was compressed against the differential cover that resulted in a 7.6x10.1 cm (3.0x4.0”) dent that was approximately 2.5 cm (1.0”) in depth. The fuel tank engaged the right tailpipe that resulted in a vertically oriented concave area of deformation to the tank that was 5.6 cm (5.5”) in width and 4.4 cm (1.75”) in depth that involved the right aspect of the sending unit. The sending unit was not damaged and remained intact within the tank. There were no perforations to the tank.

The left aspect of the tank was crushed against the deformed left frame rail. The trailing end of the left rear frame rail was crushed to a depth of 111.7 cm (44.0") which deformed the rail to an "S"-type bend, aft of the axle and kinked the box frame rail at the apex of the formed bow over the axle. The tank contact against this deformed frame rail crushed the left aspect of the tank wall.

The left bottom edge of the fuel tank was deformed to a crease and crushed full thickness from contact by the intruding forward wall of the trunk and the trunk mounted radio units. The crease extended 53.4 cm (21.0") inboard of the left corner. There were no apparent punctures associated with this damage.

The right third of the fuel tank remained intact with minimal damage and no significant reduction in volume. The left and right fuel tank straps were intact and did not exhibit damage. The single braided steel jacketed fuel supply line remained attached to the sending unit and was intact.

The aluminum driveshaft fractured 10.2 cm (4.0") forward of the centerline of the rear U-joint yoke. The rear axle rotated in a downward direction. The differential housing was rotated approximately 30 degrees downward at the forward aspect. Both rear coil springs dislodged from their respective mounts and were found loose, lying horizontal on the rear axle.

The bottom mid aspect of the trunk floor was burned through by the road flares that were stored in the trunk of the CVPI. The flares ignited during the fire and burned a 35.6x19.1 cm (14.0x7.5") opening in the deformed trunk floor. The edges of the trunk floor at the area of the burn presented the image of a perforation due to corrosion or extreme heat. Flare residue was present in this area.

A portable hydraulic floor jack was stored in the trunk, positioned longitudinal to the CVPI. The forward aspect of the jack was exposed through the above referenced opening in the trunk floor. The wheels of the floor jack contacted the mid bottom aspect of the fuel tank; however, there was no penetration of the tank from the jack.

The OEM shield kit that was installed on the rear components remained intact during the crash. This kit included a rubberized band shield around the lower aspect of the differential cover with round bolt heads, fiberglass-reinforced hard plastic shields that surrounded the sway-bar brackets on the rear axle tubes, rubberized shields mounted to the bottom aspect of the fuel tank straps, and the installation of three heavy-duty rivets installed at the leading edge of the mounting bracket for the vapor canister. The post-crash inspection of this shield kit revealed the following:

- This kit was not engaged by the fuel tank as it was crushed and displaced forward by the impact induced damage.
- There was no direct crash-related damage to these components.
- The shield kit was damaged by the ensuing fire
    1. The left sway bar shield was completely consumed by the fire. The stainless steel band clamps remained in-place on the axle tubes. The right

sway bar shield remained intact; however, the exterior surface was burned by fire and melted by the intense heat.

2. The differential cover shield remained intact with the exposed surface charred by the fire. The round-head blots remained concealed by the thickness of the shield.
3. Both fuel tank strap shields were completely consumed by the fire.
4. The vapor canister rivets remained intact. The aft mounted bolts disengaged from the brackets that were welded to the floor of the trunk.

Fuel Tank Removal – 2003 Ford CVPI

The 2003 Ford Crown Victoria was positioned on an electro-hydraulic dual stanchion lift. Two mechanical technicians from the Missouri Highway patrol performed the mechanical functions associated with the removal of the fuel tank under the direction of the SCI team and MSHP's expert consultant.

The initial procedure of the removal of the vehicle's fuel tank involved the removal of the left quarter panel and C-pillar as the upper end of the filler tube remained engaged to the quarter panel. The quarter panel and C-pillar components were severely crushed and separated from the body of the Crown Victoria. The rear left door latch remained engaged to the striker post which remained engaged to the C-pillar; therefore the sheet metal quarter panel and C-pillar were supported solely by the latch mechanism. The mechanics pried the latch from the striker post and removed the sheet metal components from the vehicle. The filler tube had separated from the quarter panel and was removed from the deformed sheet metal by cutting the quarter panel with shears to allow the upper end of the tube to disengage from the deformed panel.

The tank section of the filler tube was marked with a felt-tip marker to document its position in the tank prior to removal. This section was removed without effort as the grommet and plastic spacer had completed disintegrated in the fire. The metal positioning bracket was torn and was no longer engaged to the filler tube. The filler tube was removed from the tank. The end of the tube was dented from probable contact against the forward wall of the tank as the tank was crushed to near full depth at the left third of the tank. The check valve was no longer engaged in the tube and was incinerated by the ensuing fire. The check valve was probably fractured and/or displaced from the filler tube by the tank crush and tube engagement against the inside surface of the tank.

The exhaust tailpipes were crushed and deformed by the impact. A reciprocating saw was used to cut the right tailpipe over the axle while the left tailpipe was cut aft of the muffler. Both tailpipes were removed from the Crown Victoria to provided clearance for the removal the fuel tank. Both rear coil springs had separated from their installed positions and were lying horizontally on the frame and rear axle assembly. The unloaded springs were removed without the use tools.

The fuel tank remained securely fastened to the vehicle's undercarriage by the two tank straps. The right tank strap was unbolted at the upper end and the lower retaining pin was removed from the strap bracket which allowed for complete removal of the strap. The

left tank strap was also unbolted at the upper end, however, the lower pin could not be removed, therefore the strap was deflected rearward, away from the tank. The single steel jacketed fuel line was cut forward of the sending unit along with the fuel gauge wires.

At this point, the tank was retained in the vehicle by the deformation of the frame rails. A hydraulic ram was positioned between the frame rails to spread the left rail laterally left. As the tank was manually lowered, the forward aspect of the tank contacted the differential cover. A hydraulic puller was attached to the transmission cross member and chained to the left side of the rear axle to pull the axle forward. This hydraulic pull moved the axle forward to allow for the complete removal of the tank without causing additional damage to the tank.

Fuel Tank Damage – 2003 Ford CVPI
Removed From Vehicle

The fuel tank was removed from the CVPI by the MSHP technicians without causing additional damage to the tank. The tank was placed in a cordoned-off area where the SCI team could inspect the tank for evidence of rupture/fuel leakage.

The top aspect of the tank contained three valves that were secured to the tank with rubber grommets **(Figure 14)**. The left and center valves were completely consumed by the ensuing fire. The rubberized grommet for the valve mounted on the left side of the tank was severely charred with fragments of the valve resting on the top surface of the tank. The center valve unit was completely incinerated. The valve on the right side of the tank was melted by the fire and heat; however, the valve remained intact to close off the tank opening for this unit. The fuel return line that serviced this valve was melted to the right side of the fuel tank.

Figure 14. Top view of the fuel tank.

Figure 15. Rear aspect of the CVPI's fuel tank.

The tank was crushed as described above in the *In-Vehicle Observations* section of this report. The left lower rear quadrant of the fuel tank was crushed to near full thickness between the intruding trunk wall and the left frame rail and tailpipe **(Figure 15)**. A square area of deformation that measured 17.8 cm (7.0") laterally and 10.8 cm (4.25") in depth was noted to the lower left aspect of the rear wall of the tank. This near full thickness crushing of the tank resulted from compression of the trunk and the left side mounted police radio cluster. The radio cluster did not penetrate the tank or the trunk wall.

The upper rear aspect of the tank was deformed by the intrusion of the trunk wall. This area of deformation formed a crease near the top aspect. Within the crease was an abrasion of the sheet metal tank material and an extremely small (pin hole-size) puncture of the tank. There were no other punctures of the tank and all seams remained intact. The circular sending unit that was screwed to the forward wall of the tank remained intact along with the single fuel supply line.

Filler Tube – 2003 Ford CVPI

The filler tube of the 2003 Ford CVPI consisted of a one-piece steel tube that extended from the quarter panel filler location, under the inner fender, and to the left upper side of the fuel tank. The upper end of the filler tube was flared to accommodate the plastic filler cap and the steel collar that secured the upper end of the filler tube to the left quarter panel. Four sheet metal screws secured the tube to the quarter panel. The tube was reduced to 3.2 cm (1.25") in diameter and formed with a series of bends to extend along the upper aspect of the inner fender without interfering with the shock absorber mount and tire.

As the tube extended inboard under the inner fender, a positioning bracket was affixed to the left side seam of the fuel tank. The filler tube passed through the bore of this bracket that was positioned 6.4 cm (2.5") inboard of the inner fender seam edge. Located immediately inboard of this positioning bracket was a tapered plastic spacer that was 4.1 cm (1.625") in depth. The rubberized grommet that sealed the fitment between the filler tube and the fuel tank was located immediately inboard of the spacer and was 1.6 cm (0.625") thick on the outboard aspect of the fuel tank.

Based on an exemplar filler tube, the steel tube extended approximately 18.1 cm (7.125") into the fuel tank of the CVPI. Located on the tank end of the filler tube was a plastic check valve. The valve extended an additional 7.9 cm (3.125") from the end of the filler tube. This spring-loaded check valve remained closed, and opened only during the refueling process. The valve was designed to prevent fuel flowing back through the tube from the tank.

A fuel spill recovery tube (formed steel) extended from the upstream end of the filler tube at the cap location and transitioned to a neoprene hose at the location of the positioning bracket.

In the vicinity of the filler tube, the inner fender and forward wall of the trunk were formed to a common seam and welded together with a series of spot-type welds. This common seam formed a sheet metal edge that was vertically oriented and exposed to the

aft aspect of the filler tube. The formed inner fender edge extended 22.9 cm (9.0") vertically and protruded 2.2 cm (0.875") forward of the forward trunk wall. Based on the inspection of an exemplar vehicle, the air gap between this inner fender edge and the filler tube was 0.6 cm (0.25"). **Figures 16 and 17** are views of the inner fender edge and filler tube location on an exemplar 2003 CVPI.

Figure 16. Filler tube position in relation to the inner fender on an exemplar 2003 CVPI.

Figure 17. Close-up view of the proximity of the filler tube to the inner fender edge.

The inboard aspect of the sheet metal inner fender was formed to an edge that was the thickness of the sheet metal. This horizontally oriented edge extended 15.2 cm (6.0") forward of the apex of the edge of the vertical seam. The centerline of the filler tube was located 2.5 cm (1.0") forward of the vertical seam edge and 5.1 cm (2.0") below the horizontal seam edge.

Positioned forward of the filler tube within the inner fender location was the redesigned rear shock absorber mount location. The rear shock absorbers were relocated for Model Year 2003 outboard of the frame rails away from the fuel tank location. The lower end of the left rear shock absorber was mounted to bracket that was welded to the rear axle. The upper end of the shock absorber was mounted to a formed bracket in the shape of a flat inverted "V" that was welded to the frame rail forward of the filler tube location. The bracket was positioned longitudinally to the vehicle and was 4.4 cm (1.75") wide at the top aspect and tapered to a width of 6.4 cm (2.5") at the vehicle frame location. The upper rear corner of the bracket was located 5.1 cm (2.0") forward of the centerline of the steel filler tube and 5.7 cm (2.25") below the centerline of the filler tube. The top of the shock absorber protruded through the top of this bracket and was secured with a conventional nut and bushing. The top threaded stud of the shock absorber was positioned 9.5 cm (3.75") forward of the centerline of the filler tube.

Filler Tube Damage – 2003 Ford CVPI

During the initial visual inspection of the 2003 Ford CVPI, it was noted that the filler tube had separated from the fuel tank, as the upper end remained engaged to the left quarter panel **(Figure 18)**. As previously noted, the left rear quarter panel and C-pillar of the CVPI were completely separated from the vehicle's body. These components remained attached to the vehicle solely by the engagement of the left rear door latch and

C-pillar mounted striker post. Closer inspection of the downstream end of the filler tube revealed that the filler tube sheared during the impact. The fuel tank end of the filler tube remained in the tank; however, the grommet was completely consumed by the fire.

Figure 18. Separated filler tube and left rear quarter panel at lower left corner of image.

Inspection of the tank end of the filler tube revealed an impact induced dent to the check-valve end of the tube. (The check valve was missing from the filler tube). This dent resulted from the tube engaging against either the forward wall of the tank due to crushing of the tank, or impacting the back wall of the tank due to forward displacement of the upper end of the filler tube, thus rotating the downstream end of the tube rearward. This dent also supported the probability that the check valve was damaged or fractured during this in-tank contact event.

The tube was partially cut 26.7 cm (10.5") upstream of the tank-end of the filler tube. This segment of the filler tube was dented 17.1-22.9 cm (6.75-9.0") above the tank-end, the area that is originally located at the tank grommet and above (external to the tank). Located upstream of this dent, was a crease in the steel tube that extended 19.1-25.4 cm (7.5-10.0") above the tank-end. This crease was located in the area of the tube that was reduced in diameter from 3.5 cm (1.375") to 3.2 cm (1.25"). The upper end of the filler tube had a mating cut/tear that was located 38.1 cm (15.0") downstream of the filler cap location. **Figures 19 and 20** are views of the separated filler tube verses an exemplar filler tube.

Figure 19. The damaged and separated filler tube in relation to an exemplar tube.

Figure 20. Close-up view of the separation location of the filler tube.

Filler Tube Damage – 1999 Lincoln Town Car

The struck Lincoln Town car was built on a similar chassis/platform as the crash involved 2003 CVPI. The fuel system (tank and filler tube) and the configuration of the inner rear fender and trunk were nearly identical to the CVPI. The secondary impact in this crash that involved the frontal area of the CVPI against the rear of the Lincoln Town car resulted in severe damage to the rear of the Lincoln, with the highest concentration of damage occurring to the left rear quarter panel.

During the inspection process of the Lincoln, it was observed that the fuel tank filler tube was contacted and partially crushed by the forward displacement of the vertical seam edge of the inner fender. The aft aspect of the tube was crushed outboard of the positioning bracket. The inner fender edge was deformed in a concave configuration from the engagement against the filler tube. At this point, the crush to the Lincoln ceased as maximum engagement occurred. Slight restitution of the inner fender was noted aft of the filler tube. There was no fuel leakage associated with this engagement. **Figures 21 and 22** are views of the deformation from engagement of the Lincoln's inner fender edge against the filler tube.

Figure 21. Filler tube location on the 1999 Lincoln Town Car.

Figure 22. Deformation of the filler tube and inner fender edge from engagement during crash.

Trunk Contents – 2003 Ford CVPI

The MSHP had a required set of equipment/contents that were stored in the trunk of the CVPI's **(Figure 23)**. This required list was the basic equipment for Troopers assigned to road patrol. Most Troopers transported additional equipment for their personal needs; and in some cases, transported additional job-related gear for the Hazardous-Material, SWAT, and the crash reconstruction team members. The required equipment typically stored in the trunk of the MSHP CVPI's included the following:

Figure 23. Typical trunk contents of the MSHP CVPI's.

- OEM full-size spare tire secured to the top forward aspect of the trunk with jack positioned forward of the tire against the frame-work for the rear seat back.
- The police radio equipment that was mounted on the left side of the trunk.
- 12 road flares
- 1 36x24x6.4 cm (14x9.5x2.5") steel case first aid kit
- 1 30x17x15 cm (12x6.5x6.0") plastic box finger print kit
- 1 91x3 cm (36x1.25") wood baton
- 1 27x19x10 cm (10.5x7.5x3.75") steel ammunition box containing 9mm and shotgun rounds
- 1 dual wheel Roll-a-Tape measuring wheel
- 1 52x51x17 cm (20.5x20x6.75") aluminum case with a tire puncture spike-strip
- 1 "B" type dry chemical fire extinguisher
- 1 plastic bag containing bio-hazard gear (gloves and coveralls)
- 3 48 cm (19") stacked traffic cones
- 1 roll of crime scene tape
- 1 canvas bag of blankets

The contents of the crash involved 2003 Ford CVPI were removed from the vehicle, inventoried, and documented during the vehicle inspection phase of this SCI investigation. It should be noted that the road flares ignited during the fire and burned through the deformed floor of the vehicle's trunk, left of the longitudinal centerline. Sulfur-like deposits were present in the area of the trunk burn through. The contents of the trunk were as follows:

- The OEM spare tire was found in the OEM stowed position; however, the anchor portion of the hold down bracket was deformed as the tire loaded the bracket during the rear-impact crash. The spare tire was consumed by the fire.
- The OEM jack was found in its original position forward of the tire.
- A homemade wooden box (50 percent burned) was located on the right side of the trunk that contained police paper and evidence tags.
- A Type B fire extinguisher was positioned longitudinally on the right side of the trunk with the valve oriented forward.
- A small glass jar was removed from the right side of the trunk, possible finger print kit container.
- The charred fragments of a gasmask were removed from the right side of the trunk.
- A brief case was positioned on the mid floor area of the trunk and contained a cluster of three-ring binders for police manuals. This case was consumed by the fire.
- A second gasmask and blanket were burned and removed for the center area.
- The standard issue ammunition box was found positioned longitudinally in the center area of the trunk. Two rounds pierced the steel box.
- The first aid kit was positioned to the left of the ammunition box and was intact.
- The Roll-a-Tape measuring wheel handle (extended) was lateral to the vehicle nd located in the aft portion of the trunk.

- The orange traffic cones, safety vest, and latex gloves were melted together in the right center aspect of the lower trunk, surrounded by paper towels.
- An aerosol can of marker paint was present in the center area with paint remaining in the can.
- The spike strip box was positioned longitudinally left of the first aid kit. The aluminum box was disintegrated, as was the pliable belt material.
- A small hydraulic floor jack was positioned longitudinally on the left aspect of the trunk floor with the handle positioned under the jack. The forward aspect of the jack penetrated the trunk at the area of the road-flare burn-through. The wheels of the jack contacted and dented (no penetration) the lower rear aspect of the fuel tank.
- The road flares were positioned on the floor of the trunk and were completely consumed.
- The police installed radio cluster on the left side of the trunk was crushed forward into the forward wall of the trunk. The square shape of this deformation was transferred into the left aft aspect of the fuel tank. Again, no penetration resulted from this contact.

None of the trunk contents penetrated the fuel tank or became involved with the fuel system components. There was no fuel leakage associated with the trunk deformation or contents thereof.

The spare tire hold-down bracket appeared to be properly installed at the time of the crash. The crash forces displaced the tire rearward which loaded the tire against the hold-down bracket. The washer of the bracket deformed and pulled through the hub bore in the spare tire. The hook end of the bracket deformed due to the loading and disengaged from the floor mounted anchor bracket.

Occupant Demographics

Driver - 2003 Ford CVPI

Age/Sex:	25-year old male
Height:	168-173 cm (66-68”), estimated by investigating officer
Weight:	75 kg (165 lb), estimated by investigating officer [The autopsy report listed the driver’s height and weight at 160 cm (63”) and 82 kg (180 lb) respectively.]
Seat Track Position:	Appeared to be adjusted to the full rear track position
Manual Restraint Usage:	None, driver was conducting official police business in parked vehicle on roadside
Usage Source:	Police
Type of Medical Treatment:	None, expired in vehicle due to fire

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98	Injury Source
100 percent thermal injury to total body surface with skin splitting of the abdomen. Compound heat fractures of the skull with open defect and exuded brain matter (charring of brain), heat fractures of the right femur and bilateral radius and ulna.	Maximum (992032.6,0)	Impact induced fire
Inhalation injury with soot present in the trachea and bronchi. Carbon monoxide < 10 percent	Moderate (919200.2,0)	Impact induced fire

Source – Medical examiner's autopsy report

Driver Kinematics

The driver of the 2003 Ford CVPI was seated in the front left position of the vehicle while parked on the outboard shoulder of the interstate roadway, attending to official police business. The vehicle was parked with the engine running. The driver was in the process of issuing or explaining a routine traffic citation to a motorist who was seated in the front right position of the CVPI. Due to the nature of the traffic stop, it was doubtful that the police officer or the civilian were restrained by the manual 3-point lap and shoulder belt systems. Both front seat tracks were adjusted to the same longitudinal positions and appeared to be in the full rear track adjusted positions. The officer was wearing his standard police uniform that consisted of a medium blue wool-blend short-sleeved shirt over his safety vest, dark blue pants, his utility belt, socks and shoes, and his hat.

As the CVPI was impacted in the rear by the 2001 Ford F-350, the driver initiated a rearward trajectory in response to the 6 o'clock direction of force. His back loaded the seat back support and his head probably loaded the adjustable head restraint. The adjusted position of the head restraint was not known. The impact rotated the vehicle in a counterclockwise direction as it was displaced forward. It was possible that the driver's head impacted the left B-pillar based on the vehicle dynamics and his kinematic response. This contact scenario was not supported by injury or contact evidence due to the extent of the fire.

The forward displacement of the CVPI resulted in a secondary impact event against the rear of the parked 1999 Lincoln Town Car. The frontal area of the CVPI impacted the rear bumper of the Lincoln and overrode the structure, engaging the sheet metal trunk and left quarter panel of the Town Car. This impact probably deployed the advanced frontal air bag system in the CVPI. The driver would have initiated a forward trajectory in response to the frontal crash force and loaded the deployed front left air bag. Due to the complete burn of the vehicle's interior, occupant contact points could not be determined. The driver's knees probably loaded the knee bolster.

The driver would have rebounded from the secondary impact event into the seat back. The ensuing fire consumed the passenger compartment of the CVPI and as a result, the driver expired due to thermal injury.

Front Right Occupant – CVPI

Age/ Sex:	48-year old male
Height:	185.0 cm (72.8"), hospital records
Weight:	90 kg (198.4 lb), hospital records
Seat Track Position:	Full rear
Manual Restraint Use:	None
Usage Source:	Vehicle inspection/nature of crash
Mode of Transport From Scene:	Transported by helicopter to a regional trauma center
Type of Medical Treatment:	Admitted for 65 days for treatment of burns to 25 percent of total body surface.

Front Right Occupant Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Thermal burns to 25 percent of total body surface. Full thickness burns to left hand and bilateral lower extremities; right leg to level of the mid thigh and left leg to knee level. Partial thickness burns to left face with nasal hair singing and 2nd degree burns of both feet.	Critical (992030.5,0)	Impact induce fire

Source: Medical records – Emergency room, surgical reports, progress reports, and discharge summary

Front Right Occupant Kinematics – 2003 Ford CVPI

The front right occupant of the CVPI was a civilian who was involved in a routine traffic stop by the on-duty police officer/driver of the 2003 CVPI. The civilian was seated in the CVPI as the officer was explaining the procedure for the issuance of a traffic citation. Due to the nature of the traffic stop and the parked status of the CVPI, the front right occupant was not restrained by the manual safety belt system. The front right seat track was adjusted to a full rear position.

In response to the initial impact, the front right occupant would have initiated a rearward trajectory with respect to the CVPI. The fire destroyed the interior of the vehicle; therefore specific interior contact points could not be identified. His back probably loaded the seat back as his head contacted the adjustable head restraint. There were no crash induced injuries (i.e., soft tissue, fractures or internal injury) noted in the medical records for this occupant.

As the CVPI was accelerated forward, the front of the CVPI impacted the rear of the Lincoln Town Car. This impact probably deployed the CVPI's advanced frontal air bag system. The unrestrained front right occupant would have initiated a forward trajectory in response to this impact event. Again, due to the complete interior burn of the CVPI, specific occupant contact points could not be identified. The passenger probably rebounded into the front right seat back where he came to rest.

Passing motorists stopped at the crash site and approached the right side of the CVPI. They allegedly opened the right front door and pulled the front right occupant from the CVPI. Although his clothing was on fire, an attempt to suppress the fire was made by another passing motorist who stopped to render aid to the driver of the F-350. This witness secured the fire extinguisher from the F-350 and used it to extinguish the fire on the front right occupant. This occupant was subsequently transported by an air ambulance (helicopter) to a regional trauma center where he was admitted for 65 days for treatment and recovery of his burns.

Conclusions

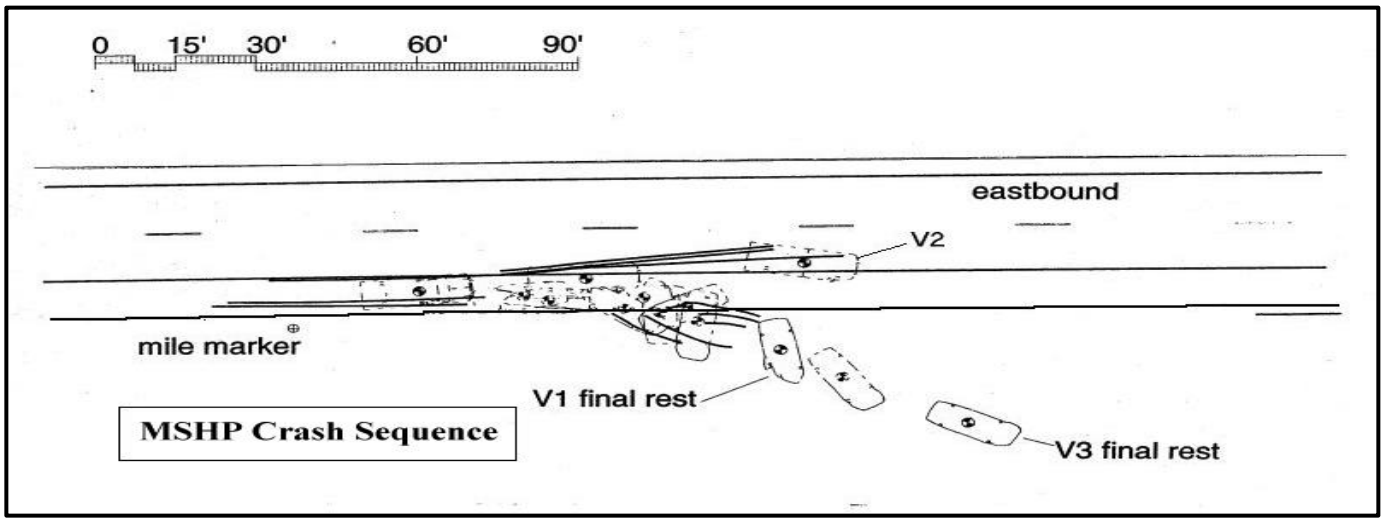
The 2003 Ford CVPI fire resulted from fuel leakage from the filler tube. As the Ford F-350 engaged the left rear quarter panel of the CVPI, the left side mounted filler tube was displaced forward and probably rotated in a counterclockwise direction during the initial impact event. The forward displacement of the upper end of the filler tube would have displaced the downstream (in-tank) end of the tube against the back wall of the fuel tank as the tank was crushed by the forward displacement of the trunk wall. This resulted in filler tube contact against the inside surface of the fuel tank that probably fractured the plastic in-tank check valve from the end of the filler tube.

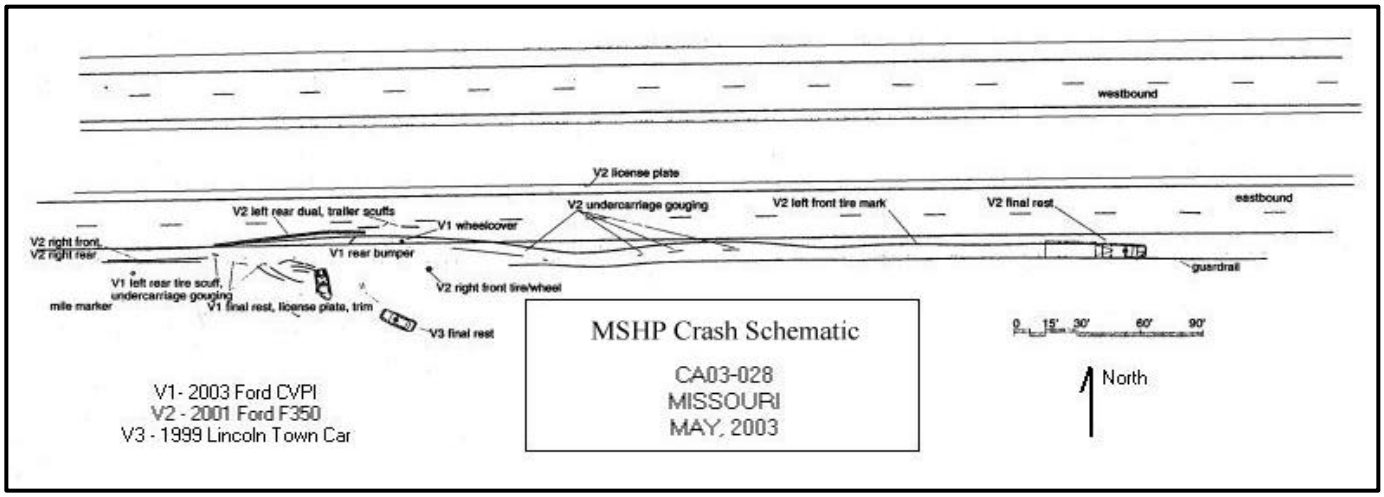
The vertical seam edge of the inner fender was crushed against the rear aspect of the filler tube as the tube was displaced forward, possibly contacting the left rear shock absorber mount. The shock mount could have momentarily arrested the forward displacement of the filler tube as the vertical seam edge engaged and cut the steel filler tube. As the tube was cut by the seam edge, the forward aspect of the filler tube sheared due to the continued engagement of the F-350 against the left side surface of the CVPI. This contact displaced the quarter panel forward and separated the panel from the trunk and side surface. The upper end of the filler tube remained attached to the separated quarter panel.

As the filler tube was cut by the seam edge of the inner fender, the hydraulic pressure of the gasoline within the fuel tank was forced passed the damaged or separated check valve within the tank. The fuel spewed from the tank under hydraulic pressure through the filler tube segment that remained attached to the tank by the grommet and was ignited by an undetermined source.

The impact with the F-350 resulted in significant integrity loss of the left side structure of the CVPI. The left rear quarter panel and full length of the left C-pillar were completely separated from the vehicle. As a result of this separation, the left rear door opened. The floor panel separated from the sill, originating at the left C-pillar and extending forward

to the left A-pillar. This left side integrity loss allowed the ensuing fire to immediately engulf the left passenger compartment of the vehicle. As a result, the driver was immediately involved in the fire to which he succumbed.





Figures 24 and 25. MSHP schematic of the crash sequence.