

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

Calspan Operations
Division of Veridian
Buffalo, New York 14225

**CALSPAN ON-SITE AIR BAG/DRIVER FATALITY INVESTIGATION
CALSPAN CASE NO. CA97-013
VEHICLE: 1994 FORD PROBE
LOCATION: MAINE
CRASH DATE: MARCH, 1997**

Contract No. DTNH22-94-D-07058

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

<p>1. <i>Report No.</i> CA97-013</p>	<p>2. <i>Government Accession No.</i></p>	<p>3. <i>Recipient's Catalog No.</i></p>	
<p>4. <i>Title and Subtitle</i> Calspan On-Site Air Bag/Driver fatality Investigation Vehicle: 1994 Ford Probe Location: Maine</p>		<p>5. <i>Report Date:</i> July, 1998</p>	
		<p>6. <i>Performing Organization Code</i></p>	
<p>7. <i>Author(s)</i> Crash Research Section</p>		<p>8. <i>Performing Organization Report No.</i></p>	
<p>9. <i>Performing Organization Name and Address</i> Transportation Sciences Crash Research Section Calspan Operations P.O. Box 400 Buffalo, New York 14225</p>		<p>10. <i>Work Unit No.</i> 1115 (7320-7329)</p>	
		<p>11. <i>Contract or Grant No.</i> DTNH22-94-D-07058</p>	
<p>12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590</p>		<p>13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: March, 1997</p>	
		<p>14. <i>Sponsoring Agency Code</i></p>	
<p>15. <i>Supplementary Notes</i> On-site investigation of a single vehicle crash that resulted in air bag deployment and the death of the 51 year old male driver.</p>			
<p>16. <i>Abstract</i></p> <p>This on-site investigation focused on the injury mechanisms that resulted in the death of a 51 year old male driver of a 1994 Ford Probe. The Probe was equipped with frontal air bags which deployed during the crash for the driver and right passenger position. The driver lost control of the Probe as he was traveling on a snow-covered state route with a left curve and negative grade during a heavy wet snowfall that resulted in several inches on snow accumulation on the asphalt road surface. The vehicle yawed slightly in a clockwise direction and impacted a W-beam guardrail system that bordered a quadrant of an intersection. The impact involved the front bumper fascia of the Probe which crushed the bumper structure to a residual depth of 1.5 cm (0.6") at the centerline of the vehicle. The Probe underwent a deceleration of 13-16 km/h (8-10 mph) from the 12 o'clock direction of force impact. As a result of the crash, the W-beam guardrail was crushed to a maximum depth of 20 cm (8"). The air bag system deployed late in the crash sequence as a result of the deformation to the guardrail beam.</p> <p>The driver was seated in a mid track position and was not restrained by the manual 3-point lap and shoulder belt system. He was probably leaning in a forward direction pre-crash in an attempt to drive the Probe through the heavy snowfall. At impact, he was displaced in a forward direction against the steering assembly and the driver air bag module. The frontal air bag system subsequently deployed. The driver's forward position impeded the normal deployment of the driver air bag and as a result, the lower half of the bag membrane deployed from the H-configuration cover flaps while the upper half of the membrane deployed through the top of the module cover, separating the cover from the module assembly.</p> <p>The driver sustained multiple soft tissue abrasions and contusions (AIS-1) of the chest and fractures of the right 3rd and 4th ribs (AIS-2) from bag expansion. In addition, he sustained small subarachnoid hemorrhage (AIS-3) from contact with the windshield header. He exited the vehicle and fell onto the snow covered road surface perpendicular to the vehicle. An autopsy identified the cause of death as cardiac arrhythmia which resulted in sudden heart stoppage (commotio cordis). It should be noted that the driver had an enlarged heart which weighed 600 grams, nearly twice the size of a normal adult male heart.</p>			
<p>17. <i>Key Words</i> Air bag deployment, out-of-position driver, impeded deployment path, cardiac arrhythmia</p>		<p>18. <i>Distribution Statement</i> General Public</p>	
<p>19. <i>Security Classif. (of this report)</i> Unclassified</p>	<p>20. <i>Security Classif. (of this page)</i> Unclassified</p>	<p>21. <i>No. of Pages</i> 12</p>	<p>22. <i>Price</i></p>

TABLE OF CONTENTS

	<u>Page No.</u>
Background	1
Crash Scene	2
Summary	2
Vehicle Data	3
Vehicle Damage	3
Manual Restraint Systems	5
Automatic Restraint System	5
Driver History	7
Driver Demographics	7
Driver Injuries	7
Driver Kinematics	9
Autopsy Results	11

CALSPAN ON-SITE AIR BAG/DRIVER FATALITY INVESTIGATION
CALSPAN CASE NO. CA 97-013
LOCATION: MAINE
VEHICLE: 1994 FORD PROBE
DATE OF CRASH: MARCH, 1997

Background

This on-site investigation focused on the mechanism of injury that resulted in the death a 51 year old male driver of a 1994 Ford Probe. The Probe was equipped with frontal driver and passenger side air bags which deployed as a result of a minor frontal impact (**Figure 1**) sequence with a W-beam guardrail system. The driver of the vehicle was not restrained by the manual 3-point lap and shoulder belt system and was out-of-position in a forward direction during the deployment of the supplemental air bag system. His forward position impeded the deployment path of the driver side air bag. The lower half of the bag deployed from the symmetrical module cover flaps while the upper half of the bag deployed through the top of the module/steering wheel spoke cover which separated the cover from the steering assembly (**Figure 2**). The air bag module cover flaps and bag membrane expanded against the driver's chest which resulted in vertically oriented abrasions to the chest (AIS-1), and fractures of right 3rd and 4th ribs (AIS-2). The expanding air bag produced superficial abrasions to the underside of his chin (AIS-1). His head impacted the windshield and windshield header which resulted in small subarachnoid hemorrhage (AIS-3). The medical examiner concluded that the driver sustained blunt force trauma to the chest which resulted in cardiac arrhythmia and stoppage of the heart (commotio cordis) and resulted in death with no underlying injury of the torso, C-spine, or head.



Figure 1. Frontal damage to the 1994 Ford Probe.

The investigating state trooper provided the initial notification of the crash to NHTSA on March 28. He expressed concerns over the driver fatality in the minor severity crash and the possible event of a defective air bag deployment. Mechanical technicians for the state police identified a flaw in the deployment path of the driver side air bag module as noted above. The vehicle had been towed from the scene to the garage at the state police headquarters where it was stored for the SCI inspection. The NHTSA COTR subsequently assigned the crash to the Calspan Special Crash Investigation Team on March 28 and an on-site investigation was conducted on April 9-10.



Figure 2. Altered deployment path of the driver air bag.



Figure 3. Overview of the crash scene.

Crash Scene

The crash occurred during nighttime hours on a rural two-lane state route at the mouth of a 3-leg T intersection with a private road (**Figure 3**). The roadway was snow covered due to a heavy, wet snowfall with temperatures in the 0 degree C (30 degree F) range. Visibility was rated by the investigating officer as poor at the time of the crash. On the approach to the crash scene, the roadway was curved to the left with a negative grade of 5 degrees. Both travel lanes were bordered by wide asphalt shoulders. A W-beam guardrail paralleled both roadways at the northeast quadrant of the intersection which protected traffic from a steep negative embankment. The posted speed limit was 89 km/h (55 mph).

Summary

Pre-Crash

The driver had departed a meeting at a local lodge and was en route to his residence. He was traveling in an easterly direction on the two-lane state route at an unknown, but presumed slow rate of speed due to the extreme weather conditions. On the approach to the crash scene, the driver was negotiating the gradual left curve with a downgrade of 5 percent. The vehicle drifted across the south (right) shoulder and traversed the mouth of the intersection with the private road. The investigating police officer stated that the pre-crash tire tracks on the snow covered road surface indicated that the vehicle broke traction and yawed in a clockwise (CW) direction immediately prior to the guardrail impact. Based on the front bumper fascia contact with the guardrail, the damage to the W-beam, and the minimal deflection of the vehicle, the extent of pre-crash CW yaw was estimated at 10 degrees. The loss of control probably resulted from the poor condition of the front tires on the wet snow that had accumulated on the asphalt road surface.

Crash

The Ford Probe impacted the continuous W-beam guardrail system that bordered the southeast quadrant of the intersection (**Figure 4**). The front bumper fascia of the Probe contacted the W-beam rail between two strong post guardrail posts, crushing the beam to a depth of 21.3 cm (8.0"). The direct contact damage on the fascia began 58.4 cm (23.0") right of center and extended 127.6 cm (50.25") to the left front bumper corner. Residual crush at bumper level was 1.5 cm (0.6") located at the mid point of the fascia. There was crush at the locations of C1-C2 and C5-C6. Vehicle damage was limited to the bumper fascia and the reinforcement bar. The resultant direction of force was within the 12 o'clock sector with an estimated velocity change of 13-16 km/h (8-10 mph). This threshold level impact induced deceleration was sufficient to deploy the Ford Probe's driver and passenger side air bag system. In addition, the guardrail impact involved an elongated time frame (delta T) which resulted in air bag deployment late in the crash sequence.



Figure 4. Struck guardrail.

Post-Crash

The Ford Probe rebounded approximately 0.6 m (2.0') from the struck guardrail and came to rest nearly perpendicular to the W-beam guardrail system. At rest, the vehicle's engine was stalled and the headlamps remained on. The driver apparently opened the driver's side door and exited the vehicle where he collapsed in a face down attitude perpendicular to the vehicle with his feet adjacent to the sill area of the vehicle. A passer-by detected the vehicle near the guardrail and observed the driver lying outside the Probe. Additional motorists stopped at the scene and assisted in providing CPR to the driver. The local fire and rescue squad responded to the call and arrived on-scene. They reported to the investigating police officer that the driver was found in full cardiac arrest with no vital signs. On-scene attempts of resuscitation failed and the driver was pronounced deceased.



Figure 5. Overall view of the Ford Probe.

Vehicle Data

The involved vehicle was a 1994 Ford Probe SE, two-door hatchback (**Figure 5**). The Probe was identified by vehicle identification number (VIN) 1ZVLT20A8R5 (production number deleted) and was manufactured on 2/21/94. The odometer reading at the time of our inspection was 96,280 km (59,827 miles). The vehicle was equipped with P205/55R15 all-season radial tires. The rear tires were recently replaced and had a tread depth of 7.9 mm (10/32"). The front drive tires were in worn condition with a measured depth of 1.6 mm (2/32") for the left front and 2.4 mm (3/32") for the right front. The drive train consisted of a transverse mounted 4-cylinder, 2.0 liter engine and a 4-speed automatic overdrive transmission with a console mounted transmission selector lever. In addition to the frontal air bags for the driver and right passenger positions, the Probe was equipped with front bucket seats with manual adjusters, power windows and door locks, and a tilt steering wheel.

Vehicle Damage

Exterior

The 1994 Ford Probe sustained minor frontal damage as a result of the impact sequence with the struck W-beam guardrail. The direct contact damage consisted of abrasions across the full width of the bumper fascia. The overall length of the contact damage was 127.6 cm (50.25"). Measurement stands were positioned at the corners of the vehicle which reflected the overall length and width of the Ford Probe. A crush profile was subsequently documented for the frontal damage. Based on the placement of the stands, the vehicle sustained a maximum crush depth of 1.5 cm (0.6") that was located 14.0 cm (5.5") right of center. The mid aspect of the compressible bumper fascia sustained minimal residual crush while the outboard aspects of the bumper rebounded to its original length. The residual crush profile was at bumper level as follows: C1 = 0 cm, C2 = 0 cm, C3 = 1.3 cm (0.5"), C4 = 1.5 cm (0.6"), C5 = 0 cm, and C6 = 0 cm. The Collision Deformation Classification (CDC) for this impact event was 12-FDEW-1.



Figure 6. Profile view of the crush profile.

There was no damage to the hood face or headlight assemblies that were in the open and on-position at the time of the crash. The investigating officer noted in his report that the headlights remained on post-crash. The front license plate frame was not cracked, however, the plate was bent forward from probable disengagement from the guardrail. The hood and both doors remained closed during the crash and remained fully operational. There was no displacement of the vehicle's wheelbases.

Interior

The interior of the Ford Probe sustained minor damage that was associated with air bag deployment and driver contact (**Figure 7**). There was no deformation that resulted from the exterior damage or intrusion of the passenger compartment.



Figure 7. Overall view of the deployed frontal air bags and the driver contact points.

The front driver air bag's deployment path was impeded by the forward position of the driver. As a result, the lower half of the air bag membrane deployed from the H-configuration module cover flaps while the upper half of the bag deployed between the module/spoke cover and the steering wheel rim. As a result, the cover separated from the mounting bracket. Fabric transfers from the driver's sport coat were present on the back side of the upper half of the bag. These are further discussed in the *Automatic Restraint System* section of this summary report.

The driver was not restrained by the manual 3-point lap and shoulder belt system. His forward response to the 12 o'clock impact force, in combination with the subsequent expansion of the air bag against the driver's torso, resulted in compression of the energy absorbing steering column. The 4-spoke steering wheel rim was not deformed, however, the shear capsule brackets were displaced 2.5 cm (1.0") forward. Compression of the steering column fractured the plastic lens of the instrument cluster. The driver's right hand probably separated from the steering wheel rim and impacted the stalk that was mounted to the right side of the steering column.

The driver's forehead impacted and fractured the laminated windshield in a star-like pattern 24.1 cm (9.5") left of center and 12.7 cm (5.0") below the windshield header. The superior aspect of his scalp contacted the windshield header directly above the glazing contact point. The police removed hair from this contact point as evidence during their initial investigation. The medical examiner concluded that the hair was consistent with the head hair of the driver.

Previous damage was noted to the lower outboard aspect of the driver's seat back support. The fabric was worn through to the foam padding as a result of driver ingress and egress from the vehicle.

Manual Restraint Systems

The front seat manual belt systems were a continuous loop system with an inertia activated retractor located in the lower B-pillar. A double-fold energy management loop was incorporated into the lap belt webbing of both front belt systems and was located 7.6-12.7 cm (3.0-5.0") above the floor anchorage. The driver side management loop was intact with no separation of the stitching. The D-rings were a fixed configuration to the B-pillars. The latchplate was snug on the belt webbing, however, it did not contain a sliding cinch bar. At the time of our inspection, and confirmed through on-scene police photographs, the latchplate was positioned 55.9 (22.0") above the floor anchorage point. At this position, the belt could not extend around an occupant and buckle into the center mounted buckle assembly. The overall condition of the belt webbing was good with minimal edge wear from previous usage. The tab of the latchplate exhibited minor routine wear marks from infrequent usage. These indicators, in combination with the position of the occupant at deployment, and the lack of bag transfers on the webbing suggest the driver was not belted during this crash.

Automatic Restraint System

The Ford Probe was equipped with a frontal air bag system for the driver and right passenger positions which deployed as a result of the impact sequence with the W-beam guardrail system. The vehicle impacted the barrier in a head-on configuration (12 o'clock impact force). Due to the minor severity impact and the deformation to the guardrail beam, the air bag system deployed late in the crash sequence, following the forward movement of the driver.

The system consisted of front mounted electro-mechanical crash sensors, an interior mounted safeing sensor and control/diagnostic module, a driver air bag module that was mounted in a typical configuration within the steering wheel rim, and a front passenger air bag module that was mounted in the upper mid aspect of the right instrument panel.

The front driver air bag was concealed within a module cover that consisted of symmetrical cover flaps in terms over overall height and width. The vertically oriented hinge points of the flaps varied in width due to the taper of the flaps. As a result of the forward positioned driver at deployment, the normal deployment path of the cover flaps and air bag membrane was impeded. Although the cover flaps opened at the designated tear points, the expansion of the bag was restricted by the position of the driver. Therefore, the lower half of the air bag membrane deployed through the module cover flaps and the upper half expanded between the module cover assembly, separating the cover from the steering wheel mount (**Figure 8 and 9**).



Figure 8. View of the deployed driver air bag through the top of the separated module cover.



Figure 9. Additional view of the upper air bag membrane and red fabric transfer.

The horizontal tear seam of the cover flaps was 17.1 cm (6.75") in width. The vertical height of the upper flap was 7.9 cm (3.125") while the lower flap was 7.0 cm (2.75"). The width at the top hinge of the upper flap was 12.7 cm (5.0") and the same dimension of the lower flap hinge point was 8.3 cm (3.25"). The word PROBE was molded into the upper flap and SRS was molded into the lower cover flap. There was no occupant contact evidence or damage observed to the flaps.

The vinyl module cover was totally disengaged from the retainer lip on the module assembly mounting bracket. Exhaust gas residue from the air bag spewed onto the left side of the module/steering wheel spoke cover.

The driver air bag was tethered by internal straps which restricted the rearward excursion of the bag. The straps were sewn to the face of the bag in the form of a circular reinforcement at the center area of the bag. The center point of this tether reinforcement was captured between the tear seam of the upper and lower flaps. The lower half of the bag membrane had deployed from the cover flaps while the upper half extended from the top of the displaced module cover. Expansion of the bag displaced the module cover into the chest of the driver. The bag was vented by two 3.2 cm (1.25") diameter ports that were located at the 10 and 2 o'clock sector of the bag. An identification label was attached to the top of the bag at the 12 o'clock sector. The printing on the bar coded label was smudged as a result of bag expansion through the top of the cover assembly. This label identified the bag as follows:

P11 4074-01C
TAC719H10078

The back panel of the driver air bag (panel exposed toward front of vehicle opposite of driver) contained a blue/gray fabric transfer that extended from the inflator area of the bag toward the peripheral seam (**Figure 10**). The transfer originated near the above mentioned label with a width of 5.1 cm (2.0") and extended 16.5 cm (6.5") in length toward the seam. The transfer flared to a maximum depth of 19.7 cm (7.75"). This transfer resulted from bag membrane expansion against the lining of the driver's red sport coat.

A second fabric transfer was located on the bag in the vicinity of the left vent port. This transfer extended 8.3 cm (3.25") on the back of the bag and wrapped 7.6 cm (3.0") onto the face of the bag, originating at the 11 o'clock sector (**Figure 9**). This transfer resulted from expansion against the red sport coat that was visible in the autopsy photographs of the driver's body. The driver bag was not damaged as a result of the impeded deployment path of the bag.



The front right passenger air bag deployed from a mid mount module assembly in the right instrument panel. The single cover flap opened at the lower and side aspects of the flap and was hinged at the top surface to the upper instrument panel. The overall dimensions of the flap were **Figure 10. Blue/gray fabric transfer to driver air bag.**

77.2 cm (12.0") in width and 14.0 cm (5.5") in height. The hinge length of the flap was 39.1 cm (15.4"). The front right passenger flap rotated upward and contacted and fractured the laminate windshield. The passenger air bag was not tethered. The bag was vented by two 6.4 cm (2.5") diameter ports located on the side panels of the bag at the 3 and 9 o'clock sectors. The ports were centered 8.9 cm (3.5") rearward of the mid instrument panel. There was no driver contact to the passenger air bag, or damage resulting from the deployment sequence.

Driver History

The driver of the Ford Probe was a 51 year old male with a height of 171.5 cm (67.5") and weight of 90.7 kg (200.0 lbs.). He had cardiac history that included a diagnosis of supraventricular tachycardiac (rapid ventricular rhythm) in 1991 and 9/28/96. The medical examiner noted that the body contained a thick layer of subcutaneous tissue and that it lacked muscle tone. At autopsy, the driver's heart was noted to be enlarged to a weight of 600 grams.

Driver Demographics

Age/Sex:	51 year old male
Height:	171.5 cm (67.5")
Weight:	90.7 kg (200.0 lb)
Manual Restraint Usage:	None, 3-point lap and shoulder belt was available
Usage Source:	Vehicle inspection
Eyewear:	None reported
Vehicle Familiarity:	Unknown
Route Familiarity:	Frequent travel
Trip Plan:	Returning to residence
Medical History:	Previous heart attack two years prior to crash
Type of Medical Treatment:	CPR by passing motorists and resuscitation attempts by the local rescue squad, deceased at scene

Driver Injuries

Injury	Injury Severity (AIS 90)	Injury Source
<u>Cause of Death</u> Cardiac arrhythmia with heart stoppage (commotio cordis)	N/A, not codeable under AIS 90 rules	Deployment of the front driver air bag/separation of module cover
Small subarachnoid hemorrhage patches of the right posterior parietal region	Serious (140684.3,1)	Probable rebound contact into the left integral head restraint

Injury	Injury Severity (AIS 90)	Injury Source
Small subarachnoid hemorrhage patches of the left inferior frontal region	Serious (140684.3,2)	Windshield header
Right 3 rd and 4 th anterolateral rib fractures with intercostal hemorrhage	Moderate (450220.2,1)	Deployment of the front driver air bag/separation of module cover
Left chest contusion which extended from the shoulder to the nipple	Minor (490402.1,2)	Deployment of the front driver air bag/separation of module cover
Right chest contusion at the attachment of the arm	Minor (490402.1,1)	Deployment of the front driver air bag/separation of the module cover
Small abrasions of the left lateral chest at the nipple	Minor (490402.1,2)	Deployment of the front driver air bag/separation of the module cover
Vertical linear superficial abrasions over the sternum	Minor (490202.1,4)	Deployment of the front driver air bag/separation of the module cover
Oblique abrasions of chest, right of sternum	Minor (490202.1,1)	Deployment of the front driver air bag/separation of the module cover
2.5 cm oval contusion of right chest	Minor (490402.1,1)	Deployment of the front driver air bag/separation of the module cover/separation of the module cover
3.5 cm transverse abrasion (scratch) mid-clavicular line below the left rib margin	Minor (490602.1,2)	Deployment of the front driver air bag/separation of the module cover against object in chest pocket (probable)
Faint blue contusion of the left upper quadrant of the abdomen	Minor (590402.1,2)	Deployment of the front driver air bag/separation of the module cover
Two small abrasions of the left inferior mid forehead	Minor (290202.1,7)	Windshield
Right lower eyelid contusion	Minor (297402.1,1)	Ground

Injury	Injury Severity (AIS 90)	Injury Source
Fine linear abrasions below left chin on left below beard	Minor (390602.1,5)	Expansion of the front driver air bag
8 mm abrasion right 1 st intraphalangeal knuckle	Minor (790202.1,1)	Ground
<i>Supplemental Notes</i> Trachea is distorted (membrane portion almost non-existent)	N/A, not codeable under AIS 90 rules	Expansion of the front driver air bag
Small focal hemorrhage on the left side of the hyoid bone and posterior laryngeal area	N/A, not codeable under AIS 90 rules	Expansion of the front driver air bag
Acute thyroid gland hemorrhage	N/A, not codeable under AIS 90 rules	Expansion of the front driver air bag
Hemorrhage over the left clavicle and sternum with hemorrhage noted in posterolateral right lower chest wall	N/A, not codeable under AIS 90 rules	Deployment of the front driver air bag/separation of the module cover
Considerable dissecting hemorrhage in the left pectoralis muscle	N/A, not codeable under AIS 90 rules	Deployment of the front driver air bag/separation of the module cover
Marked distention of stomach and small intestine with gas extending to colon	N/A, not codeable under AIS 90 rules	N/A, pre-existing
Acute pulmonary congestion	N/A, not codeable under AIS 90 rules	N/A, pre-existing
Striking vascular congestion of neck vessels and superior vena cava with liquid blood	N/A, not codeable under AIS 90 rules	N/A, pre-existing
Fractures of cartilages in the right lower chest at sternal attachments with some hemorrhage	N/A, not codeable under AIS 90 rules	N/A, probably resuscitative per medical examiner

Driver Kinematics

The interior of the vehicle provided detailed evidenced which established the position of the driver at deployment of the frontal air bag system. Immediately prior to the crash, the driver was seated in an upright driving posture with the left front seat track adjusted to a mid track position. At the time of SCI vehicle

inspection, the seat track was positioned 13.7 cm (5.4") rearward of the full forward position and 8.6 cm (3.4") forward of the full rear position (**Figure 11**). The seat back with the integral head restraint was reclined several positions rearward of the vertical. The driver was wearing gray slacks, a white long sleeve shirt with a black tie, and a red sport coat with a bluish/gray synthetic lining.



Figure 11. Overall view of the driver's seated position.

The driver's family stated to the investigating officer that he was a dedicated belt user. The belt system, however, did not yield evidence of frequent usage for the recorded mileage on the vehicle's odometer. The latchplate had minimal wear marks and the webbing was in good condition with the latchplate positioned low on the webbing. In addition, there were no transfers from the deploying driver's side air bag on the webbing, therefore it was concluded that the driver was not restrained at the time of the crash.

On his approach to the crash site, it was presumed that the driver was leaning forward in an attempt to provide himself with an improved line of sight through the windshield while traveling through the heavy snow conditions. As the vehicle drifted to the right and impacted the W-beam guardrail in a head-on configuration, the driver responded to the 12 o'clock impact force and moved in a forward direction against the steering wheel rim and front driver air bag module. The air bag system subsequently deployed late in the crash sequence as the driver was positioned against the air bag module cover.

The deployment of the driver's side air bag was impeded by the forward position of the driver. Initially, the H-configuration module cover flaps opened against his chest, however, there was no distinct injury pattern from the cover flap contact. The driver's forward position restricted the subsequent expansion of the air bag membrane as the lower quadrant of the bag deployed through the cover flaps. The upper quadrant of the tethered air bag expanded within the module cover and displaced the complete module/steering wheel spoke cover from its mounting with the inflator bracket. Clothing fabric transfers were noted to the back side of the driver's air bag at the 12 o'clock sector between the inflator and the peripheral seam. A narrow band red transfer resulted from the exterior surface of the driver's sport coat while a wide band of a blue/gray transfer resulted from bag expansion against the lining of the jacket. As a result of the bag expansion, the bag membrane and module cover impacted the chest of the driver. He sustained multiple contusions and abrasions of the chest and fractures of the right 3rd and 4th anterolateral ribs.

The driver's loading force against the steering assembly and the subsequent expansion of the air bag resulted in 2.5 cm (1.0") of steering column compression. This was confirmed by 2.5 cm of forward displacement of the shear capsule brackets. There was no deformation of the four-spoke steering wheel rim or spokes. The driver's right hand probably separated from the steering wheel rim and impacted the stalk that was mounted to the right side of the steering column. The contact resulted in an 8 mm scratch

laceration of the right 1st intraphalangeal knuckle.

The underside of the driver's chin was contacted by the continued expansion of the air bag. The bag contact produced linear abrasions below the driver's chin and probably rotated the head in a rearward direction. The driver's forehead subsequently impacted the windshield directly forward of the steering column and 12.7 cm (5.0") below the windshield header. There was a faint tissue transfer located directly below the star-like crack. The police recovered hair from the headliner fabric at the header area which probably resulted from a head contact by the driver following the chin contact sequence. There was no damage to the header area, however, the driver sustained a small subarachnoid hemorrhage over the left inferior frontal region.

The expansion of the driver air bag against the chest and chin of the driver probably accelerated his body in a rearward direction. Although not supported by contact evidence, the driver's rebound trajectory resulted in a small subarachnoid hemorrhage of the right posterior-parietal region of the scalp from probable contact against the integral head restraint.

Immediately following the crash, as the vehicle came to rest, the driver opened the left front door and exited the vehicle. He subsequently collapsed onto the snow covered road surface and expired in a face-down attitude perpendicular to the vehicle. His contact with the road surface resulted in fine gravel about the face and a contusion of the right lower eyelid.

Autopsy Results

The medical examiner performed a complete autopsy on the body. He noted that there was no evidence of internal injury to the head, neck, torso, or abdominal areas to support death of the driver. He concluded that the death was attributed to blunt force trauma to the chest which resulted in cardiac arrhythmia and stoppage of the heart (commotio cordis). This investigator concluded that the blunt force chest trauma was attributed to the deployment of the driver's side air bag system. The front driver air bag deployed between the module/spoke cover and the steering wheel which separated the cover from the mounting bracket. Bag expansion displaced the cover into the chest of the driver resulting in the death.