

**TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER**

**Veridian Engineering
Buffalo, New York 14225**

ON-SITE DRIVER AIR BAG RELATED SEVERE INJURY CRASH INVESTIGATION

VEHICLE: 1991 FORD TAURUS

VERIDIAN CASE NO. CA97-029

LOCATION: NORTH CAROLINA

CRASH DATE: MAY, 1997

Contract No. DTNH22-94-07058

Prepared for:

**U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, DC 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 be 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 of the involved vehicle(s) or their safety systems.

TECHNICAL REPORT STANDARD TITLE PAGE

| | | | |
|--|---|---|-------------------------|
| <p>1. <i>Report No.</i> CA97-029</p> | <p>2. <i>Government Accession No.</i></p> | <p>3. <i>Recipient's Catalog No.</i></p> | |
| <p>5. <i>Title and Subtitle</i> On-site Driver Air Bag Related Severe Injury Investigation Vehicle: 1991 Ford Taurus Location: North Carolina</p> | | <p>4. <i>Weights</i></p> | |
| | | <p>6. <i>Report Date:</i> July 2001</p> | |
| <p>8. <i>Author(s)</i> Crash Data Research Center</p> | | <p>7. <i>Performing Organization Code</i></p> | |
| <p>10. <i>Performing Organization Name and Address</i> Transportation Sciences Crash Data Research Center Veridian Engineering P.O. Box 400 Buffalo, New York 14225</p> | | <p>9. <i>Performing Organization Report No.</i></p> | |
| | | <p>11. <i>Work Unit No.</i> CO1115.752.(0000-9999)</p> | |
| | | <p>12. <i>Contract or Grant No.</i> DTNH22-94-D-07058</p> | |
| <p>13. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, DC 20590</p> | | <p>14. <i>Type of Report and Period Covered</i> Technical Report Crash Date: May 1997</p> | |
| | | <p>15. <i>Sponsoring Agency Code</i></p> | |
| <p>16. <i>Supplementary Notes:</i> On-site investigation of the injury mechanisms of an 80 year old male driver of a 1991 Ford Taurus.</p> | | | |
| <p>17. <i>Abstract</i></p> <p>An on-site investigation was conducted into a three vehicle, front-to-rear type crash involving an air bag equipped 1991 Ford Taurus L, 4-door sedan, a 1996 Ford Explorer, sport utility vehicle, and an unknown third vehicle which was not reported on the Police Accident Report (PAR). The driver of the Ford Taurus was an unrestrained 80 year old male with a reported height of 184 cm (73 in) and weight of 84 kg (185 lbs). He sustained a fracture/dislocation of C4 and C5 with resulting quadriplegia (AIS-4) induced by an unspecified cervical cord injury. He expired six weeks post-crash due to complication of pneumonia. The right front passenger of the Taurus was an unrestrained 82 year old female with a reported height of 152.4 cm (60.0 in) and weight of 59 kg (130 lbs). She sustained minor injuries (AIS-1) as a result of the crash and was subsequently transported to a medical facility for treatment.</p> <p>The crash occurred during the month of May, 1997, and was reported to the National Highway Traffic Safety Administration (NHTSA) by the son of the deceased driver on September 15, 1997. The case was subsequently assigned to Calspan's Special Crash Investigation Team on September 15, 1997. The Ford Taurus was located at a salvage yard and was available for an on-site inspection which was initiated on September 17, 1997. The Ford Explorer was not available for inspection during this on-site investigation.</p> | | | |
| <p>18. <i>Key Words</i> Supplemental Restraint System Driver air bag deployment Fracture dislocation Quadriplegia</p> | | <p>19. <i>Distribution Statement</i> General Public</p> | |
| <p>20. <i>Security Classif. (of this report)</i> Unclassified</p> | <p>21. <i>Security Classif. (of this page)</i> Unclassified</p> | <p>22. <i>No. of Pages</i> 19</p> | <p>23. <i>Price</i></p> |

TABLE OF CONTENTS

BACKGROUND 1

SUMMARY 1

CRASH DATA 7

VEHICLE DAMAGE 10

AUTOMATIC RESTRAINT SYSTEM 12

VEHICLE VELOCITY ESTIMATES 13

CRASH SEQUENCE 13

DEMOGRAPHIC DATA 15

DRIVER INJURY 16

DRIVER KINEMATICS 16

RIGHT FRONT PASSENGER INJURY 17

RIGHT FRONT PASSENGER KINEMATICS 17

ON-SITE DRIVER AIR BAG DEPLOYMENT/ SEVERE INJURY INVESTIGATION

CALSPAN CASE NO. CA 97-029

LOCATION: STATE OF NORTH CAROLINA

DATE OF CRASH: MAY, 1997

BACKGROUND

An on-site investigation was conducted into a three vehicle, front-to-rear type crash involving an air bag equipped 1991 Ford Taurus L, 4-door sedan, a 1996 Ford Explorer, sport utility vehicle, and an unknown third vehicle which was not reported on the Police Accident Report (PAR). The driver of the Ford Taurus was an unrestrained 80 year old male with a reported height of 184 cm (73 in) and weight of 84 kg (185 lbs). He sustained a fracture/dislocation of C4 and C5 with resulting quadriplegia (AIS-4) induced by an unspecified cervical cord injury. He expired six weeks post-crash due to complication of pneumonia. The right front passenger of the Taurus was an unrestrained 82 year old female with a reported height of 152.4 cm (60.0 in) and weight of 59 kg (130 lbs). She sustained minor injuries (AIS-1) as a result of the crash and was subsequently transported to a medical facility for treatment.

The crash occurred during the month of May, 1997, and was reported to the National Highway Traffic Safety Administration (NHTSA) by the son of the deceased driver on September 15, 1997. The case was subsequently assigned to Calspan's Special Crash Investigation Team on September 15, 1997. The Ford Taurus was located at a salvage yard and was available for an on-site inspection which was initiated on September 17, 1997. The Ford Explorer was not available for inspection during this on-site investigation.

SUMMARY

The crash site consisted of a four lane undivided bituminous roadway in an active construction zone with two available lanes for both north and southbound travel. Two additional curbside southbound lanes were under construction at the time of the crash. The crash occurred during daylight hours. Weather conditions were police reported as clear and dry. The posted speed limit was 56 km/h (35 mph). The driver of the Taurus was familiar with the area and traveled it on a daily basis.



Figure 1. Overview of the Taurus' path of travel.

The Ford Taurus L, 4-door sedan (3.0L, V-6), was manufactured in April, 1991, and was identified by vehicle identification number (V.I.N.) 1FACP50U6MA (production numbers omitted). The odometer read 38,530 kilometers (23,942 miles) at the time of inspection. This vehicle was equipped with manual lap and shoulder belts in the four outboard seated positions. A lap belt was available for the front and rear center seated positions. The Taurus was also equipped with a Supplemental Restraint System (SRS) that consisted of a driver's side air bag. This vehicle was not equipped with an Anti-lock Braking System (ABS).

The Ford Explorer 4x4, 4-door sport utility vehicle (4.0L, V-6), was identified by V.I.N. 1FMDU34X8TU (production number omitted). The vehicle was manufactured with standard equipment that included a SRS which consisted of driver and passenger side air bags, 4-wheel anti-lock brakes (ABS), manual lap and shoulder belts for the four outboard seated positions, and a lap belt for the center rear seated position.

The Taurus was traveling southbound in the outboard lane, nearest to an active construction zone, at a police reported speed of 56 km/h (35 mph). The driver was approaching a 4-leg intersection that was controlled by an overhead traffic signal system. On the driver's approach to the intersection, the overhead signal system was in a red phase for north/southbound traffic flow. The 1996 Ford Explorer was stopped in the outboard travel lane for the red signal phase ahead of the Ford Taurus. A third, unknown vehicle, was stopped in front of the Explorer for the red signal phase. The driver of the Taurus failed to detect the stopped vehicles in sufficient time and consequently impacted the full frontal area of the Taurus with the rear of the stopped Ford Explorer. The Taurus' front bumper fascia contacted and underrode the rear bumper of the Explorer.

Police at the scene of the crash reported that there were no visible tire impressions left by any of the involved vehicles. The scene inspection, which was conducted several months post-crash, did not yield evidence of braking actions on behalf of the Taurus' driver. However, measured bumper heights of exemplar vehicles indicated that compression of the Taurus' front suspension, resulting from braking actions, was necessary in order for the front bumper fascia of the Taurus to underride the rear bumper of the Explorer. The top of an exemplar Taurus' bumper measured 52.0 cm (20.5 in). The bottom of an exemplar Explorer's bumper yielded a height of 44.5 cm (17.5 in).

The impact resulted in a 12 o'clock/6 o'clock impact configuration to the Taurus and Explorer respectively and initiated the deployment sequence of the Taurus' driver side air bag system. The impact to the Ford Taurus compressed the front bumper Energy Absorption Devices (EAD), resulting in longitudinal striations to the male end component. Direct contact damage produced longitudinal abrasions to the top surface of the bumper fascia which extended rearward into the header panel with subsequent deformation of the upper radiator support panel. There was no residual crush at the bumper level. Crush measurements at the radiator support yielded a maximum crush value of 17.2 cm (6.75 in)

at C4 which was located 60 cm (24 in) left of the right front bumper corner. Crush values are reported in Table 1. The damage resulted in a 12 o'clock direction of force with a Collision Deformation Classification (CDC) of 12-FDEW-1. The Taurus sustained a ROLDMISS calculated total delta V of 18.4 km/h (11.4 mph).

Table 1. 1991 Ford Taurus' Crush Measurements

| Crush Measurement | C1 | C2 | C3 | C4 | C5 | C6 |
|--------------------------------|--------------------|--------------------|---------------------|-----------------------|--------------------|----------------------|
| Front bumper | NO RESIDUAL CRUSH | | | | | |
| Front radiator support | 2.0 cm (0.8 in) | 15 cm (6 in) | 16.5 cm (6.5 in) | 17.20 cm (6.75 in) | 15 cm (6 in) | 3.8 cm (1.5 in) |
| Resulting average crush | 1.0 (0.4 in) | 7.6 cm (3.0 in) | 8.3 cm (3.3 in) | 8.6 cm (3.4 in) | 7.6 cm (3.0 in) | 1.90 cm (0.75 in) |



Figure 2. Right lateral view of the crush damage to the upper radiator support of the Ford Taurus.

The Explorer was displaced forward by the impact force and impacted its front plane with the rear of the unknown lead vehicle. The PAR reported that the driver and the passenger side air bags of the Explorer did not deploy as a result of this impact. The Taurus was towed from the scene of the crash.

The 1996 Ford Explorer was not inspected during the on-site investigation and photographs or other vehicle documentation did not exist from the insurance company or other sources. The PAR identified the damage to the Explorer as BD-2 on the North Carolina Total Accident Damage (TAD) scale. This indicated that the damage was to the rear plane of the Explorer and was distributed across the full width of the vehicle. The translated CDC was approximately 06-BDLW-1. Roldmiss calculated the total delta

V at 13.8 km/h (8.6 mph). Damage to the front of the Explorer which resulted from its secondary impact with the third unknown vehicle was not reported on the PAR. The Explorer and the unknown third vehicle were driven from the scene.

The SRS of the Taurus consisted of a driver side air bag system that deployed as a result of the impact with the Explorer. The air bag system consisted of two crash sensors which were located on the outboard aspects of the frame rail and one safing sensor housed in the diagnostic module located in the center instrument panel area. The air bag module was concealed in the hub of the four spoke steering wheel rim and deployed from asymmetrical H-configuration module cover flaps. The upper flap measured 20.5 cm (8.1 in) in width and 13.4 cm (5.3 in) in height and displayed the word "FORD" in the lower right corner and the acronym "SRS" in the lower left corner. The inside of the upper flap displayed the identification:

T.A.P. 200088

CAV 4

The lower flap measured 20.5 cm (8.1 in) in width and 4.5 cm (1.8 in) in height. There was no damage present to the air bag module cover flaps. The deployed driver side air bag was 69 cm (27 in) in diameter in its deflated state. The bag was tethered by four straps which were located at the 3, 6, 9, and 12 o'clock positions. Two vent ports measuring 2.0 cm (0.8 in) in diameter were located at the 1 and 11 o'clock positions. A warning label on the underside of the driver's sun visor read:

This vehicle has a DRIVER AIR BAG. All occupants, including the driver, should still use seat belts for effective protection.

Air bag contact evidence consisted of a vertical grey vinyl transfer and was present at the top underside aspect of the air bag, located between the 11 and 12 o'clock positions. The vinyl transfer was adjacent to the 11 o'clock positioned vent port and measured 11.0 cm (4.3 in) in length and 3.0 cm (1.2 in) in width. The air bag also sustained weather damage from four months of durated exposure to outside elements. Driver contact evidence was not present to the face or inside of the module cover flap. The steering column's shear capsules did not show evidence of compression.

The driver of the Ford Taurus L was an 80 year old male. His height was reported (by a relative) at 184 cm (73 in) and weight at 84 kg (185 lbs). The position of the seat track and adjustment of the seat back are unknown due to the delayed notification date and acknowledgment from tow yard personnel and police that the seat had been moved. However, the driver, who had a height of 184 cm (73 in), probably placed the left front seat track in a mid-to-full back position. The left front head restraint was placed at the full down position. There was no evidence within the vehicle to support belt usage. There were no signs of belt loading and the latch plate and fixed D-ring did not show abrasions typical of routine usage.

Therefore, it was concluded that the driver was not restrained by the 3-point manual belt system at the time of the crash and was not a frequent belt user.

Prior to impact, the driver of the Taurus was displaced forward due to braking actions. It was probable that the air bag may have deployed late in the crash sequence due to the underriding damage pattern and the relatively low delta V [calculated at 18.4 km/h (11.4 mph)] which would have displaced the driver further forward. The combination of these events positioned the driver at the outer limit, but still within range, of the deploying air bag. He subsequently loaded the air bag as it expanded between his upper torso and face, and the steering wheel rim. This resulted in 2.5 cm (1.0 in) of deformation to the upper steering wheel rim and a grey vinyl transfer to the top underside of the air bag from expansion against the inside of the upper module cover flap. The vinyl transfer was adjacent to the 11 o'clock positioned vent port and measured 11.0 cm (4.3 in) in length and 3.0 cm (1.2 in) in width. Steering column compression was not evident. Air bag expansion against the driver resulted in a fracture dislocation of C4 and C5 with resulting quadriplegia (AIS-4) induced by an unspecified cervical cord injury, right temporal hemorrhage (AIS-4), superior forehead ecchymosis (AIS-1), superior forehead abrasions (AIS-1), and nose abrasions (AIS-1). Evidence of an extension injury was suspected, but not reported by medical records. The cervical cord injury sustained by the driver could have been compounded as he was displaced rearward from the expansion of the deployed air bag which allowed for the probable rotation of his head over the left front head restraint. The restraint was in the full down position at the time of inspection.

The driver of the Taurus was transported from the scene of the crash via ambulance to a local trauma center. He was reported to have been coherent during transport. Injury information obtained from the neurological facility whose physician initially examined the driver revealed a fracture through the osteophyte (abnormal bony outgrowth) at C4-C5, anteriorly, through the disc space with posterior dislocation, C4 on C5. The driver had Forestier's disease, a widely distributed overgrowth of bone on the spinal column. This was noted on the radiology report that indicated anterior osteophytes extending from C3 through C6. It was also noted that the driver's spinal canal was slightly narrow between C4 and C6 due to this condition. Risk of spinal cord injury with damage to the cervical vertebrae is greater in individuals who have narrow spinal canal diameters (*Wheless' Textbook of Orthopedics*).

While in the emergency room, and during his first week of hospitalization, the driver remained coherent. Approximately one week following the crash, the male driver developed pneumonia. He recovered from the pneumonia and approximately 10 days later, his treating physicians made the decision to transfer him to a rehabilitation facility for treatment after an initial hospitalization stay of 24 days. He remained at the rehabilitation facility for approximately a day and a half before he began experiencing respiratory difficulties. He was transferred to a nearby hospital where he was again diagnosed with pneumonia. He survived an additional 24 days in a semiconscious state. The death certificate listed immediate cause of death as respiratory failure. Medical bills totaled \$104,348.05 for treatment in all three medical facilities.

The 82 year old female passenger who was seated in the right front position was not restrained by the manual lap and shoulder belt. There were no signs of belt loading, the latch plate and fixed D-ring did not show abrasions typical of routine usage, and contact points were not consistent with a restrained occupant. A relative reported her height at 152.4 cm (60.0 in) and weight at 59 kg (130 lbs). The position of the seat track and adjustment of the seat back were unknown due to the delayed notification date and acknowledgment from tow yard personnel and police that the seat had been moved. The passenger was found on the right front floor area of the vehicle at the crash scene and sustained injuries that were consistent with occupant contact found in the vehicle. This unrestrained female passenger responded to pre-impact braking actions and the 12 o'clock direction of force impact. She extended her right hand in front of her in an attempt to brace against the windshield. Contact evidence indicated that her right dorsal hand and head contacted the windshield. A small spiderweb-type crack was located 28 cm (11 in) left of the right A-pillar and 40.6 cm (16.0 in) forward (with respect to the vehicle) of the leading edge of the right side instrument panel which resulted from contact with the passenger's head. Another small spiderweb-type crack was located approximately 12.0 cm (4.7 in) inferior to the first, along the surface of the windshield, which resulted from contact with the passenger's right hand. In addition, there was a large vertical skin oil transfer to the windshield that measured 18 cm (7 in) in height and 3.8 cm (1.5 in) in width at the area of the spiderweb-type cracks. The passenger sustained a right thumb contusion (AIS-1) and laceration (AIS-1), and a contused forehead (AIS-1) from contact to the windshield. The passenger also sustained an ankle contusion (AIS-1), not further specified, which resulted from contact to either the right toe pan, kick panel, or floor which resulted from this occupant's response to the 12 o'clock direction of force impact. She was transported to local hospital for treatment and subsequently released.

The driver of the Ford Explorer was a 45 year old female who was reported (PAR) to have sustained possible injuries as a result of the crash. She was not transported to a medical facility for treatment.



Figure 3. Overall view of the Ford Taurus' passenger compartment

ON-SITE DRIVER AIR BAG DEPLOYMENT/ SEVERE INJURY INVESTIGATION

CALSPAN CASE NO. CA 97-029

LOCATION: STATE OF NORTH CAROLINA

DATE OF CRASH: MAY, 1997

CRASH DATA

Location: U.S. Route on an approach to an intersection

State: North Carolina

Area/Type: Urban/ Commercial

Crash Date/ Time: May, 1997, Daytime hours

Investigating Police
Agency: Local Police Department

Crash Type: Car/ Sport Utility Vehicle - Front-to-rear type impact configuration

Air Bag Vehicle

Occupant Injury
Severity: Driver: Severe (AIS-4)

Right Front
Passenger: Minor (AIS-1)

Ambience

Viewing Conditions: Daylight

Weather: Clear

Precipitation: None

Road Surface: Dry

Highway

Type: Major arterial

Number of Lanes: Four, undivided (in an active construction zone)

Surface: Asphalt

Edge: Curbed

Vertical Alignment: -1 percent grade in a southbound travel direction

Horizontal Alignment: Straight

Estimated Coefficient of Friction: .75

Traffic Density: Moderate to heavy

Vehicles

| | <u>Air Bag Vehicle</u> | <u>Vehicle #2</u> |
|--------------|-------------------------------------|---|
| Description: | 1991 Ford Taurus L, 4-door sedan | 1996 Ford Explorer, 4-door Sport utility vehicle |
| V.I.N.: | 1FACP50U6MA | 1FMDU34X8TU |
| Color: | White | Unknown (not inspected) |
| Odometer: | 38,530 km (23,942 miles) | Unknown (not inspected) |
| Engine: | 3.0 liter/ V-6 | 4.0 liter/V-6 |

Vehicles (Cont'd.)

| | <u>Air Bag Vehicle</u> | <u>Vehicle #2</u> |
|--------------------------|---|--|
| Transmission: | Column mounted transmission selector level | Unknown (not inspected) |
| Steering: | Power-assisted with tilt wheel | Power-assisted rack-and-pinion |
| Brakes: | Front disc and rear drum | 4-wheel anti-lock brakes |
| Manual Restraints: | 3-point lap and shoulder belts in the four outboard seated positions, lap belts for the front and rear center seated positions. | 3-point lap and shoulder belts in the four outboard seated positions, lap belt for the rear center seated position. |
| Automatic Restraints: | Supplemental Restraint System (SRS) that consisted of a driver's side air bag system which deployed as a result of the vehicle's impact with the rear of vehicle #2. | Supplemental Restraint System (SRS) that consisted of a driver and passenger side air bag. Air bags did not deploy as a result of the crash. |
| Tow Status: | Towed due to vehicle damage | Not towed, driven from the crash scene |

Vehicle #3

Vehicle #3 was not reported on the police accident report, but was indicated to have been struck by vehicle #2 and sustained minor damage. Vehicle #3 was reportedly driven from the scene of the crash.

VEHICLE DAMAGE

Air Bag Vehicle

Exterior: The 1991 Ford Taurus L, 4-door sedan, sustained moderate frontal damage from its underriding impact with the rear of the Ford Explorer. The impact to the Taurus compressed the Energy Absorption Devices (EAD) resulting in longitudinal striations to the male end of the EAD. Direct contact damage included longitudinal abrasions to the top surface of the bumper fascia which extended rearward into the header panel with subsequent deformation of the upper radiator support panel. The field L and direct contact damage began at the left front bumper corner and extended 156.2 cm (61.5 in) to the right front bumper corner. Residual crush was not present at the bumper level. Crush measurements were present at the radiator support and yielded a maximum crush value of 17.2 cm (6.75 in) at C4 which was located 60 cm (24 in) left of the right front bumper corner. The crush at the radiator support was averaged with the lack of crush at the bumper level and the following average crush values resulted:

| Crush Measurement | C1 | C2 | C3 | C4 | C5 | C6 |
|--------------------------------|--------------------|--------------------|---------------------|-----------------------|--------------------|----------------------|
| Front bumper | NO RESIDUAL CRUSH | | | | | |
| Front radiator support | 2.0 cm (0.8 in) | 15 cm (6 in) | 16.5 cm (6.5 in) | 17.20 cm (6.75 in) | 15 cm (6 in) | 3.8 cm (1.5 in) |
| Resulting average crush | 1.0 cm (0.4 in) | 7.6 cm (3.0 in) | 8.3 cm (3.3 in) | 8.6 cm (3.4 in) | 7.6 cm (3.0 in) | 1.90 cm (0.75 in) |

Exterior damaged components to this vehicle included the front bumper fascia, headlamps, grille, hood, radiator support, windshield, and the right side fender.

CDC: 12-FDEW-1.

Repair Cost: The police accident report estimated the damage at \$2,200.00. The insurance company evaluated the severity of the damage and ruled that the vehicle was not repairable. The vehicle was sent to a salvage yard as a total loss.

Interior: The interior of the 1991 Ford Taurus L did not sustain intrusion damage that was associated with exterior crush damage, however, the interior did sustain minor damage that was associated with driver and right front passenger contact.

The driver initiated a forward trajectory in response to braking actions and the frontal impact sequence. He contacted his knee/s with the center of the cover plate on the driver's side knee bolster, immediately inferior to the steering column. This resulted in two abrasions to the coverplate. The first began 1.90 cm (0.75 in) left of the right perimeter of the coverplate and 1.3 cm (0.5 in) inferior to the top aspect of the cover plate. It measured 5 cm (2 in) in length and 1.90 cm (0.75 in) in width. The second abrasion was centered on the top of the coverplate and had a diameter of 1.0 cm (0.4 in). As the driver's side air bag deployed, the driver was positioned at the outer limit, but still within range of the deploying air bag. He subsequently loaded the air bag as it expanded between his upper torso and face, and the steering wheel rim. This resulted in 2.5 cm (1.0 in) of deformation to the upper steering wheel rim and a grey vinyl transfer to the top underside of the air bag from expansion of the air bag against the inside of the upper module cover flap. The vinyl transfer was located between the 11 and 12 o'clock positions, adjacent to the 11 o'clock positioned vent port, and measured 11.0 cm (4.3 in) in length and 3.0 cm (1.2 in) in width. Contact evidence was not present to the face or inside of the module cover flap. The steering column's shear capsules did not show evidence of compression. The driver was displaced rearward by the expansion of the air bag which allowed for the rotation of his head over the left front head restraint which was placed in the full down position.

The right front passenger moved on a forward trajectory as a result of braking actions and attempted to brace by extending her arms forward toward the instrument panel area of the vehicle. The 12 o'clock impact force displaced her further forward which allowed her right dorsal hand and head to contact the windshield. A small spiderweb-type crack was located 28 cm (11 in) left of the right side A-pillar and 40.6 cm (16.0 in) forward (with respect to the vehicle) of the leading edge of the right side instrument panel which resulted from contact with the passenger's head. Another small spiderweb-type crack was located approximately 12.0 cm (4.7 in) inferior to the first, along the surface of the windshield, which resulted from contact with the passenger's right hand. In addition, there was a large vertical skin oil transfer to the windshield that measured 18 cm (7 in) in height and 3.8 cm (1.5 in) in width at the area of the spiderweb crack. The passenger's left hand, also extended to brace herself, contacted the rearview mirror which was consequently displaced into the windshield header and dislodged from the windshield. The glazing of the rearview

mirror evidenced a skin oil transfer that measured 3.8 cm (1.5 in) in diameter. It was located 3 cm (1.2 in) from the right perimeter of the glazing's housing and began at the upper aspect of the glazing, extending 3.8 cm (1.5 in). The passenger also contacted the lower aspect of the glove compartment door with her knee/s as she responded to braking actions and crash forces. Two abrasions were located on the glove compartment door. The first was located 24.8 cm (9.75 in) left of the right compartment door perimeter and 43 cm (17 in) above the floor of the vehicle. It measured 1.9 cm (.75 in) in diameter. The second vertical abrasion was located 14.6 cm (5.75 in) left of the right compartment door perimeter and 43 cm (17 in) above the floor of the vehicle. It also measured 1.9 cm (.75 in) in diameter.

AUTOMATIC RESTRAINT SYSTEM

The 1991 Ford Taurus L was equipped with a driver's side Supplemental Restraint System (SRS) which deployed as a result of the frontal impact sequence with the Ford Explorer. The system consisted of two crash sensors that were mounted to the outboard aspect of the frame rail. A diagnostic module equipped with a safing sensor was located in the center instrument panel. The SRS also consisted of a steering wheel mounted air bag module and an instrument panel indicator lamp. The air bag was concealed in the hub of the four spoke steering wheel rim and deployed from asymmetrical H-configuration module cover flaps. The upper flap measured 20.5 cm (8.1 in) in width and 13.4 cm (5.3 in) in height and displayed the word "FORD" in the lower right corner and the acronym "SRS" in the lower left corner. The inside of the upper flap displayed the identification:

T.A.P. 200088

CAV 4

The lower flap measured 20.5 cm (8.1 in) in width and 4.5 cm (1.8 in) in height. There was no damage present to the air bag module cover flaps. The deployed driver side air bag was 69 cm (27 in) in diameter in its deflated state. The bag was tethered by four straps which were located at the 3, 6, 9, and 12 o'clock positions. Two vent ports measuring 2.0 cm (0.8 in) in diameter were located at the 1 and 11 o'clock positions. A warning label on the underside of the driver's sun visor read:

This vehicle has a DRIVER AIR BAG. All occupants, including the driver, should still use seat belts for effective protection.

Air bag contact evidence consisted of a vertical grey vinyl transfer and was present to the top underside aspect of the air bag, located between the 11 and 12 o'clock positions. The vinyl transfer was adjacent to the 11 o'clock positioned vent port and measured 11.0 cm (4.3 in) in length and 3.0 cm (1.2 in) in width. Contact evidence was not present to the face or inside of the module cover flap. The steering column's shear capsules did not show evidence of compression and crash damage was not related to the SRS components.

VEHICLE VELOCITY ESTIMATES

| | 1991 Ford Taurus | 1996 Ford Explorer |
|---------------------------------|---|-----------------------------|
| Travel Speed | 56 km/h (35 mph) estimated by police | Stopped |
| Total Delta V | 18.4 km/h (11.4 mph) | 13.8 km/h (8.6 mph) |
| Longitudinal Delta V | 18.4 km/h (11.4 mph) | 13.8 km/h (8.6 mph) |
| Lateral Delta V | 0 km/h (0 mph) | 0 km/h (0 mph) |
| Energy Absorption | 17,952 joules (13,238 ft/lb) | 15,616 joules 11,516 ft/lb) |
| Barrier Equivalent Speed | 17.7 km/h (11.0 mph) | 14.4 km/h (8.9 mph) |

CRASH SEQUENCE

Pre-Crash: The 80 year old male driver was reportedly conducting a weekly routine by transporting his wife, an 82 year old female right front passenger, to a local business. The Taurus was traveling southbound in the outboard lane, nearest to an active construction zone, at a police reported speed of 56 km/h (35 mph). The driver was approaching a 4-leg intersection that was controlled by an overhead traffic signal system. On the driver's approach to the intersection, the overhead signal system was in a red phase for north/southbound traffic flow. The 1996 Ford Explorer was stopped in the outboard travel lane for the red signal phase ahead of the Ford Taurus. A third, unknown vehicle, was stopped in front of the Explorer for the red signal phase. The driver of the Taurus applied the vehicle's brakes in an attempt to avoid an impact.

Crash: The full frontal area of the Taurus impacted with the rear of the stopped Ford Explorer. The Taurus' front bumper fascia contacted and underrode the rear bumper of the Explorer which resulted in the engagement of the Taurus' top bumper fascia and the grille/header panel with the rear bumper of the stopped Explorer. The impact to the Ford Taurus compressed its Energy Absorption Devices (EAD), resulting in longitudinal striations to the male aspect of the component. Direct contact damage produced longitudinal abrasions to the top surface of the bumper fascia which extended rearward into the header panel with subsequent deformation of the upper radiator support panel. The impact resulted in a 12 o'clock/6 o'clock impact configuration to the Taurus and Explorer respectively and initiated the deployment sequence of the Taurus' driver side air bag system. ROLDMISS calculated the total delta V at 13.8 km/h (8.6 mph) The initial impact displaced the Explorer forward and its frontal plane impacted with the rear of the third unknown vehicle.

Post-crash:

Final Rest: The vehicles came to final rest in their respective travel lanes and at pre-crash heading angles.

Driver Activities: The driver of the Taurus was coherent following the collision, but was unable to move, and was removed from the vehicle by emergency medical personnel who responded to the scene of the crash.

Passenger Activities: The right front passenger was found in the right front floor area of the vehicle post-crash and was removed from the vehicle by emergency medical personnel.

Police Activities: Police officers responded to the scene of the crash, assisted occupants in the involved vehicles, conducted a crash investigation, and assisted in scene clearance.

EMS Activities: EMS personnel administered emergency first aid to the driver and passenger of the Taurus at the scene of the crash and subsequently transported the occupants to a local trauma center for further treatment.

Scene Clearance: The Taurus was towed from the scene of the crash due to vehicle damage. The Explorer and the third unknown vehicle were driven from the scene by their respective drivers.

HUMAN DEMOGRAPHICS/OCCUPANT DATA

| 1991 Ford Taurus | Driver | Right Front Passenger |
|----------------------------------|---|---|
| Age/Sex | 80 year old male | 82 year old female |
| Height | 184 cm (73 in) | 152.4 cm (60.0 in) |
| Weight | 84 kg (185 lbs) | 59 kg (130 lbs) |
| Manual Restraint Usage | Not wearing the available 3-point manual lap and shoulder belt | Not wearing the available 3-point manual lap and shoulder belt |
| Usage Source | Vehicle inspection | Vehicle inspection |
| Eyewear | None | None |
| Vehicle Familiarity | Purchased the vehicle new approximately 6 years prior to the crash. | |
| Route Familiarity | Familiar with the area and traveled on a daily basis. | |
| Trip Plan | Transporting right front passenger from residence to a local business. | |
| Type of Medical Treatment | Transported to a trauma center from the scene of the crash where he was hospitalized for 24 days. The driver was then transferred to a rehabilitation center where he remained for approximately a day and a half before he began experiencing respiratory difficulties. He was transferred to a nearby hospital and survived an additional 24 days in a semiconscious state. | Transported to a trauma center from the scene of the crash where she was treated for sustained injuries and released. |

DRIVER INJURY DATA

| Injury | Injury Severity (AIS-90) | Injury Mechanism |
|--|---------------------------------|-------------------------|
| Right temporal hemorrhage | Severe (140629.4,1) | Driver side air bag |
| Fracture through the osteophyte at C4-C5, anteriorly, through the disc space with posterior dislocation, C4 on C5. | Severe (640218.4,6) | Driver side air bag |
| Superior forehead ecchymosis | Minor (290402.1,7) | Driver side air bag |
| Nose abrasions | Minor (290202.1,4) | Driver side air bag |
| Superior forehead abrasions | Minor (290202.1,7) | Driver side air bag |

DRIVER KINEMATICS

Pre-crash, the driver of the Taurus was probably in a normal upright driving position. Although the position of the seat track was not confirmed by the investigation, the driver, who had a height of 184 cm (73 in), probably placed the left front seat track in a mid-to-full back position. The adjustable head restraint was placed in the full down position. There was no evidence within the vehicle to support belt usage. There were no signs of belt loading and the latch plate and fixed D-ring did not show abrasions typical of routine usage. Therefore, it was concluded that the driver was not restrained by the 3-point manual belt system and was not a routine user of the belt. The driver moved forward toward the steering wheel due to pre-impact braking actions. At impact, the driver was further displaced forward toward the deploying air bag due to the 12 o'clock direction of force impact and contacted his knee/s with the left knee bolster's coverplate. It was probable that the air bag may have deployed late in the crash sequence due to the underriding damage pattern and the relatively low delta V (calculated at 18.4 km/h (11.4 mph) sustained by the Taurus. The combination of these events positioned the driver at the outer limit, but still within range, of the deploying air bag. He subsequently loaded the air bag as it expanded between his upper torso and face, and the steering wheel rim. This resulted in 2.5 cm (1.0 in) of deformation to the upper steering wheel rim and a grey vinyl transfer to the top underside of the air bag from contact with the inside of the upper module cover flap. The vinyl transfer was adjacent to the 11 o'clock positioned vent port and measured 11.0 cm (4.3 in) in length and 3.0 cm (1.2 in) in width. Steering column

compression was not evident. The driver's contact to the deploying air bag resulted in a fracture dislocation of C4 and C5 with resulting quadriplegia (AIS-4) induced by an unspecified cervical cord injury, right temporal hemorrhage (AIS-4), superior forehead ecchymosis (AIS-1), forehead abrasions (AIS-1), and nose abrasions (AIS-1). The cervical cord injury sustained by the driver could have been compounded as he was displaced rearward from the expansion of the deployed air bag which allowed for the rotation of his head over the left front head restraint which was placed in the full down position at inspection.

DRIVER MEDICAL TREATMENT

The driver of the Taurus was transported from the scene of the crash via ambulance to a local trauma center. While in the emergency room, and during his first week of hospitalization, the driver remained coherent. Approximately one week following the crash, the male driver developed pneumonia. He recovered from the pneumonia and approximately 10 days later, his treating physicians made the decision to transfer him to a rehabilitation facility for treatment after an initial hospitalization stay of 24 days. He was transferred to a rehabilitation center where he remained for approximately a day and a half before he began experiencing respiratory difficulties. He was transported to a nearby hospital where he was again diagnosed with pneumonia. He survived an additional 24 days in a semiconscious state.

RIGHT FRONT PASSENGER INJURY DATA

| Injury | Injury Severity (AIS-90) | Injury Mechanism |
|----------------------------------|---------------------------------|-------------------------------------|
| Right thumb laceration | Minor (790602.1,1) | Windshield |
| Right thumb contusion | Minor (790402.1,1) | Windshield |
| Forehead contusion | Minor (290402.1,7) | Windshield |
| Ankle contusion (unknown aspect) | Minor (890402.1,9) | Right toe pan, kick panel, or floor |

RIGHT FRONT PASSENGER KINEMATICS

Pre-crash, the right front passenger was probably in an upright and forward position and moved on a forward trajectory as a result of pre-impact braking forces. She attempted to brace herself by extending her arms forward, but was displaced further forward due to the 12 o'clock impact force. Her right dorsal hand and head subsequently contacted the windshield. A small spiderweb-type crack was located

28 cm (11 in) left of the right A-pillar and 40.6 cm (16.0 in) forward (with respect to the vehicle) of the leading edge of the right side instrument panel which resulted from contact with the passenger's head. Another small spiderweb-type crack was located approximately 12.0 cm (4.7 in) inferior to the first, along the surface of the windshield, which resulted from contact with the passenger's right hand. In addition, there was a large vertical skin oil transfer to the windshield that measured 18 cm (7 in) in height and 3.8 cm (1.5 in) in width at the area of the spiderweb cracks. The passenger's left hand, also extended to brace, contacted the rearview mirror which was consequently displaced into the windshield header and dislodged from the windshield. The glazing of the rearview component evidenced a skin oil transfer that measured 3.8 cm (1.5 in) in diameter. It was located 3 cm (1.2 in) from the right edge of the glazing's housing and began at the upper aspect of the glazing extending 3.8 cm (1.5 in). The passenger also contacted the lower aspect of the glove compartment door with her knees (unknown aspect) as she continued toward the 12 o'clock direction of force. Two abrasions were located on the glove compartment door. The passenger was found on the right front floor area of the vehicle at the crash scene and sustained injuries that were consistent with occupant contact found in the vehicle.

RIGHT FRONT PASSENGER MEDICAL TREATMENT

The right front passenger was transported to a local hospital for treatment of sustained injuries and was subsequently released.