TRANSPORTATION SCIENCES
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VERIDIAN ON-SITE AIR BAG RELATED ADULT PASSENGER FATALITY INVESTIGATION
VERIDIAN CASE NO. CA00-002
VEHICLE: 1993 MERCURY GRAND MARQUIS
LOCATION: MARYLAND
CRASH DATE: JANUARY 2000

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

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

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16. *Abstract* This on-site investigation focused on the injury severity and injury mechanisms for an 85 year old female front right passenger of a 1993 Mercury Grand Marquis. The Mercury was equipped with frontal air bags for the driver and front right passenger positions. The 87 year old male driver of the Grand Marquis relinquished control of the vehicle in a private subdivision and struck a tree that resulted in deployment of the frontal air bag system. Immediately following the crash, the occupants exited the vehicle and walked to their residence and called the community's security office to arrange for towing of the vehicle. The driver did not report injury, however, the passenger complained of lower left abdominal pain and refused medical treatment. Later that evening, the front right passenger developed a severe headache and was transported to a local hospital where she was diagnosed with a left subdural hematoma. She was transferred to a regional trauma center where surgery was performed to drain the hematoma. She expired five days following the crash.			
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BACKGROUND

This on-site investigation focused on the injury severity and injury mechanisms for an 85 year old female front right passenger of a 1993 Mercury Grand Marquis. The Mercury was equipped with frontal air bags for the driver and front right passenger positions. The 87 year old male driver of the Grand Marquis relinquished control of the vehicle in a private subdivision and struck a tree **(Figure 1)** that resulted in deployment of the frontal air bag system. Immediately following the crash, the occupants exited the vehicle and walked to their residence and called the community's security office to arrange for towing of the vehicle. The driver did not report injury, however, the passenger complained of lower left abdominal pain and refused medical treatment. Later that evening, the front right passenger developed a severe headache and was transported to a local hospital where she was diagnosed with a left subdural hematoma. She was transferred to a regional trauma center where surgery was performed to drain the hematoma. She expired five days following the crash.

Figure 1. Frontal damage to the 1993 Grand Marquis.

The local County Police Department was notified of the crash by the Medical Examiner following the death of the passenger. The police initiated an investigation of the crash and notified NHTSA's Crash Investigation Division of the fatal outcome. The notification was forwarded to the Veridian SCI team on January 11 and an on-site investigation was conducted on January 12.

SUMMARY

Crash Site

The crash occurred on private property in a large retirement community during daylight hours. The weather was reported as mostly sunny with no precipitation and temperatures in the mid single digits Celsius (mid 40s F). The crash occurred in a mid block area on a residential street **(Figure 2)** that was 8.6 m (28.2') in width bordered by 15 cm (6") barrier curbs. A lawn area bordered the south curbline while a concrete sidewalk paralleled the north curbline. The dry asphalt road surface was straight with a slight negative grade. The posted speed limit was 40 km/h (25 mph). The struck tree was 33 cm (13") in diameter and was located 1.0 m (3.3') outboard of the

Figure 2. Overall view of the crash site.

south curbline. There were no defects or visual obstructions at the crash scene. The crash schematic is included as **Figure 12,** Page 10.

Vehicle Data

The involved vehicle was a 1993 Mercury Grand Marquis, 4-door sedan, that was equipped with frontal air bags for the driver and right passenger positions. The vehicle was a rear-wheel drive platform with a 4.6 liter, V-8 engine linked to a four-speed automatic overdrive transmission. In addition to the frontal air bag system, the Grand Marquis was equipped with four-wheel disc brakes with anti-lock (ABS) and variable rate power steering. The interior of the vehicle was configured as a six passenger platform with a 50/50 split bench front seat with dual center folding armrests, power six-way front seat adjustments, adjustable head restraints, tilt steering wheel, and 3-point lap and shoulder belts for the four outboard seated positions. The seats were covered with the leather option. The vehicle was owned by the driver and was identified by vehicle identification number 2MELM75W9PX (production number deleted). The Grand Marquis was manufactured on 11/92 and had an approximate odometer reading of 129,000 km (80,000 miles).

Crash Sequence

Pre-Crash

The driver and his wife were returning to their residence and were traveling in an easterly direction on the local street at an estimated speed of 24-32 km/h (15-20 mph). The driver had negotiated a moderate right curve that transitioned onto a straight segment of roadway. The apex of the curve was located 60 m (200') west of the impending crash site. As he was traveling on the straight segment of road, the driver relinquished directional control and allowed the vehicle to drift to the right.

Figure 3. Struck curb with trajectory into tree.

The right front tire impacted and overrode the barrier curb 6.9 m (22.6') west of the struck tree. The vehicle continued on a straight line trajectory in a tracking mode to impact **(Figure 3)**. There was no evidence of tire marks on the lawn area between the point of departure and the struck tree to indicate avoidance actions.

Crash

The front right area of the Grand Marquis impacted a 33.0 cm (13.0") diameter tree that was located 1 m (3.3') outboard of the curbline. The vehicle's impact speed was computed at 28.5 km/h (17.7 mph) by the damage and trajectory algorithm of the WinSMASH program. The resultant direction of force was within the 12 o'clock sector with a maximum crush value of 19.7 cm (7.75"). The velocity change was computed at 23.2 km/h (14.4 mph) with a longitudinal component of -23.2 km/h (-14.4 mph). The impact induced deceleration was sufficient to deploy the vehicle's frontal air bag system. The off-set frontal impact probably induced a slight clockwise rotation, not exceeding 5 degrees. The Grand Marquis came to rest engaged against the struck tree.

Post-Crash

The front seat occupants exited the vehicle without assistance. The front right door was restricted from opening by the rearward displacement of the right front fender, therefore the front right passenger had to exit the vehicle through the left door. Both occupants walked to their residence which was located approximately 90 m (100 yards) from the crash site. At their residence, the driver called the community's security office to report the crash and arrange for towing of the vehicle.

The security officer responded to the scene of the crash, then proceeded to the driver's residence. At the residence, the front right passenger complained of lower left abdominal pain which she attributed to the seat belt system. She further stated that she was a nurse and refused medical treatment. The driver did not report injury. The vehicle was towed to a local Lincoln Mercury dealership.

Approximately 9.5 hours post-crash, the front right passenger complained of a severe headache. Her husband arranged for ambulance transport to a local hospital. At this facility, the passenger's condition deteriorated. She was diagnosed with a left subdural hematoma and left cerebral edema and prepared for helicopter transport to a regional trauma center.

At the trauma center, emergency surgery was performed to drain the hematoma with the placement of an inter-cranial pressure (ICP) bolt. The passenger was transferred to the intensive care unit where her condition continued to deteriorate over the next several days. The passenger expired five days following the crash.

The body was transported to the Medical Examiner's office, however, no autopsy was performed since the passenger was hospitalized prior to the death. The Medical Examiner's officer required a copy of the PAR for their files and called the local County Police Department that had jurisdiction in the area of the crash. The Department did not have previous notification of the crash since it occurred on private property and there were no reportable injuries. At his point, the police initiated their investigation and notified NHTSA of the crash. The police ordered towing of the vehicle to their impound facility where it was secured for this SCI investigation.

Vehicle Damage

Exterior - 1993 Mercury Grand Marquis

The Mercury Grand Marquis sustained moderate frontal damage as a result of the frontal impact sequence with the tree. The direct contact damage to the bumper fascia began 21.8 cm (8.6") right of center and extended 32.8 cm (12.9") to the right **(Figure 4.)**. The impact fractured the bumper fascia and fragmented the alloy bumper reinforcement beam at the impact location. The bumper beam separated from its mounting points at the energy absorbing devices (EAD). There was no evidence of the compression on the left EAD, however, the right EAD was abraded full length, indicative of compression. This EAD had returned 5.7 cm (2.25") to its original position. The deformed and fractured bumper beam was supported exclusively by the bumper fascia post-crash, therefore this structural component was not used to document a crush profile.

The tree penetrated through the bumper beam and engaged the cross member which extended laterally between the frame rails and the upper radiator support panel. This deformation involved the full frontal width of the vehicle resulting in a combined induced and direct damage length of 156.8 cm (61.75"). Maximum crush was 19.7 cm (7.75") located on the cross member 37.5 cm (14.75") right of center **(Figure 5)**. Crush profiles were documented at the level of the cross member and the radiator support panel due to the separation of the bumper reinforcement beam. The cross member crush profile was as follows: C1 = 0 cm , C2 = 0 cm , C3 = 7.0 cm (2.75"), C4 = 16.5 cm (6.5"), C5 = 12.7 cm (5.0"), C6 = 9.2 cm (3.6"). This profile was used for reconstruction in the WinSMASH program. The residual profile at the level of the radiator support was as follow: C1 = 0 cm, C2 = 3.6 cm (1.4"), C3 = 8.3 cm (3.25"), C4 = 12.1 cm (4.75"), C5 = 9.2 cm (3.6"), C6 = 2.5 cm (1.0"). It should be noted that these profiles understate the overall damage to the Grand Marquis due to the fracture of the bumper reinforcement beam. The maximum crush value was adjusted to a depth of 49.5 cm (19.5") to reflect the rearward displacement of the bumper for the WinSMASH reconstruction program. The Collision Deformation Classification (CDC) for this impact sequence was 12-FZEN-2.

Figure 4. Front right damage to the Grand Marquis.

Figure 5. Overhead view of the crush profile to the cross member.

Interior

Interior damage to the Grand Marquis was minimal and was associated with deployment of the frontal air bag system and occupant contact. The upper steering wheel rim was deformed approximately 1.3 cm (0.5") forward from probable driver loading against the deployed air bag. There was no compression of the energy absorbing steering column. The rear view mirror was deflected to the right and the glass was fractured from a probable fling contact by the front right passenger **(Figure 6)**. There was no intrusion of interior components. The

Figure 6. Fractured rear view mirror.

woodgrain trim panel that was mounted under the front right passenger air bag module assembly was missing from the vehicle. It was unknown if this panel separated during the crash or had separated prior to the crash.

Manual Restraint Systems

The Mercury Grand Marquis was equipped with 3-point lap and shoulder belt systems in the four outboard seated positions. The front belt systems consisted of continuous loop webbing with sliding latchplates that retracted onto emergency locking retractors located in the lower B-pillars. The upper D-rings were adjustable with both front systems adjusted to the lowest positions **(Figure 7)**. The adjustments provided 9.5 cm (3.75") of vertical travel to the D-rings. The driver side belt system yielded evidence of occasional usage, but not frequent usage over the 129,000 km (80,000) miles recorded on the vehicle. Wear marks were present on the latchplate and the webbing was soiled in the areas of the D-ring and latchplates. There was no loading evidence on the belt system.

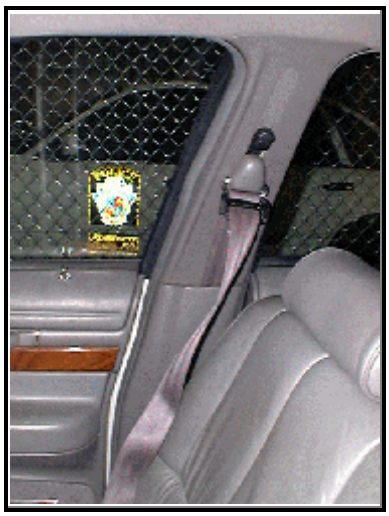

Figure 7. Adjusted position of the front right passenger's D-ring.

The front passenger belt system yielded more extensive evidence of routine usage. Wear marks were present on the latchplate and the edges of the webbing were frayed between the D-ring an the latchplate. Again, there was no evidence of usage at the time of the crash. Although unconfirmed, the front right passenger was probably wearing the belt incorrectly with the shoulder belt webbing positioned under her arm. Improper belt usage was based on the passenger's initial complaint of left abdominal pain that resulted from probable belt loading and forward trajectory of her torso and head into the path of the deploying air bag.

Frontal Air Bag System

The Mercury Grand Marquis was equipped with a Supplemental Restraint System (SRS) that consisted of frontal air bags for the driver and right passenger positions. The air bag system deployed as a result of the frontal impact sequence with the tree.

Sensing was achieved by two electro-mechanical crash sensors mounted to the forward aspect of the upper radiator support panel. The sensors were identified with the following Part Nos. and Bar Coded nomenclature:

	Left Sensor	Right Sensor
	F2AB-148004-BA	F2AB-14004-BR
	6A3122268	6A31620847

The tree impact was located directly outboard of the right crash sensor. The grille was displaced into the right crash sensor which rotated the sensor approximately 20 degrees inboard with respect to the vehicle. A small dent was noted to the face of the sensor case, however, it did not impede the performance of the

sensor. The system was monitored by a control module that was mounted to the top surface of the transmission tunnel, under the mid instrument panel.

The driver air bag was housed within the four-spoke steering wheel rim with the spokes located at the 3/9 and 4/8 o'clock positions. The module was concealed by two H-configuration asymmetrical cover flaps. Both flaps were 20.3 cm (8.0") in width at the horizontal tear seam. The upper cover flap measured 12.7 cm (5.0") in height while the lower flap was 3.8 cm (1.5") in height. Both flaps were approximately 7.9 mm (5/16") in thickness.

The driver air bag was constructed of a typical nylon-type fabric sewn with an internal peripheral seam. The overall bag diameter in its deflated state was 66.0 cm (26.0"). The driver air bag was vented by two 2.8 cm (1.1") diameter ports located on the back side of the bag at the 11 and 1 o'clock sectors. The ports were centered 8.9 cm (3.5") below the peripheral seam. Internally, the bag was tethered by four tether straps sewn to the face of the bag with a 17.8 cm (7.0") diameter reinforcement. With the steering wheel assembly positioned in a 12/6 o'clock position, the tether straps were located at the 12/6 and 3/9 o'clock positions. **Figure 8** is an overall view of the driver air bag module.

Figure 8. Overall view of the driver air bag, cover flaps, and the vent ports.

There was no damage or driver contact evidence to the bag membrane. Deployment of the driver air bag did separate the cruise control trim panel that was positioned between the spokes on the left side of the steering wheel rim.

The front right passenger air bag module was a mid mount design that was concealed by a single cover flap **(Figure 9)** in the right instrument panel. The flap was hinged at the top aspect and opened at the side and bottom tear points. The flap measured 40.0 cm (15.75") horizontally and 13.7 cm (5.4") vertically. The acronym SRS was molded into the lower left corner of the cover flap. The air bag module assembly was loose in the mid instrument panel.

The passenger air bag membrane measured approximately 66.0 cm (26.0") horizontally and 61.0 cm (24.0") vertically in its extended, but deflated state **(Figure 10)**. The bag was not tethered internally. A single vent port was located on the left side panel of the bag and was 5.7 cm (2.25") in diameter. The bag membrane was not damaged and did not yield evidence of passenger contact (i.e., lipstick, makeup and/or tissue transfers).

Figure 9. Deployment of the front right air bag from the mid mount module assembly.

Driver Demographics

Age/Sex:	87 year old male
Height:	180 cm (71")
Weight:	82 kg (180 lb)
Manual Restraint Usage:	None
Eyeware:	Unknown
Mode of Transport From Scene:	Walked from scene to residence
Type of Medical Treatment:	None

Figure 10. Profile view of the deployed front right air bag.

Driver Injuries

Injury	Severity (AIS 90)	Injury Mechanism
Not injured	N/A	N/A

Driver Kinematics

The driver was seated in a presumed normal driving posture with the seat track adjusted to a mid-to-rear track position with the seat back reclined to 20 degrees and the head restraint adjusted to the full down position. The adjustable steering column was set to the mid point of the five adjustment positions. In this position, the driver's seat back support was 54.6 cm (21.5") rearward of the center point of the driver air bag module, measured horizontally. There was no evidence of restraint loading and minimal bending of the upper steering wheel rim, therefore it was presumed that the driver was not restrained.

At impact, the driver initiated a forward trajectory in response to the 12 o'clock impact force and loaded the deployed driver air bag. His loading force was transmitted through the air bag which resulted in a forward deflection of the upper steering wheel rim. The air bag prevented the driver from direct contact with the steering wheel rim and additional frontal components. There was no evidence of knee contact to the bolster panel or compression of the energy absorbing steering column. The driver did not complain of injury and did not seek medical attention.

Front Right Passenger Demographics

Age/Sex:	85 year old female
Height:	160.0 cm (63.0")
Weight:	63.5 kg (140.0 lb)
Manual Restraint Usage:	3-point lap and shoulder belt system, probably worn improperly with shoulder belt under arm
Usage Source:	Passenger statements/injury complaint/vehicle inspection
Eyeware:	Non-prescription plastic framed eyeglasses
Mode of Transport From Scene:	Walked from scene to residence
Type of Medical Treatment:	Transported to local hospital 9.5 hours post-crash with transfer to a regional trauma center where she expired 5 days following the crash

Front Right Passenger Injuries

Injury	Severity (AIS 90)	Injury Mechanism
Left subdural hematoma, not further specified	Severe (140438.4,6)	Acceleration injury from expansion of the front passenger air bag
Left cerebral edema	Serious (140660.3,2)	Acceleration injury from expansion of the front passenger air bag
Erythema of the face	N/A, not codeable under AIS 90	Front right passenger air bag
Left abdominal pain	N/A, not codeable under AIS 90	Manual restraint system

* Source of Injury - Hospital personnel

Front Right Passenger Kinematics

The front right passenger was seated in a presumed normal posture with her seat track adjusted to a mid track position. The seat back support was reclined to 24 degrees and the adjustable head restraint was in the full down position. Although there was no loading evidence on the manual belt system, the passenger initially complained of left abdominal pain induced from the seat belt. This statement was the basis to support belt usage, however, it was unknown if the belt system was worn properly.

As the vehicle overrode the barrier curb, the passenger probably responded by moving in a forward direction and raising her left arm in a bracing action. This would have positioned the passenger within the deployment path of the front right air bag. The vehicle traveled an additional 6.9 m (22.6') across the lawn

area and impacted the tree which resulted in deployment of the frontal air bag system. Assuming a travel velocity of 27-32 km/h (17-20 mph), the Grand Marquis would have traversed this distance in approximately one second.

The forward positioned passenger was struck by the expanding front right air bag as she responded to the frontal impact force **(Figure 11).** The air bag expanded against her left anterior forearm, displacing the wrist/hand into the rear view mirror. This contact fractured the mirror glass and displaced the mirror to the left. No injury was reported from this contact sequence. The passenger was probably wearing a winter-type coat and/or gloves which could have protected her from soft tissue injuries.

Figure 11. Deployment path of the front right air bag.

The continued expansion of the front right air bag resulted in contact against the face of the passenger. It was reported by the investigating officer that she sustained superficial abrasions of the face, however, these abrasions were not medically noted. (The hospital did report minor facial erythema which is not a codeable injury under AIS rules.) This expansion accelerated her head in a rearward direction as the passenger was displaced into the seat back support where she came to rest. There was no evidence of contact to the air bag membrane, cover flap, or rebound contact to the seat back, head restraint, or the B-pillar.

Immediately following the crash, the passenger exited the vehicle from the left front door and walked with the driver to their residence that was located approximately 90 m (300') from the crash site.

Medical Treatment

The security officer responded to the occupant's residence as a follow-up to his investigation. This officer noted that the front right passenger complained of pain to the lower left abdomen which she attributed to the seat belt system.

Later that evening, the passenger complained of a severe headache and was transported to a local hospital where she was diagnosed with a left subdural hematoma and left cerebral edema. The passenger was transferred by helicopter to a regional trauma center where her condition continued to deteriorate. Surgery was performed to drain the hematoma with the placement of an inter-cranial pressure (ICP) bolt. The passenger expired five days following the crash..

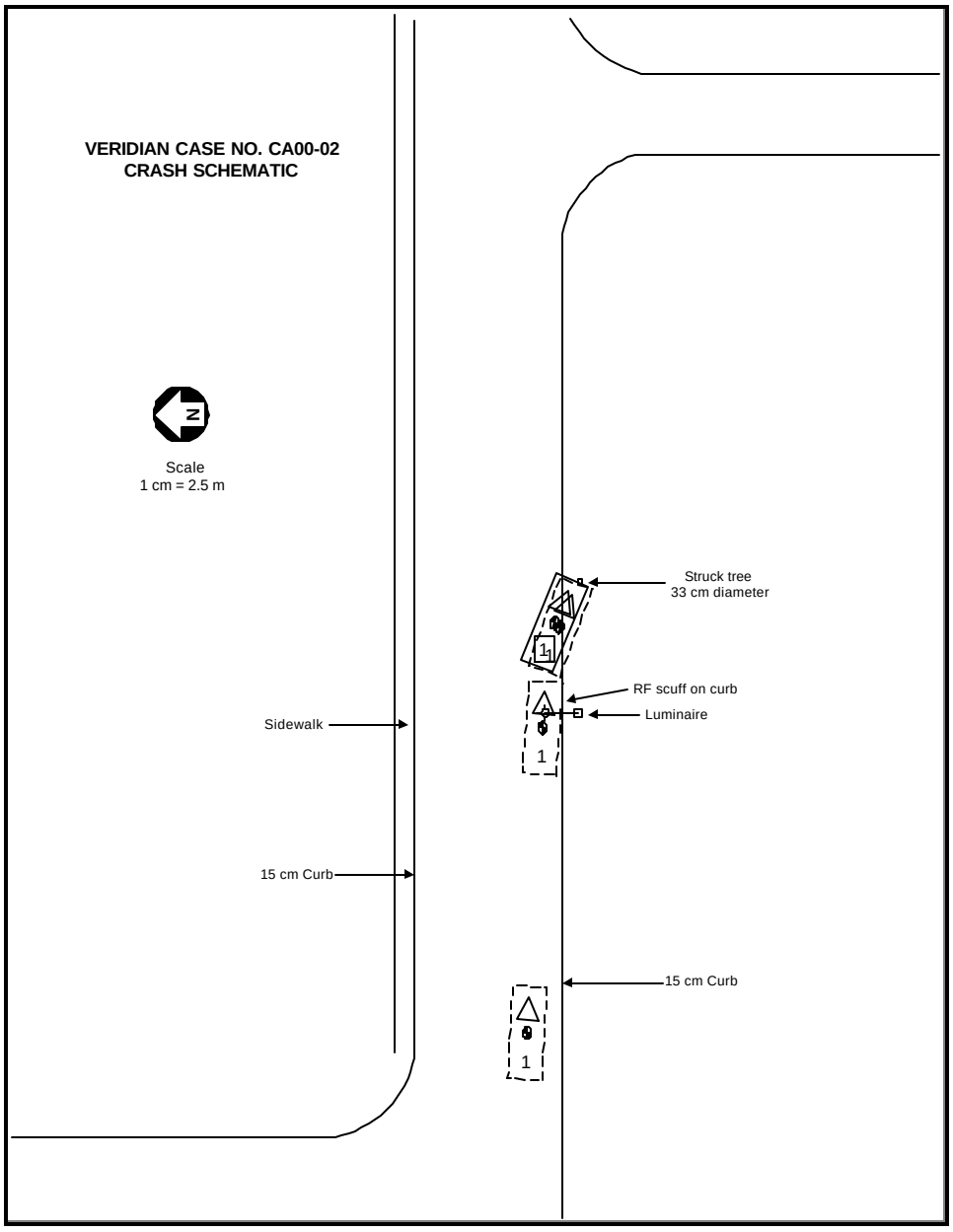

Figure 12. Crash Schematic