TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

Calspan Corporation
Buffalo, New York 14225

CALSPAN ON-SITE DRIVER AIR BAG DEPLOYMENT/FATALITY INVESTIGATION

CALSPAN CASE NO. CA98-30

VEHICLE - 1995 MITSUBISHI MIRAGE

LOCATION - DELAWARE

CRASH DATE - MAY, 1998

Contract No. DTNH22-94-07058

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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 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.

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This on-site investigation focused on the injury mechanisms that resulted in the death of a 38 year old female, unrestrained driver of a 1995 Mitsubishi Mirage. The crash occurred on a two lane north/south road in a right curve for northbound traffic. Immediately prior to the crash, the driver slumped forward and her head contacted the steering wheel evidenced by hair embedded in the 9 o'clock spoke of the steering wheel rim. The driver then had a Grand Mal epileptic seizure and subsequently lost directional control of the vehicle.

The Mitsubishi initiated a straight trajectory and drove out of the right curve. During this pre-crash trajectory, the right front passenger attempted to attend to the driver by extending his left arm and also unsuccessfully attempted to redirect the vehicle back to the roadway. The vehicle continued across the southbound lane and departed the left side of the road. The crash occurred with the center of the Mitsubishi's front plane impacting a 21.8 cm (8.6 in) diameter tree located 4.3 m (14.3 ft) from the road edge.

The Mitsubishi was equipped with a Supplemental Restraint System that consisted of driver and front passenger air bags that deployed as a result of the crash. The driver of the Mitsubishi sustained an aortic laceration as a result of contact with the deploying driver air bag and expired approximately 5 hours post-crash. The 14 year old male, restrained, right front passenger sustained a fractured left forearm, as he attempted to redirect the vehicle away from the tree.

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CALSPAN CASE NO. CA98-30

VEHICLE: 1995 MITSUBISHI MIRAGE
LOCATION: DELAWARE
CRASH DATE: MAY, 1998

BACKGROUND

This on-site investigation focused on the injury mechanisms that resulted in the death of a 38 year old female, unrestrained driver of a 1995 Mitsubishi Mirage. The crash occurred when the vehicle departed the left side of the roadway and impacted a tree. The Mitsubishi was equipped with a Supplemental Restraint System that consisted of driver and front passenger air bags that deployed as a result of the crash. The driver of the Mitsubishi sustained an aortic laceration as a result of contact with the deploying air bag and expired approximately 5 hours post-crash. The 14 year old male, restrained, right front passenger in the Mitsubishi sustained a fractured left forearm as he attempted to redirect the vehicle away from the tree.

The Field Operations Branch of the National Highway Traffic Safety Administration was informed of the crash by the Delaware State Patrol on May 8. NHTSA in-turn assigned the investigation to the Special Crash Investigation Team (SCI) at Calspan on the same day. The vehicle was impounded by the investigating police department pending SCI investigation on May 11.

SUMMARY

This single vehicle crash occurred in the afternoon hours of May, 1998. At the time of the crash, it was daylight and the weather was not a factor. The crash occurred on a two lane north/south road in a right curve for northbound traffic. The width of the road was 5.9 m (19.4 ft) and the radius of the curve near the point of impact was 351 m (1150 ft). A 21.8 cm (8.6 in) diameter tree located 4.3 m (14.3 ft) west of the road edge line was the point of impact. The speed limit in the area of the crash was 56 km/h (35 mph). **Figure 1** is a northbound trajectory view 30 m (100 ft) from the point of impact. **Figure 2** is a view of the tree and the final rest position of the vehicle.

Figure 1: Northbound trajectory view 30 m (100 ft) from the POI.

Figure 2: View of the POI and final rest of the vehicle.

The 1995 Mitsubishi Mirage was traveling northbound in a right curve, driven by an unrestrained 38 year old female with a height and weight of 160 cm (63 in) and 89 kg (196 lb). As reported by the driver's husband, it was the driver's habit to not wear a seat belt. The driver's 14 year old son was the restrained right front seated passenger.

Immediately prior to the crash, the driver slumped forward and her head contacted the steering wheel evidenced by hair embedded in the 9 o'clock spoke of the steering wheel rim. The driver then had a Grand Mal epileptic seizure and subsequently lost directional control of the vehicle. It was probable that the driver repositioned to an upright posture as a result of the seizure. The driver's husband reported, the driver had a 20 year history of epilepsy, however, she had been seizure free for approximately 3 years. He further indicated the only time that she had a seizure was during the birth of their two sons and when the doctor was adjusting her medication. The medical records indicated she may have not been taking her prescribed medication, however, the basis of that information was unclear.

The Mitsubishi initiated a straight trajectory and drove out of the right curve. During this pre-crash trajectory, the right front passenger attempted to attend to the driver by extending his left arm and also unsuccessfully attempted to redirect the vehicle back to the roadway. The vehicle continued across the southbound lane and departed the left side of the road. The crash occurred with the center of the Mitsubishi's front plane impacting a 21.8 cm (8.6 in) diameter tree located 4.3 m (14.3 ft) from the road edge.

Figure 3: Front view of the Mitsubishi.

The damage to the Mitsubishi Mirage was localized to the front center section of the vehicle. The Mitsubishi sustained 21.6 cm (8.5 in) of direct contact damage to the center aspect of the vehicle's front bumper structure. The direct contact damage began 10.2 cm (4.0 in) left of center and ended 11.4 cm (4.5 in) right of center. The crush profile measured across the width of the bumper reinforcement was: C_1=0, C_2=8.1 cm (3.2 in), C_3=22.9 cm (9.0 in), C_4=15.2 cm (6.0 in), C_5=0, C_6=0. The field L=137 cm (54 in). The maximum crush of 33.0 cm (13.0 in) was located 6.4 cm (2.5 in) left of centerline. The impact damage extended rearward into the engine compartment deforming the upper and lower radiator supports. The hood was buckled and

Figure 4: Right lateral view of the Mitsubishi.

deformed in the typical pattern. There was no measurable change in the wheelbase dimensions. The Collision Deformation Classification (CDC) of the vehicle was 12-FCEN-2. The delta V of the vehicle calculated by the barrier model of WINSMASH algorithm was 21.6 km/h (13.4 mph). **Figures 3 and 4** are front and right lateral views of the Mitsubishi respectively.

The force of the impact caused the deployment of the Mitsubishi's Supplemental Restraint System. The deploying air bag contacted the driver in the chest and face causing multiple thoracic and facial trauma. The right front passenger sustained an unspecified fracture of the left wrist as a result of interaction with the deploying driver air bag. The vehicle came to rest at the point of impact, in contact with the tree. There was no post-impact rotation.

The police and medical personnel responded to the crash scene. The driver and right front passenger were transported to the emergency room of a local hospital approximately 28 miles from the scene. Stabilization of the driver was attempted and approximately 3 hours post-crash she was transferred to a level 1 trauma center, located approximately 113 km (70 miles) away, via life-flight. The driver succumbed to her sustained injuries approximately 5 hours post-crash.

AIR BAG VEHICLE

The 1995 Mitsubishi Mirage, 4 door sedan, was identified by a vehicle identification number (VIN) of JA3AA26A5SU (production sequence deleted). The date of manufacture was July, 1994. The vehicle's power train consisted of a 1.5 liter, I-4 engine linked to a 4-speed automatic transmission. The vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags. The vehicle was not ABS equipped. The odometer read 85,267 km (52,984 miles).

The vehicle's front seating positions were cloth covered bucket seats with reclining back rests. The investigating officer verified that the seat track positions had not been disturbed from the at-crash positions. The track position of the left front seat measured 7.6 cm (3.0 in) forward of the rearmost position. The total seat track travel measured 24.1 cm (9.5 in). The seat back was reclined 20 degrees. The horizontal measurement from the center of the seat back to the driver air bag module was 66 cm (26 in). The track position of the right front seat measured 7.1 cm (2.8 in) forward of the rearmost position, with a total travel of 24.1 cm (9.5 in). The seat back was reclined 15 degrees. The horizontal measurement from the center of the right front seat back to the leading edge of the front passenger air bag module was 94 cm (37 in).

INTERIOR DAMAGE

The only damage to the interior of the Mitsubishi were those associated to the deployment of the SRS and interaction with the occupants. There was no interior damage associated to the external forces of the crash. The left center of the windshield exhibited a fracture caused by contact from the upper left corner of the center mirror. The fracture was located 8.6 cm (3.4 in) left of center and 35.6 cm (14.0 in) above the instrument panel. The center mirror was displaced from its mount by a probable contact from the right front passenger. There was a scuff on the back (non-reflective) side of the mirror attributed to this contact.

The left aspect of the driver's knee bolster, near the heater vent, exhibited contact from the driver's left knee. The bolster was displaced forward and cracked above the impact sight, **Figure 5**. There was no deformation to the steering wheel rim. However, the steering column exhibited indications of having been loaded. The trim panels forward of the steering wheel were displaced, **Figure 6**. The displacement of the steering column's shear plate measured approximately 5 mm (0.2 in) and 10 mm (0.5 in) on its outboard and inboard sides, respectively, **Figure 7.**

Figure 5: View of the driver's left knee contact.

Figure 6: Right lateral view of the steering wheel.

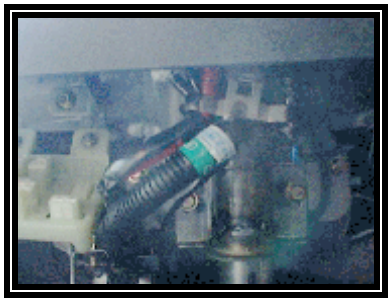

Figure 7: View of the steering column's shear plate.

MANUAL RESTRAINT SYSTEM

The manual restraint system in the Mitsubishi Mirage consisted of 3-point lap and shoulder belts for the four outboard seating positions. The center rear position was equipped with a lap belt. The front seat belt systems consisted of a continuous loop lap and shoulder belt webbing with a sliding latch plate. An inertia activated locking retractor was located in the base of each B-pillar. The restraint's upper anchorages (D-rings) were adjustable. The left front D-ring was adjusted to 2.5 cm (1.0 in) below the full up position. The right front D-ring was adjusted 2.5 cm (1.0 in) above the full down position. Both front restraints were found in the stowed position at inspection. The respective retractors were not locked. The driver reportedly refused to wear a seat belt and was unrestrained in this crash. The webbing of the right front restraint exhibited two witness marks corresponding to the hardware surfaces of the buckled latch plate and D-ring respectively. These marks were indicative that the right front restraint was in use at the time of the crash.

SUPPLEMENTAL RESTRAINT SYSTEM

The Mitsubishi Mirage was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags. The SRS was controlled by the air bag control module located in the occupant compartment. The impact sensors were mounted in the control module. The driver air bag module was located in the typical manner in the center hub of the steering wheel. The front passenger air bag module was a top mount located in the right aspect of the instrument panel.

The driver air bag deployed as designed from the H-configuration module, **Figure 8**. The width of the vinyl cover flaps measured 16.0 cm (6.3 in) at the center seam. The height of the upper and lower flaps were 6.4 cm (2.5 in) and 5.8 cm (2.3 in), respectively. There was no contact evidence on the interior or exterior surfaces of the cover flaps.

The driver air bag measured 66 cm (26 in) in its deflated state. The air bag was not tethered. The bag was vented by two 3.3 cm (1.3 in) diameter ports located in the 11/1 o'clock sectors on the back side of the bag. There were two distinct areas of occupant contact on the face of the air bag, **Figure 9**. The contact evidence consisted of cross-hatch abrasions caused by contact with the driver's prescription glasses. An area approximately 48 cm (19 in) by 23 cm (9 in) extended over the 8 to 12 o'clock sectors and a 15 cm x 10 cm (6 in x 4 in) area was noted in the right lower quadrant. The large abraded area in the upper left quadrant extended onto the back side of the bag. At inspection, the glasses were found on the left side of the instrument panel. It was noted that the metal frames of the glasses were bent and distorted. The lenses were intact. A bar code label was located in the 12 o'clock sector on the back side of the with the following designation:

P66280-34110
TBD4 11410877

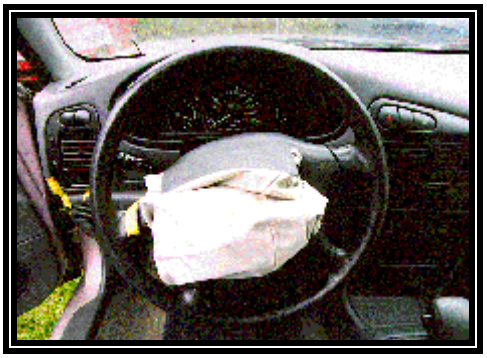

Figure 8: View of the driver air bag module.

Figure 9: View of the contact evidence on the air bag face.

Figure 10 is a view of the top-mount front passenger air bag module. The exterior dimensions of the module measured 32.5 cm x 19.1 cm (12.8 in x 7.5 in) width by height. The single vinyl cover flap was hinged on the forward aspect of the module and measured 22.9 cm x 10.2 cm (9.0 in x 4.0 in). The front passenger air bag extended from the inflator 64 cm (25 in). The face of the air bag measured 58 cm x 51 cm (23 in x 20 in) width by height in its deflated state. The air bag was not tethered and was vented by two 6.4 cm (2.5 in) diameter vent ports located on the bag's side panels. A 20 square cm (8 sq in) area of fabric abrasion was noted on the face of the bag, **Figure 11**. This abrasion was probably caused by

an interaction between the right front occupant and the fully expanded air bag. The following manufacturer's designation was located in the 12 o'clock sector of the bag:

BBNN007
4SS947173
190794
014193

Figure 10: View of the front passenger air bag module.

Figure 11: Front passenger air bag.

DRIVER DEMOGRAPHICS

Age/Sex:	38 year old female
Height:	160 cm (63 in)
Weight:	89 kg (196 lb)
Manual Restraint Usage:	Unrestrained
Usage Source:	Vehicle inspection/Driver injury pattern/Police investigation
Eyeware:	Prescription eye glasses

DRIVER INJURIES

Injury	Severity (AIS 90)	Injury Mechanism
Perforation of the right ventricle w/ pericardial tamponade	Critical (441012.5,4)	Deploying driver air bag
Left pulmonary laceration w/ hemothorax (bleeding parenchymal and massive air leak)	Critical (441440.5,2)	Deploying driver air bag
Severe closed head injury - GSC=3, unconscious at scene	Severe (160804.4,0)	Deploying driver air bag
Left pulmonary contusion	Serious (441406.3,2)	Deploying driver air bag

Injury	Severity (AIS 90)	Injury Mechanism
Bilateral periorbital ecchymosis and swelling	Minor (297402,1.1) Minor (297402.1,2)	Deploying driver air bag/glasses
Massive bony crepitus to nose (crush injury to mid-face w/ crepitus)	Critical (251000.1,4)	Deploying driver air bag
Right 1st rib fracture	Minor (450212.1,1)	Left arm contact from the right front passenger
Pale contusions over both cheeks	Minor (290402.1,1) Minor (290402.1,2)	Deploying driver air bag
Superficial abrasion over the right lower cheek and jaw	Minor (290202.1,1)	Deploying driver air bag
Abraded and contused lower lip	Minor (290202.1,8) Minor (290402.1,8)	Deploying driver air bag
Contusions to the anterior right shoulder, right upper chest, left shoulder, left chest, mid-chest	Minor (790402.1,3) Minor (490402.1,0)	Deploying driver air bag
3 contusions to the anterior shin (leg unspecified)	Minor (890402.1,9)	Driver's knee Bolster

NOTE: the above injuries were identified in the medical records submitted by the treating hospitals and the medical examiner's external examination. An invasive autopsy was not performed.

DRIVER KINEMATICS

The driver of the Mitsubishi Mirage was seated in a normal driving position with the seat adjusted in a mid to rear track position. The track position was 7.6 cm (3.0 in) forward of the rear most position (16.5 cm (6.5 in) rearward of full forward). The driver was not wearing the manual 3-point restraint. Immediately prior to the crash, the driver slumped forward and her head contacted the steering wheel. The police and SCI investigator identified several strands of the driver's hair embedded in the 9 o'clock spoke of the steering wheel rim, adjacent to the horn pad **Figure 8**. The driver then had a Grand Mal epileptic seizure and subsequently relinquished directional control of the vehicle. The driver had a reported history of epilepsy however, she had been seizure free for approximately 3 years prior to the crash. In the course of the seizure, the driver probably returned to an upright posture. The right front passenger reached across to attend to the driver and unsuccessfully attempted to redirect the trajectory of the vehicle. The right front passenger indicated the driver's foot remained on the accelerator and he unsuccessfully attempted to take the vehicle out of gear.

Upon impact with the tree, the driver initiated a forward trajectory in response to the 12 o'clock direction of the impact. The driver's left knee contacted and cracked the knee bolster (**Figure 5**). The forward kinematic pattern positioned the driver within the deployment zone of the driver air bag. The deploying air bag contacted the driver's chest resulting in the right ventricle perforation, left pulmonary laceration, contusion and hemothorax and the thoracic contusions. The probable cause of the right 1st rib fracture was a rebound contact from the left arm of the right front passenger. The passenger's left arm was extended across the driver air bag module and fractured during the deployment. The arm then rebounded impacting the driver.

The driver's forward trajectory and interaction with the deploying air bag loaded the steering column evidenced by the displacement of the shear capsules and deformation to the interior trim panels forward of the steering wheel rim. The displacement of the steering column's shear plate measured approximately 5 mm (0.2 in) and 10 mm (0.5 in) on its outboard and inboard sides, respectively, refer to **Figure 7**.

The sudden deceleration of the chest caused the driver's head to rotate forward and into contact with the deploying air bag. The abrasions on the face of the air bag are indicative of the direct contact between the driver's glasses and the expanding air bag. The interaction between the expanding air bag and the driver's glasses coupled with the driver's forward kinematic pattern caused the periorbital ecchymosis and facial and head trauma.

MEDICAL INTERVENTION

Reportedly, the ambulance arrived at the scene 3 minutes after notification (an estimated 8 minutes post-crash). Upon arrival, the driver was found in the left front seat breathing at 8 breaths per minute. Rapid extrication from the vehicle was executed. Assessment of the driver showed the right pupil to be reactive and 5 mm and the left pupil to be non-reactive and 9 mm. The driver's Glasgow Coma Score (GSC) was 3. The driver became pulseless and apneic at the scene. CPR was initiated in the field and the driver regained a pulse with no spontaneous respirations. An airway could not be established due to the fact the driver's teeth were clenched from the seizure. Assisted respirations continued throughout the driver's transport. The driver was transported via helicopter to the emergency room of a local hospital (43 minutes post-crash) and arrived 51 minutes post-crash.

Upon arrival in the emergency room, the driver was intubated via the oral tracheal route. A significant amount of frothy bloody fluid was coming from the mouth and nose and once intubated the fluid came from the endo-tracheal tube. This fluid emission continued throughout the course of the trauma code. The driver's pupils were both 8 mm fixed and dilated. Her GSC was 3 and remained 3 throughout. The driver became intermittently hypertensive and hypotensive and CPR had to be intermittently initiated. A chest tube was placed on the left and a massive air leak identified. The continued hypotension indicated an intra-thoracic or intra-abdominal bleed, however it could not be identified. It was decided, in conjunction with

the family, that the patient could be best served by a transfer to a level 1 trauma center. The driver was transferred in an unstable fashion via helicopter 1 hour 28 minutes after arrival in the ER (2 hours 19 minutes post-crash).

The driver arrived in the ER of the trauma center 3 hours 20 minutes post-crash. She was unresponsive, difficult to ventilate and hemo-dynamically unstable with persistent hypotension.
After a brief period of treatment in the ER, it was recognized that exploration in the operating room was necessary. The findings of the operation are as follows:

1. No evidence of intra-abdominal bleeding on a limited exploratory laparotomy;
2. Left pulmonary laceration w/ active bleeding and huge air leak;
3. Pericardial tamponade w/ 30-50 cc of blood in the pericardium;
4. Small hole in the right ventricle w/ active bleeding.

The patient had periods of hypotension and at least two periods of bradycardia arrest that necessitated cardiac message. She continued to have problems with heart rhythm and uncontrolled bleeding from the lung. The patient continued to deteriorate and had further sequences of arrest at which time it was thought further resuscitation was futile. The patient was pronounced dead 5 hours 14 minutes post-crash.

RIGHT FRONT PASSENGER DEMOGRAPHICS

Age/Sex:	14 year old male
Height:	173 cm (68 in) estimated
Weight:	56 kg (123 lb) estimated
Manual Restraint Usage:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection/Passenger statements
Eyeware:	None

RIGHT FRONT PASSENGER INJURIES

Injury	Severity (AIS 90)	Injury Mechanism
Unspecified fracture of the left forearm	Moderate (751800.2,2)	Deploying driver air bag

RIGHT FRONT PASSENGER KINEMATICS

The right front passenger was seated in a presumed normal posture with the seat adjusted in a mid-to-rear track. The track position was 2.8 in forward of the rearmost position (6.7 in rearward of the forward most position). The passenger was restrained by the manual 3-point belt system. Inspection of the right front restraint in the extended and latched position identified abrasions on the webbing consistent with the

hardware surfaces at the latch plate and D-ring.

Immediately prior to the impact, the right front passenger extended his left arm toward the driver. and his torso was possibly turned toward the left. The passenger was attempting to aid his mother during her seizure and redirect the trajectory of the vehicle. At impact, the passenger initiated a forward trajectory in response to the 12 o'clock direction of the impact. The passenger's left arm was probably extended in front of the driver air bag module. The deploying driver air bag contacted and fractured the passenger left forearm. The air bag deployment caused the arm to rebound and the arm then impact the driver. This probable contact caused the driver's right first rib fracture. The passenger contacted and loaded his manual 3-point restraint and the deployed right front passenger air bag. The passenger then rebounded back into the seat. It was probable the center mirror was contacted and displaced during this kinematic sequence resulting in the afore-mentioned windshield fracture.