TRANSPORTATION SCIENCES
Crash Data Research Center

Veridian Engineering
Buffalo, New York 14225

VERIDIAN ON-SITE AIR BAG RELATED FETAL FATALITY INVESTIGATION
VERIDIAN CASE NO. CA98-055
VEHICLE: 1998 MITSUBISHI MIRAGE DE
LOCATION: PENNSYLVANIA
CRASH DATE: OCTOBER 1998

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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 driver injury mechanisms and cause of death of a fetus that resulted from an air bag deployment crash. The subject vehicle was a 1998 Mitsubishi Mirage that was equipped with frontal air bags for the driver and front right positions. The 19 year old female driver of the Mitsubishi was initiating a left turn at an urban four-leg intersection when the front right aspect of her vehicle struck the left drive axle of a straight truck. The minor severity crash deployed the vehicle's frontal air bag system. The driver air bag module cover flap and the expanding air bag membrane contacted the protruding abdomen of the driver which resulted in a chest wall contusion at the lower sternal region and an abruption of the placenta. In addition, the driver sustained comminuted fractures of the left proximal radius and ulna from bag expansion. She was transported by ambulance to a regional trauma center where her injuries were diagnosed and an emergency caesarian section was performed which delivered a still born fetus.			
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BACKGROUND

This on-site investigation focused on the driver injury mechanisms and cause of death of a fetus that resulted from an air bag deployment crash. The subject vehicle was a 1998 Mitsubishi Mirage that was equipped with frontal air bags for the driver and front right positions. The 19 year old female driver of the Mitsubishi was initiating a right turn at an urban four-leg intersection when the front left aspect of her vehicle struck the left drive axle of a straight truck. The minor severity crash **(Figure1)** deployed the vehicle's frontal air bag system. The driver air bag module cover flap and the expanding air bag membrane contacted the protruding abdomen of the driver which resulted in a chest wall contusion at the lower sternal region and an abruption of the placenta. In addition, the driver sustained comminuted fractures of the left proximal radius and ulna from bag expansion. She was transported by ambulance to a regional trauma center where her injuries were diagnosed and an emergency caesarian section was performed which delivered a still born fetus.

Figure 1 - Minor severity frontal damage to the Mitsubishi Mirage.

NHTSA's Special Crash Investigation Division was notified of the crash on October 5, 1998 by the medical examiner who performed an autopsy on the 33 week old fetus. The notification was immediately forwarded to the Veridian SCI Team. Cooperation with local officials was obtained and an on-site investigation was conducted two days following notification. The on-site investigation included an inspection of the Mitsubishi Mirage, evaluation of the crash scene, and interviews with the driver of the Mitsubishi Mirage, the driver's mother and grandmother, the rescue team, and residents in the vicinity of the crash site. The straight truck was not inspected.

SUMMARY

Crash Site

The crash occurred near a four-leg intersection in an urban/commercial area. The Mitsubishi Mirage was traveling on a two lane street that was 9.3 m (30.5') in width. Both edges of the street were bordered by shallow curbs with 1.9 m (6.2') wide concrete sidewalks paralleling the curblines. Buildings were located within a close proximity to the curblines. This asphalt street was straight and level. The straight truck was traveling on a two lane street where parallel parking was permitted adjacent to the north curbline. A double yellow centerline was off-set to the road width to facilitate the parallel parking. The eastbound travel lane was 3.8 m(12.5') in width while the westbound lane was 8.5 m (27.9'), inclusive of the parking lane. The street was straight with a downgrade on the approach to the intersection that transitioned to a sag at the

intersection. The 12.3 m (40.3')wide road surface was bordered by curbs with sidewalks paralleling the curblines. North/south traffic flow through the intersection was regulated by stop signs. East/westbound traffic was not controlled through the intersection. The posted speed limits were 40 km/h (25 mph).

Crash Sequence

Pre-Crash

The 19 year old female driver of the Mitsubishi Mirage was traveling in a northerly direction on an approach to the four-leg intersection **(Figure 2)**. The driver stopped her vehicle for the regulatory stop sign and check for approaching vehicles in both the east and west travel directions. She noted the intersection area was clear of approaching eastbound traffic and she initiated a right turn onto the two lane intersecting street. The 1998 Kenworth straight truck was traveling in a westbound direction on an approach to the intersection **(Figure 3)**. Due to non-contact vehicles parked at the north curbline, the driver of the truck was straddling the centerline of the street as he approached the intersection. As the driver of the Mitsubishi initiated the right turning maneuver, she observed the truck immediately prior to the impending crash. She braked rapidly in an attempt to avoid the crash.

Figure 2 - Approach of the 1998 Mitsubishi Mirage to the intersection prior to the right turn

Figure 3 - Trajectory of the 1998 Kenworth medium/heavy truck, 30 m from POI

Crash

The front left and center areas of the Mitsubishi Mirage impacted the left rear side area of the truck, presumably at the left leading axle. The impact crushed the front bumper of the Mirage and displaced the left headlamp assembly and left front fender **(Figure 4)**. The resultant directions of force were within the 1 o'clock sector for the Mirage and 12 o'clock for the truck. Although the truck was outside the scope of the WinSMASH reconstruction program, the damage algorithm computed a barrier equivalent total delta V of 16 km/h (10 mph) with a longitudinal delta V component of -15 km/h. (-9 mph) for the Mirage. This speed change estimate appeared reasonable for the damage to the vehicle. As a result of the crash, the Mitsubishi's frontal air bag system deployed.

Figure 4 - Close-up view of the direct contact area on the left frontal bumper of Vehicle #1

The Mitsubishi rotated counterclockwise and came to rest diagonal in its travel lane. The straight truck continued through the intersection and came to a controlled stop in its lane approximately 45 m (150') from the point of impact (POI). The Crash Schematic is attached as **Figure 11**, Page 10.

Post-Crash

Immediately following the crash, the driver of the Mitsubishi Mirage attempted to open the left front door with her left hand, but was unsuccessful due to associated pain in the forearm. She reached over with her right hand and pulled the door release handle. She then pushed the door open with her left foot and rested her left foot on the ground. She turned slightly sidewards in her seat and rested her left arm on her lap. She remained seated in this position until rescue personnel arrived on-scene.

Members of the responding rescue unit were located approximately 61 m (200') from the crash site and were outside of their station at the time of the crash. Several members heard the crash. One of the members ran to the crash scene while another notified dispatch and subsequently responded to the intersection with an ambulance. Upon arrival, rescue personnel observed the driver of the Mitsubishi seated in the driver seat with the steering assembly resting on her lap with her abdominal area within an estimated distance of 10 cm (4") from the steering wheel rim. The rescue squad wanted to place a backboard behind the driver, but the driver insisted on getting out of the vehicle with assistance. She was helped to her feet and placed on a gurney. Rescue personnel attempted to apply a splint to her left arm, but due to the extreme emotional condition of the driver and her resistance to their efforts, they subsequently stabilized the arm using rolled towels.

During the initial observation of the driver, rescue personnel noted a 12.7-15.4 cm (5.0-6.0") lateral tear of the driver's shirt fabric which was located in the upper abdominal area. It was described as having the appearance of being cut by a scissors. The rescue personnel did not observe any lesions over the abdominal or chest areas after removing the driver's clothes.

The ambulance departed the scene 12 minutes after the time of the crash. An Advanced Life Support unit from the hospital was dispatched and met the ambulance en route. They boarded the ambulance and established an IV with a saline solution. The unit arrived at the emergency room of the regional trauma center approximately 8 minutes of the departure time from the scene.

Vehicle Data - 1998 Mitsubishi Mirage

The 1998 Mitsubishi Mirage DE was manufactured in August 1998 and was identified by vehicle identification number JA3AY26A1WV (production number deleted). The Mirage was equipped with a 1.5 liter transverse gasoline engine linked to a 4-speed automatic transmission with a floor mounted shifter. The body was configured as a 4-door sedan. The braking system consisted of power-assisted front disc/rear drum brakes without anti-lock. In addition to the frontal air bag system, the Mirage was equipped with 3-point lap and shoulder belts for the four outboard positions. The center rear seated position was equipped with a lap belt. The driver’s belt system was a continuous loop webbing with a sliding latchplate and an emergency locking (inertia activated) retractor. The upper D-rings were adjustable for both front

positions. The remaining three outboard belt systems utilized a belt sensitive (ALR) and an emergency locking retractor (ELR). The outboard aspects of the front seat lap belts incorporated an energy management loop. The driver was not wearing the manual belt system, therefore the system was not loaded or damaged.

The front seated positions consisted of bucket seats with reclining back rests and adjustable head restraints. The rear bench seat had a 60/40 split backrest that was forward folding. The interior was trimmed with cloth fabric on the seats and side door panels. At the time of the SCI inspection, the vehicle's odometer reading was 13,227 km (8,219 miles).

Vehicle Damage

Exterior - 1998 Mitsubishi Mirage DE

The front left and center area of the Mitsubishi Mirage impacted the left side (presumably the leading tire of the rear axle) of a 1998 Kenworth straight medium/heavy truck which was configured with an oil tank body. The direct contact damage began at the vehicle's centerline and extended 70.8 cm (27.875"") to the left bumper corner **(Figure 5)**. During the crash sequence, the bumper fascia separated from the bumper reinforcement bar and split into two pieces. Maximum crush was 18.4 cm (7.25") located on the bumper reinforcement bar at the left corner. The combined induced and direct contact damage was 141.6 cm (55.75") that extended the full width of the reinforcement bar. Components damaged by the impact included the front bumper fascia, the bumper reinforcement bar, the left headlight assembly, the left front fender, and the hood. Although the vehicle was towed from the scene of the crash, the Mirage was driveable. The assigned Collision Deformation Classification (CDC) was 01-FYEW-1. A frontal crush profile was documented at the bumper reinforcement bar. The crush values are listed in the following table:

Figure 5 - Overall frontal view of Vehicle #1

Crush Values: Frontal bumper reinforcement bar	C_1 = 18.4 cm (7.25")	C_2 = 12.1 cm (4.75")	C_3 = 9.8 cm (3.875")
	C_4 = 5.4 cm (2.125")	C_5 = 3.8 cm (1.5")	C_6 = 3.8 cm (1.5")

Interior - 1998 Mitsubishi Mirage DE

Interior vehicle damage to the 1998 Mitsubishi Mirage DE was attributed to driver contacts **(Figure 6)** and the deployment of the frontal air bag system. The left side of the windshield exhibited a spider web-type fracture pattern that was attributed to contact by the driver's left hand. The fracture point was located 43.2 cm (17.0") left of the vehicle centerline and 26.7 cm (10.5") below the windshield

Figure 6 - Angular view of the diver contact points within the Mirage.

header. A single strand of black hair was adhered to the inboard surface of the left upper A-pillar, located 19.1 cm (7.5") below the windshield header.

The top surface of the left instrument panel exhibited five transfer marks resembling finger streak marks that probably resulted from rescue personnel during extrication activities. The pattern began 20.3 cm (8.0") left of the vehicle centerline and extended 15.2 cm (6.0") to the left in a curved pattern. Adjacent to the outboard aspect of these transfers was a 12.7 cm (5.0") diameter transfer which may have resulted from the rescuer's left hand or forearm. This transfer was located 40.0 cm (15.75") left of the vehicle centerline.

The energy absorbing steering column was displaced forward with total separation of the shear plate from the shear capsules **(Figure 7**). The shear plate displacement was measured at 3.8 cm (1.5") for both the left and right shear capsules. The steering wheel rim was not deformed. Rescue personnel indicated that the tilt column was re-adjusted upward to facilitate the extrication of the driver. The angle of the adjustable steering column measured 22 degrees when repositioned against the shear capsules. There was a beige color transfer mark along the lower outboard aspect of the steering column shroud which began at the junction of the steering wheel and extended 6.4 cm (2.5") downward. This was attributed to contact by the driver's left upper leg during the crash.

Figure 7 - View of the shear plate and shear capsule separation of the Mitsubishi Mirage.

The front left driver air bag module cover exhibited heavy teal blue color fabric transfers along the sides and bottom periphery that were attributed to contact with the driver's teal blue shirt during the deployment sequence **(Figures 8 and 9)**. Contact began 4.8 cm (1.875") below the top hinge point of the single flap and measured 1.3 cm (0.5") wide. The fabric contact pattern widened to 3.2 cm (1.25") at the bottom edge. The dimensions of the flap measured 17.5 cm (6.875") laterally along the top hinge which narrowed to 7.6 cm (3.0") along the bottom edge. The vertical height of the flap measured 12.1 cm (4.75").

Figure 8 - View of the front left air bag module cover flap showing the fabric transfer along the perimeter of the flap

Figure 9 - Close-up view of the bottom edge of the air bag module cover showing the extent of fabric transfer

There was a 1.3 cm (0.5") diameter oil-type transfer on the knee bolster located left of the steering column. This was attributed to contact by the driver's left knee. A lateral striated dirt-type transfer mark was noted on the knee bolster adjacent to the inboard aspect of the of the hood release lever and continued onto the forward portion of the left front door panel. These marks were consistent with the driver's description of pushing the door open with her left foot after the crash.

The right side of the windshield exhibited a vinyl transfer resulting from contact with the front right air bag module cover flap during the deployment sequence. The lateral dimension of the contact measured 25.4 cm (10.0") which was located 19.1 cm (7.5") right of the vehicle centerline. The vertical height of the contact measured 6.4 cm (2.5") and was located 49.5 cm (19.5") below the windshield header. There was no contact evidence visible on the front right air bag.

The right front seat was a reclining bucket seat which was located 1.9 cm (0.75") forward from the full rear track position. This placed the seat back support 81.3 cm (32.0") rearward from the opening edge of the front right air bag module cover flap.

Frontal Air Bag System

The driver was the original owner of the 1998 Mitsubishi Mirage DE and was the primary driver. She indicated that the vehicle had not been serviced for any air bag related problems. The driver indicated that the air bag indicator light in the lower right area of the instrument cluster would flash for a short time and disappear. She was not sure what the light represented as she had not reviewed the owner's manual. The ignition was cycled to the run position during the inspection and the air bag light illuminated as a steady red, which indicated air bag deployment.

The vehicle was manufactured in August 1997. Reference data from the vehicle manufacturer indicated that this vehicle was produced prior to the introduction of redesigned frontal air bags in this vehicle line.

The front left driver air bag system was comprised of a module cover with a single flap and a tethered air bag. The cover flap was hinged at the top and opened along the normal tear side and bottom seam lines. The cover measured 12.1 cm (4.75") vertically and 17.5 cm (6.875") laterally along the top portion of the flap and 7.6 cm (3.0") laterally along the bottom edge. The cover flap thickness measured 1.6 mm (1/16").

The front left driver air bag module cover exhibited a heavy teal blue fabric transfer along both sides and along the bottom edge. Contact began 4.8 cm (1.875") below the top hinge point along the vertical seam edges and measured 1.3 cm (0.5") wide. The fabric contact pattern widened vertically at the bottom edge to 3.2 cm (1.25"). The color of this transfer was consistent with the driver's description of her shirt color. Additionally, the 12.7-15.24 cm (5-6") lateral tear described by rescue personnel in the center upper abdominal area of the shirt was consistent with the 17.5 cm (6.875") lateral dimension of the flap.

The front left air bag module cover flap was backed by a 1.6 mm (1/16") thick vinyl pad with an overlaying thin circuitry panel for the horn. Neither the vinyl backing pad nor the horn circuitry panel exhibited any signs of damage.

The front left driver air bag was a tethered design with tethers located at 3 and 9 o'clock positions. The attachment of the tethers to the front surface of the air bag created a single stitched circle which had a 16.5 cm (6.5") diameter. The overall diameter of the air bag measured 67.3 cm (26.5"). There were two 4.4 cm (1.75") diameter vent ports located in 10 o'clock and 2 o'clock positions which were separated by a distance of 33.7 cm (13.5"). An identification number printed on the rear surface of the air bag was as follows:

66280-50340
ME7148674

Figure 10 - View of the front left driver air bag

The front left driver air bag exhibited dark artifacts that were detected only when a light source was placed behind the air bag resulting in diffused light passing through the air bag material (**refer to Figure 10**). These artifacts were attributed to contact with the driver's shirt during air bag expansion.

The front right air bag deployed from a mid mount module assembly from the right instrument panel. The single cover flap opened at the designated tears seams in an upward direction and contacted the windshield. There was no damage or driver contact evidence on the front right air bag membrane.

Driver Demographics - 1998 Mitsubishi Mirage

Age/Sex:	19 year old female, 33 weeks pregnant
Height:	157.5 cm (62.0")
Weight:	62.6 cm (138.0 lb)
Seat Track Position:	Forward
Eyeware:	None
Manual Restraint System Usage:	None
Usage Source:	Vehicle inspection, driver interview
Mode of Transport From Scene:	Ambulance to a regional trauma center
Type of Medical Treatment:	Admitted for three days for treatment of her injuries and an emergency caesarian section

Driver Injuries

INJURY	Injury Severity (AIS-90/Update 98)	SOURCE
Abruption of the placenta with a retroplacental hematoma that measured 11x2.2x8.6 cm	Serious (543400.3,8)	Front left driver air bag module cover flap and air bag
Comminuted fractures of the left proximal radius and ulna	Serious (752804.3,2; 753204.3,2)	Expanding front left driver air bag
Chest wall contusion at the lower sternal region	Minor (490402.1,4)	Front left driver air bag module cover flap and/or air bag
Abrasion of the lower chin at the midline	Minor (290202.1,8	Expanding front left driver air bag

* Source of Injuries - Hospital medical records

Driver Kinematics

The driver of the Mitsubishi Mirage was a 19 year old female who was 157.5 cm (62.0") tall, weighed 62.6 kg (138 lb), and was in her 33rd week of pregnancy at the time of the crash. The driver described her seat tack position as adjusted three notches rearward of the full forward position which she stated placed her close to the steering wheel. At the time of the SCI inspection, the seat track position measured 8.6 cm (3.375") rearward of the full forward position over a total seat track adjustment range of 21.9 cm (8.625"). In this position, the seat back support measured 50.8 cm (20.0") rearward from the air bag module cover at a height of 34.3 cm (13.5") above the junction with the seat cushion. The seat back angle measured 16 degrees rearward from vertical. The head restraint was adjusted 5.1 cm (2.0") above the top of the seat back support. The seat cushion was designed with a 17 degree incline with the forward edge of the seat measuring 27.9 cm (11.0") above the floor pan and 10.8 cm (4.25") rearward from the vertical plane of the instrument panel.

She was not wearing the available manual 3-point lap and shoulder belt. The left front 3-point manual lap and shoulder belt had an inertia activated locking retractor. The D-ring was adjustable and was positioned 2.5 cm (1.0") below full up over an adjustment range of 9.5 cm (3.75"). The latch plate showed some signs of wear from historical usage. The driver indicated that she routinely wore the manual belt system. On the morning of the crash, the driver stated that she had numerous household tasks to perform prior to her departure for work which distracted her from using the manual restraint system.

Prior to the crash, the driver was attempting to make a right turn at a four leg intersection. The steering wheel was rotated approximately 180 degrees clockwise due to the right turning maneuver. She applied

the brakes immediately prior to impact which resulted in the forward movement of her upper torso. Her upper abdominal area was positioned against the front left driver air bag module cover at the time of the crash. The deploying upper module cover flap impacted the upper abdominal, lower sternal area of the driver. This contact sequence was evidenced by the heavy fabric transfer along the perimeter of the cover flap and the tear of her shirt. The front driver air bag subsequently expanded against the driver's chest and chin. As a result of the cover flap contact and subsequent bag expansion, the driver sustained a chest wall contusion at the lower sternal region and an abrasion of the lower chin at the midline. The driver initiated a forward trajectory in response to the 1 o'clock impact force. The combination of air bag expansion against her body and her forward motion, resulted in compression of the energy absorbing steering column. There was no deformation of the steering wheel rim.

The driver's left hand was positioned on the steering wheel rim as she initiated the turn. The expanding air bag contacted the anterior aspect of her left forearm that resulted in comminuted fractures of the proximal radius and ulna. Her left hand subsequently separated from the steering wheel rim and was propelled up and to the left. Her left hand struck the windshield as evidenced by a spider web fracture pattern of the glazing. There was no injury associated with this contact sequence.

The driver rebounded back against the seat back support where she came to final rest with the steering wheel/column resting on her upper thighs. She elected to release the door with her right hand and pushed the door open with her left foot. The driver was then assisted from the vehicle by rescue personnel and transported via ambulance to the emergency room of a regional trauma center.

Medical Treatment

Upon arrival at the hospital, the driver experienced the onset of labor pains. A fetal monitor was applied to the driver and positive vital signs were obtained. An ultrasound was performed that identified an 8 cm placental abruption. A trauma physician ordered a CAT-scan of the driver's head prior to transferring her to the maternity unit of the hospital. The scan was performed with negative results.

The driver was transferred to the maternity unit and placed back on the fetal monitor. A fetal heart rate of 150 beats per minute with moderate variable decelerations was detected. The medical staff made the decision to perform a caesarian section. The fetal heart monitor was removed for a period of approximately three minutes to prepare the abdomen for the surgery. As the monitor was reapplied, no fetal heart rate was found. Within two minutes, the medical team moved the driver to the operating room. Within seven minutes, the incision was performed and the fetus was still born approximately two minutes later.

Fetus Data

The female fetus measured 43.2 cm (17.0") in length and weighed 2.0 kg (4.5 lb.). The fetus was devoid of any soft tissue injuries. An autopsy was performed which according to the medical examiner yielded negative findings for organ or skeletal trauma. Focal subscalp hemorrhage noted by the medical examiner was attributed to C-section activities rather than to crash related trauma. The medical examiner, however,

noted that the placenta showed signs of hemorrhage on the anterior surface located between the uterine wall and the fetus. Additionally, the medical examiner determined that 80 percent of the placenta had separated from the uterine wall during the crash sequence.

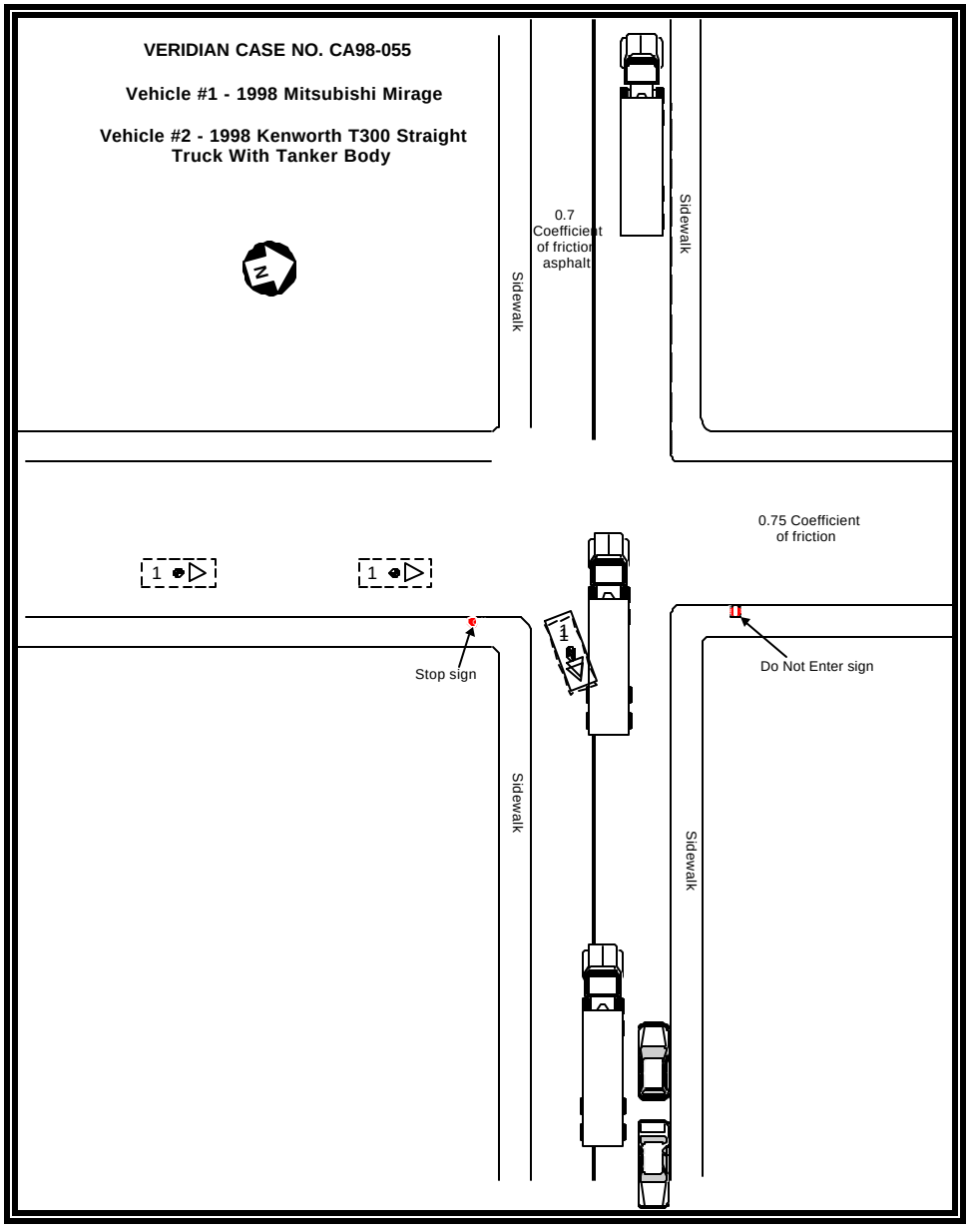

Figure 11. Crash Schematic.