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ON-SITE REDESIGNED AIR BAG INVESTIGATION

CASE NUMBER - IN-02-015
LOCATION - Indiana
VEHICLE - 2000 SATURN SL2
CRASH DATE - November 2002

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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 performance of the involved vehicle(s) or their safety systems.

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15. <i>Supplementary Notes</i> On-site investigation involving a 2000 Saturn SL2 equipped with redesigned air bags and an Event Data Recorder, a 1990 Ford Aerostar and a 1998 Mercedes Benz ML320					
16. <i>Abstract</i> This on-site investigation concerns an air bag deployment crash involving a 2000 Saturn SL2 sedan (case vehicle), a 1990 Ford Aerostar minivan (1st other vehicle), and a 1998 Mercedes Benz ML 320 sport utility vehicle (2nd other vehicle). This crash is of special interest because the case vehicle was equipped with redesigned air bags that did deploy and an Event Data Recorder (EDR) that was successfully downloaded. The case vehicle's driver (34-year-old female), who was not using the available manual, three-point, lap-and-shoulder safety belt system, sustained abdominal and thoracic injuries resulting in her death. The case vehicle was traveling west in the westbound lane of a two-lane rural road. The two other vehicles were traveling east in the eastbound lane of the same roadway. The case vehicle driver apparently fell asleep and the case vehicle drifted into the eastbound lane. The left side of the case vehicle impacted the left side of the Aerostar in a swiping-type engagement that was recorded by the EDR as a non-deployment event. The case vehicle continued west in the eastbound lane and had a head-on collision with the Mercedes, causing the case vehicle's driver and front right passenger air bags to deploy. All three vehicles were towed due to disabling damage. The case vehicle driver's injuries included: multiple bilateral pelvis fractures resulting in > 20% blood loss; fractured left femur; multiple rib fractures; fractures of the left forearm and left ankle; and various contusions, lacerations and abrasions. She was pronounced dead approximately four-and-a-half hours post-crash.					
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This on-site investigation was brought to the NHTSA's attention on November 7, 2002 by a newspaper article. This crash involved a 2000 Saturn SL2 sedan (case vehicle), a 1990 Ford Aerostar minivan (1st other vehicle), and a 1998 Mercedes Benz ML 320 sport utility vehicle (2nd other vehicle). The crash occurred in November 2002 at 5:38 p.m., in Indiana, and was investigated by the applicable county police. This crash is of special interest because the case vehicle was equipped with redesigned air bags that did deploy and an Event Data Recorder (EDR) that was successfully downloaded. The case vehicle's driver (34-year-old female, white, non-Hispanic), who was not using the available manual, three-point, lap-and-shoulder safety belt system, sustained abdominal and thoracic injuries resulting in her death. This contractor contacted the investigating police agency on November 7, 2002. Vehicle inspections were completed November 13-14, and the scene was inspected on November 15, 2002. The husband of the deceased case vehicle driver, who was not present at the crash, was interviewed on February 21, 2003. Medical records were received in April 2003. This report is based on the Police Crash Report, medical records, the interview with the driver's husband, scene and vehicle inspections, occupant kinematic principles and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling west in the westbound lane of a two-lane, undivided state highway and intended to continue straight ahead. The Ford and Mercedes were both traveling east in the eastbound lane of the same roadway, with the Ford ahead of the Mercedes, both intending to continue straight ahead. All three vehicles were traveling at or near the posted speed limit of 86 km.p.h. [55 m.p.h.]. The case vehicle driver apparently feel asleep and drifted over the center line and into the eastbound lane. The Ford and the Mercedes drivers observed the threat and both steered to their right (south). The case vehicle driver made no known avoidance maneuvers. The crash occurred in the eastbound lane of the roadway.

The left front corner of the case vehicle impacted the left side of the Ford in a swiping-type impact. The case vehicle continued westward and its front left area impacted the front left of the Mercedes, causing the case vehicle's driver and front right passenger air bags to deploy. The impact caused the case vehicle to rotate counterclockwise and its entire front engaged the left side of the Mercedes. The case vehicle was redirected into a northwesterly direction while rotating counterclockwise approximately 160 degrees. The case vehicle came to rest straddling the eastbound lane approximately 6.4 meters [21 feet] northwest of the point of impact with the Mercedes, heading northeast. After its impact with the case vehicle, the Ford rotated approximately 90 degrees counterclockwise, slid approximately 91.4 meters [300 feet] eastward and came to rest straddling the centerline, heading northwest. The Mercedes was redirected into a southeasterly direction onto an embankment on the right (south) side of the roadway and came to rest approximately 7.9 meters [26 feet] southeast of the point of impact, heading east. The Mercedes was equipped with dual frontal air bags and door-mounted side impact air bags. The two frontal air bags and the driver's side impact air bag deployed.

The case vehicle was a 2000 Saturn SL2 front wheel drive, four-door, five-passenger sedan (VIN: 1G8ZK5276YZ-----). Anti-lock brakes are an option for this vehicle, but it is unknown

if the case vehicle was so equipped. Based on the inspection, the CDC for the case vehicle's most severe (second) impact was determined to be: **12-FDEW-5 (10)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 70.0 km.p.h. [43.5 m.p.h.], -68.9 km.p.h. [-42.8 m.p.h.], and -12.2 km.p.h. [-7.6 m.p.h.]. The case vehicle's second most severe impact (first event, with the Ford) was masked by overlapping damage and a CDC could not be assigned. The WinSMASH Missing Vehicle algorithm, based on the damage to the Ford, was used on the case vehicle's second most severe impact. The Total, Longitudinal and Lateral Delta Vs are, respectively: 14.0 km.p.h. [m.p.h.], -13.8 km.p.h. [m.p.h.] and +2.4 km.p.h. [m.p.h.]. This is a borderline reconstruction, but the results appears reasonable. The case vehicle was towed due to damage.

The exact location of the first impact on the case vehicle is not known because of overlapping damage from the second impact, but it is likely that it was limited to a small portion of the left front corner. The case vehicle's highest severity impact was with the Mercedes and involved the entire front bumper. The exact length of direct damage is unknown because the bumper fascia was absent, but direct plus induced damage was measured as 71 centimeters [28 inches] from bumper corner to bumper corner. Maximum crush was measured as 109 centimeters [42.9 inches] at C1. The wheelbase on the left side was shortened 53 centimeters [20.1 inches] while the right side was lengthened 7 centimeters [2.8 inches]. The case vehicle's front bumper and fascia, grille, hood, radiator, both headlamp and turn signal assemblies, and left fender were directly damaged and crushed rearward. The left front wheel was pushed rearward and was restricted while the right front wheel was pulled forward and was not damaged or restricted. Both left side doors were jammed and required removal to extricate the driver.

The case vehicle driver's air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. There was little contact evidence despite the severity of the crash and the fact that the driver was not restrained. A scuff or makeup transfer was found on the lower center of the driver's air bag.

The front right passenger's air bag was located in the middle of the instrument panel. An inspection of the front right air bag module's cover flaps and air bag revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. There was no contact or damage evidence on the front right air bag.

Inspection of the case vehicle's interior revealed heavy intrusion, primarily in the driver's seat area. Components intruding longitudinally included: the left upper A-pillar, 66 centimeters [26.0 inches]; the driver's toe pan, 49 centimeters [19.3 inches]; the left portion of the instrument panel, 40 centimeters [15.7 inches]; and the side panel forward of the A-pillar, 28 centimeters [11.0 inches]. The driver's door sill intruded 30 centimeters [11.8 inches] laterally; intrusion by left side door components could not be evaluated because the door had been removed. The driver's seat cushion was deformed by intruding components. Evidence of contacts by the driver

were found on the driver's knee bolster, the steering wheel rim and the front of the driver's air bag.

The case vehicle was equipped with an Event Data Recorder (EDR) that was downloaded in the field. The Sensor Diagnostic Module (SDM) recorded a near-deployment event and a deployment event. The case vehicle's swiping-type impact with the Ford is the non-deployment event and the head-on impact with the Mercedes is the deployment event.

The SDM System Status reports for the Non-Deployment and Deployment events indicate that the events were recorded on ignition cycle 6,521, the SIR Warning Lamp was off and the driver's safety belt was not buckled. The Non-Deployment Pre-Crash data indicate that the case vehicle was traveling 80.5 km.p.h. [50 m.p.h.] at five seconds prior to algorithm enable, with the speed increasing to 83.7 km.p.h. [52 m.p.h.] and dropping back to 80.5 km.p.h. [50 m.p.h.] over the five second interval recorded. The brake light circuit was not activated over this five second interval. The maximum SDM recorded velocity change for the non-deployment event was -1.9 km.p.h. [-1.16 m.p.h.].

The SDM System Status at Deployment provides the additional information that there were 0.5 seconds between the non-deployment event and the deployment event. The Deployment Pre-Crash Data indicate that the case vehicle was traveling 83.7 km.p.h. [52 m.p.h.] at one second prior to algorithm enable, with no braking.

The SDM Velocity Change data indicate that the maximum change in velocity was -65.7 km.p.h. [-40.86 m.p.h.] at 110 milliseconds [0.11 seconds] after the signal to deploy was issued. The WinSMASH reconstruction results indicate longitudinal total Delta V -68.9 km.p.h. [-42.8 m.p.h.], which shows fairly close agreement between the recorded data and the reconstruction.

Immediately prior to the crash, the case vehicle's driver (34-year-old female, white, non-Hispanic, 157 centimeters and 61 kilograms [62 inches, 135 pounds]) was seated in an unknown posture. The police and the driver's husband (non-occupant) suspected the driver had fallen asleep and she may have been leaning (i.e., not upright) in her seat. Her left foot was probably on the floor, her right foot was probably on the accelerator and she presumably had at least one hand of the steering wheel. The SDM report indicates there was no pre-crash braking and only minor modulation of the throttle input. At the time of inspection, the seat back was in a fully reclined position, approximately 60 degrees from vertical.

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder safety belt system. The Event Data Recorder showed the driver's belt switch circuit status as unbuckled and there was no loading evidence of the driver's safety belt system.

The case vehicle's driver made no known pre-crash avoidance maneuvers as the case vehicle drifted over the center line. With no hard steering or braking, her position probably did not change. The swiping-type impact with the Ford probably caused her to move slightly forward and leftward. The case vehicle's impact with the Mercedes caused the air bags to deploy and caused the driver to move further forward, toward the 12 o'clock direction of force. The impact

was of sufficient force that the unrestrained driver's forward movement deflated the air bag as the front and side components intruded into her seating area.

The driver was transported by ambulance to a hospital. She sustained thoracic, abdominal and lower extremity injuries and was pronounced dead approximately four-and-half hours post-crash.

The first other vehicle was a 1990 Ford Aerostar front wheel drive, 3-door minivan (VIN: 1FMCA11UXLZA-----). Based on vehicle inspection, the CDC for the Ford was determined to be **11-LDEW-2 (340)** (maximum crush was 16 centimeters [6.3 inches]). The WinSMASH reconstruction program, missing vehicle algorithm, was used on the Ford's single impact, based on the Ford's measured crush profile and treating the case vehicle as missing (because of overlapping damage on the case vehicle). The Total, Longitudinal and Lateral DeltaV's for the Ford are: 9.0 km.p.h. [5.6 m.p.h.], -8.5 km.p.h. [-5.2 m.p.h.] and +3.1 km.p.h. [+1.9 m.p.h.]. This is a borderline reconstruction but the results appear reasonable. The Ford was towed from the scene but appeared not to have any truly disabling damage, except for the damage to the left rear wheel and tire.

The second other vehicle was a 1998 Mercedes Benz ML 320 four wheel drive, four-door sport utility vehicle (VIN: 4JGAB54E0WA-----). Based on the vehicle inspection, the CDC for the Mercedes was determined to be **12-FLEE-9 (350)** (maximum crush was 37 centimeters [14.6 inches]). The WinSMASH reconstruction program, damage algorithm based on the crush profile of both vehicles, was used on the Mercedes' single impact. The Total, Longitudinal and Lateral DeltaVs are, respectively: 40.0 km.p.h. [24.8 m.p.h.], -39.4 km.p.h. [-24.5 m.p.h.] and +6.9 km.p.h. [+4.3 m.p.h.]. The Mercedes was towed due to damage.

The drivers of the Ford and Mercedes both sustained police-reported "B" (evident, non-incapacitating) injuries. The treatment status and specific injuries for both other drivers are not known. There were no other occupants in either vehicle.

CRASH CIRCUMSTANCES

The case vehicle was traveling west in the westbound lane of a two-lane, undivided state highway and intended to continue straight ahead. The Ford and Mercedes were both traveling east in the eastbound lane of the same roadway, with the Ford ahead of the Mercedes, both intending to continue straight ahead (**Figure 1**). The weather was cloudy with no precipitation and it was dark. The asphalt surface was dry and free of defects, with white edge lines on both sides and the opposing lanes separated by double solid yellow lines. The paved surface was 7.4 meters [24.4 feet] from edge to edge. The surrounding landscape was open county and the crash location was on an elongated hill crest, with a slight positive slope for the approach from both directions. All three vehicles were traveling at or near the posted speed limit of 86 km.p.h. [55 m.p.h.]. The case vehicle driver apparently feel asleep and drifted over the center line and into the eastbound lane. The Ford and the Mercedes drivers observed the threat and both steered to their right (south). The case vehicle driver made no known avoidance maneuvers. The crash occurred in the eastbound lane of the roadway.

The left front corner of the case vehicle impacted the left side of the Ford in a swiping-type impact. The case vehicle continued westward and its front left area impacted the front left of the Mercedes, causing the case vehicle's driver and front right passenger air bags to deploy. The impact caused the case vehicle to rotate counterclockwise and its entire front engaged the left side of the Mercedes. The case vehicle was redirected into a northwesterly direction while rotating counterclockwise approximately 160 degrees. The case vehicle came to rest straddling the eastbound lane approximately 6.4 meters [21 feet] northwest of the point of impact with the Mercedes, heading northeast. After its impact with the case vehicle, the Ford rotated approximately 90 degrees counterclockwise, slid approximately 91.4 meters [300 feet] eastward and came to rest straddling the centerline, heading northwest. The Mercedes was redirected into a southeasterly direction onto an embankment on the right (south) side of the roadway and came to rest approximately 7.9 meters [26 feet] southeast of the point of impact, heading east. The Mercedes was equipped with dual frontal air bags and door-mounted side impact air bags. The two frontal air bags and the driver's side impact air bag deployed.

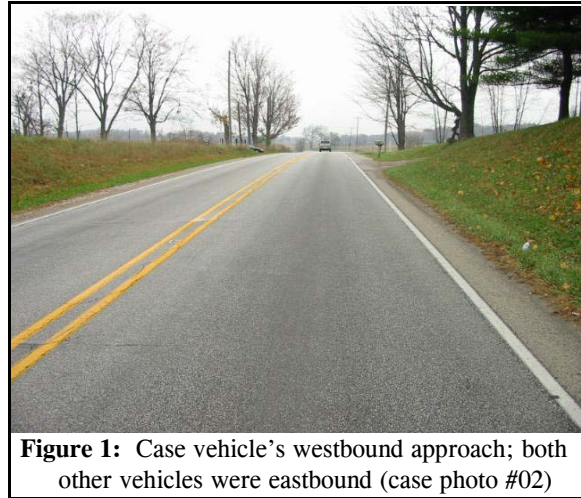


Figure 1: Case vehicle's westbound approach; both other vehicles were eastbound (case photo #02)

CASE VEHICLE

The case vehicle was a 2000 Saturn SL2 front wheel drive, four-door, five-passenger sedan (VIN: 1G8ZK5276YZ-----), equipped with an I-4 1.9 liter gasoline engine and an automatic transmission with a console mounted selector lever. Anti-lock brakes are an option for this vehicle, but it is unknown if the case vehicle was so equipped. The odometer reading is not known due to the non-functional electronic instrument panel. The Saturn's wheelbase was 260 centimeters [102.4 inches]. This vehicle was equipped with redesigned air bags at the driver and front right passenger positions and an Event Data Recorder. The case vehicle was towed due to damage.

CASE VEHICLE DAMAGE

The exact location of the first impact on the case vehicle is not known because of overlapping damage from the second impact, but it is likely that it was limited to a small portion of the left front corner. The case vehicle's highest severity impact was with the Mercedes and involved the entire front bumper (**Figure 2**). The exact length of direct damage is unknown because the bumper fascia was absent, but direct plus induced damage was measured as 71 centimeters [28 inches] from bumper corner to bumper corner. Maximum crush was measured as 109 centimeters [42.9 inches] at C1. The wheelbase on the left side was shortened 53 centimeters [20.1 inches] while the right side was lengthened 7 centimeters [2.8 inches]. The case vehicle's front bumper and fascia, grille, hood, radiator, both headlamp and turn signal assemblies, and left fender were directly damaged and crushed rearward. The left front wheel was

pushed rearward and was restricted while the right front wheel was pulled forward and was not damaged or restricted. Both left side doors were jammed and required removal to extricate the driver (**Figure 5**). The windshield was shattered across the entire width, with separation of the bonding over much of the perimeter. Left side glazing could not be evaluated due to the doors being removed. The backlight and right side glazing were intact.

Based on inspection, the CDC for the case vehicle's most severe (second) impact was determined to be: **12-FDEW-5 (10)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 70.0 km.p.h. [43.5 m.p.h.], -68.9 km.p.h. [-42.8 m.p.h.], and -12.2 km.p.h. [-7.6 m.p.h.]. The case vehicle's second most severe impact (first event, with the Ford) was masked by overlapping damage and a CDC could not be assigned. The WinSMASH Missing Vehicle algorithm, based on the damage to the Ford and treating the case vehicle as missing, was used on the case vehicle's second most severe impact. The Total, Longitudinal and Lateral Delta Vs are, respectively: 14.0 km.p.h. [8.6 m.p.h.], -13.8 km.p.h. [-8.5 m.p.h.] and +2.4 km.p.h. [+1.5 m.p.h.]. This is a borderline reconstruction, but the results appears reasonable.



Figure 2: Front of case vehicle, showing heavy crush and distorted wheelbase (case photo #17)

AUTOMATIC RESTRAINT SYSTEM

The case vehicle driver's air bag was located in the steering wheel hub (**Figure 3**). An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The deployed driver's air bag was round with a diameter of 55 centimeters [21.6 inches]. It was designed with two tethers, each 15 centimeters [5.9 inches] in width, and had no vent ports. There was little contact evidence despite the severity of the crash and the fact that the driver was not restrained. A scuff or makeup transfer was found on the lower center of the driver's air bag.



Figure 3: Front of case vehicle driver's air bag (case photo #40)

The front right passenger's air bag was located in the middle of the instrument panel (**Figure 4**). An inspection of the front right air bag module's cover flaps and air bag revealed that the cover flap opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flap. The deployed front right air bag was rectangular, measuring approximately 50 centimeters [19.7 inches] vertically and approximately 75 centimeters [29.5 inches] horizontally. It was designed with without any tether(s) or vent ports. There was no contact or damage evidence on the front right air bag.



Figure 4: Front of case vehicle front right passenger's air bag (case photo #45)

Inspection of the case vehicle's interior revealed heavy intrusion, primarily in the driver's seat area (**Figures 5 and 6**). Components intruding longitudinally included: the left upper A-pillar, 66 centimeters [26.0 inches]; the driver's toe pan, 49 centimeters [19.3 inches]; the left portion of the instrument panel, 40 centimeters [15.7 inches]; and the side panel forward of the A-pillar, 28 centimeters [11.0 inches]. The driver's door sill intruded 30 centimeters [11.8 inches] laterally; intrusion by left side door components could not be evaluated because the door had been removed. The driver's seat cushion was deformed by intruding components. Evidence of contacts by the driver were found on the driver's knee bolster, the steering wheel rim and the front of the driver's air bag.

EVENT DATA RECORDER

The case vehicle was equipped with an Event Data Recorder (EDR) that was downloaded in the field. The Sensor Diagnostic Module (SDM) recorded a near-deployment event and a deployment event. The SDM reports for the two events are attached as **Figures 9 - 13**. The case vehicle's swiping-type impact with the Ford is the non-deployment event and the head-on impact with the Mercedes is the deployment event.

The SDM System Status reports for the Non-Deployment (**Figure 9**) and Deployment (**Figure 11**) events indicate that the events were recorded on ignition cycle 6,521, the SIR Warning Lamp was off and the driver's safety belt was not buckled. The Non-Deployment Pre-Crash data (**Figures 9 and 10**) indicate that the case vehicle was traveling 80.5 km.p.h. [50 m.p.h.] at five seconds prior to algorithm enable, with the speed increasing to 83.7 km.p.h. [52 m.p.h.] and dropping back to 80.6 km.p.h. [50 m.p.h.] over the five second interval recorded. The brake light circuit was not activated over this five second interval. The maximum SDM recorded velocity change for the non-deployment event was -1.9 km.p.h. [-1.16 m.p.h.].

The SDM System Status at Deployment (**Figure 11**) provides the additional information that there was 0.5 seconds between the non-deployment event and the deployment event. The Deployment Pre-Crash Data (**Figures 11 and 12**) indicate that the case vehicle was traveling 83.7

km.p.h. [52 m.p.h.] at one second prior to algorithm enable, with no braking.

The SDM Velocity Change data (**Figures 11 and 13**) indicate that the maximum change in velocity was -65.7 km.p.h. [-40.86 m.p.h.] at 110 milliseconds [0.11 seconds] after the signal to deploy was issued. The WinSMASH reconstruction results indicate longitudinal Delta V -68.9 km.p.h. [-42.8 m.p.h.], which shows fairly close agreement between the recorded data and the reconstruction.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash, the case vehicle's driver (34-year-old female, white, non-Hispanic, 157 centimeters and 61 kilograms [62 inches, 135 pounds]) was seated in an unknown posture. The police and the driver's husband (non-occupant) suspected the driver had fallen asleep and she may have been leaning (i.e., not upright) in her seat. Her left foot was probably on the floor, her right foot was probably on the accelerator and she presumably had at least one hand of the steering wheel. The SDM report indicates there was no pre-crash braking and only minor modulation of the throttle input. Her seat track position could not be determined due to damage to the seat but, given the height and weight of the driver, a center position is most likely. At the time of inspection, the seat back was in a fully reclined position, approximately 60 degrees from vertical (**Figures 5 and 6**).

The case vehicle's driver was not using her available, active, three-point, lap-and-shoulder, safety belt system. The Event Data Recorder showed the driver's belt switch circuit status as unbuckled and there was no loading evidence on the driver's safety belt system.



Figure 5: Case vehicle's left side, showing driver's seat area (doors removed for extrication) (case photo #20)



Figure 6: Case vehicle driver's seat area, showing intrusion by front and left side components (case photo #35)

The case vehicle's driver made no known pre-crash avoidance maneuvers as the case vehicle drifted over the center line. With no hard steering or braking, her position probably did not change. The swiping-type impact with the Ford probably caused her to move slightly forward and

leftward. The case vehicle's impact with the Mercedes caused the air bags to deploy and caused the driver to move further forward, toward the 12 o'clock direction of force. The left instrument panel and knee bolster intruded rearward as she was moving forward and her knees/thighs impacted the knee bolster. Her left femoral head was fractured, left hip was dislocated and the force was transmitted to her pelvis, causing multiple bilateral fractures. The forward motion of her thorax and the rearward intrusion of the steering assembly deflated the air bag and she impacted the steering wheel hub, spokes and rim. This caused multiple left rib fractures, a contusion of the left lung and areas of abrasions and contusions on her chest and abdomen. The toe pan intruded, causing a fracture and dislocation of her left ankle. She sustained bilateral abrasions from contacting the intruding left side panel and lower left instrument panel. Her left arm flailed and struck the left instrument panel, causing a fracture in her forearm with the precise bone not specified. The intruding left door pressed her against the center console and she sustained contusions and lacerations on her right thigh. Her position at final rest is not known. It was necessary to cut away the left B-pillar and remove the left doors to extricate the driver.

CASE VEHICLE DRIVER'S INJURIES

The driver was transported by ambulance to a hospital. She sustained fatal injuries and was pronounced dead approximately four-and-half hours post-crash.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Fractures, multiple, massive, pelvis including right superior and inferior pubic bones and left superior pubic bone {obturator rings} with blood loss >20% by volume ¹ with complications of hypovolemic shock ² and cardiac arrest	852610.5 critical	Knee bolster, driver's	probable	Emergency room records
2	Fracture left femoral head with displacement superiorly and laterally	851808.3 serious	Knee bolster, driver's, left of steering column	probable	Emergency room records
3	Dislocation, obvious, left hip, not further specified	850610.2 moderate	Knee bolster, driver's, left of steering column	probable	Emergency room records

¹ According to the emergency room physician, the patient's hemoglobin was measured as 5.7 indicating that 10 units of blood volume were probably lost into her pelvis and abdomen and possibly her chest.

² The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
shock (shok): 1. a sudden disturbance of mental equilibrium. 2. a condition of profound hemodynamic and metabolic disturbance characterized by failure of the circulatory system to maintain adequate perfusion of vital organs. It may result from inadequate blood volume (hypovolemic shock); inadequate cardiac function (cardiogenic shock); or inadequate vasomotor tone (neurogenic shock, septic shock).

Case Vehicle Driver's Injuries (continued)

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Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
4	Contusion left lung, not further specified	441406.3 serious	Steering wheel hub and/or spokes and rim	probable	Emergency room records
5	Fractures, multiple, left ribs, not further specified, with left hemothorax and/or pneumothorax	450222.3 serious	Steering wheel hub and/or spokes and rim	probable	Post-mortem examination
6	Fracture left forearm, bone not specified	751900.2 moderate	Left instrument panel and below	probable	Post-mortem examination
7	Dislocation left ankle, not further specified	850210.2 moderate	Floor toe pan	certain	Emergency room records
8	Fracture left ankle, not further specified	852002.2 moderate	Floor toe pan	certain	Emergency room records
9	Abrasion, large, above right breast	490202.1 minor	Steering wheel hub and/or spokes and rim	probable	Post-mortem examination
10	Abrasion, "seat belt", on abdomen	590202.1 minor	Steering wheel rim	probable	Emergency room records
11	Contusion above right clavicle	790402.1 minor	Steering wheel rim	probable	Post-mortem examination
12	Contusion anterior right thigh, not further specified	890402.1 minor	Center console	possible	Post-mortem examination
13	Laceration, 12-16 cm (4.7-6.3 in) right upper leg	890602.1 minor	Center console	possible	EMS treatment record
14	Abrasions on medial right shin	890202.1 minor	Left instrument panel and below	probable	Post-mortem examination
15	Abrasions, large, left lateral leg, not further specified	890202.1 minor	Left side interior surface, excluding hardware and/or armrest	probable	Post-mortem examination

FIRST OTHER VEHICLE

IN-02-015

The first other vehicle was a 1990 Ford Aerostar front wheel drive, 3-door minivan (VIN: 1FMCA11UXLZA-----). Based on the vehicle inspection, the CDC for the Ford was determined to be **11-LDEW-2 (340)** (maximum crush was 16 centimeters [6.3 inches]). The WinSMASH reconstruction program, missing vehicle algorithm, was used on the Ford's single impact, based on the Ford's measured crush profile and treating the case vehicle as missing (because of overlapping damage on the case vehicle). The Total, Longitudinal and Lateral DeltaV's for the Ford are: 9.0 km.p.h. [5.6 m.p.h.], -8.5 km.p.h. [-5.2 m.p.h.] and +3.1 km.p.h. [+1.9 m.p.h.]. This is a borderline reconstruction but the results appear reasonable. The Ford was towed from the scene but appeared not to have been truly disabled, except for the damage to the left rear wheel and tire (**Figure 7**). The Aerostar's driver (46-year-old female) sustained police-reported "B" (evident, non-incapacitating) injuries. Her treatment status and specific injuries are not known. There were no other occupants in the Aerostar.



Figure 7: Left side of Ford Aerostar, showing area of maximum crush (case photo #57)

SECOND OTHER VEHICLE

The second other vehicle was a 1998 Mercedes Benz ML 320 four wheel drive, four-door sport utility vehicle (VIN: 4JGAB54E0WA-----). Based on the vehicle inspection, the CDC for the Mercedes was determined to be **12-FLEE-9 (350)** (maximum crush was 37 centimeters [14.6 inches]). The WinSMASH reconstruction program, damage algorithm based on the crush profile of both vehicles, was used on the Mercedes' single impact. The Total, Longitudinal and Lateral DeltaVs for the Mercedes are, respectively: 40.0 km.p.h. [24.8 m.p.h.], -39.4 km.p.h. [-24.5 m.p.h.] and +6.9 km.p.h. [+4.3 m.p.h.]. The Mercedes was equipped with front impact air bags and door-mounted side impact air bags. The driver and front right passenger frontal air bags and the driver's side impact air bag deployed. The Mercedes was towed due to damage (**Figure 8**). The Mercedes' driver (42-year-old male) sustained police-reported "B" (evident, non-incapacitating) injuries. His treatment status and specific injuries are not known. There were no other occupants in the Mercedes.



Figure 8: Front and left side of Mercedes SUV, showing heavy damage from offset frontal impact (case photo #70)

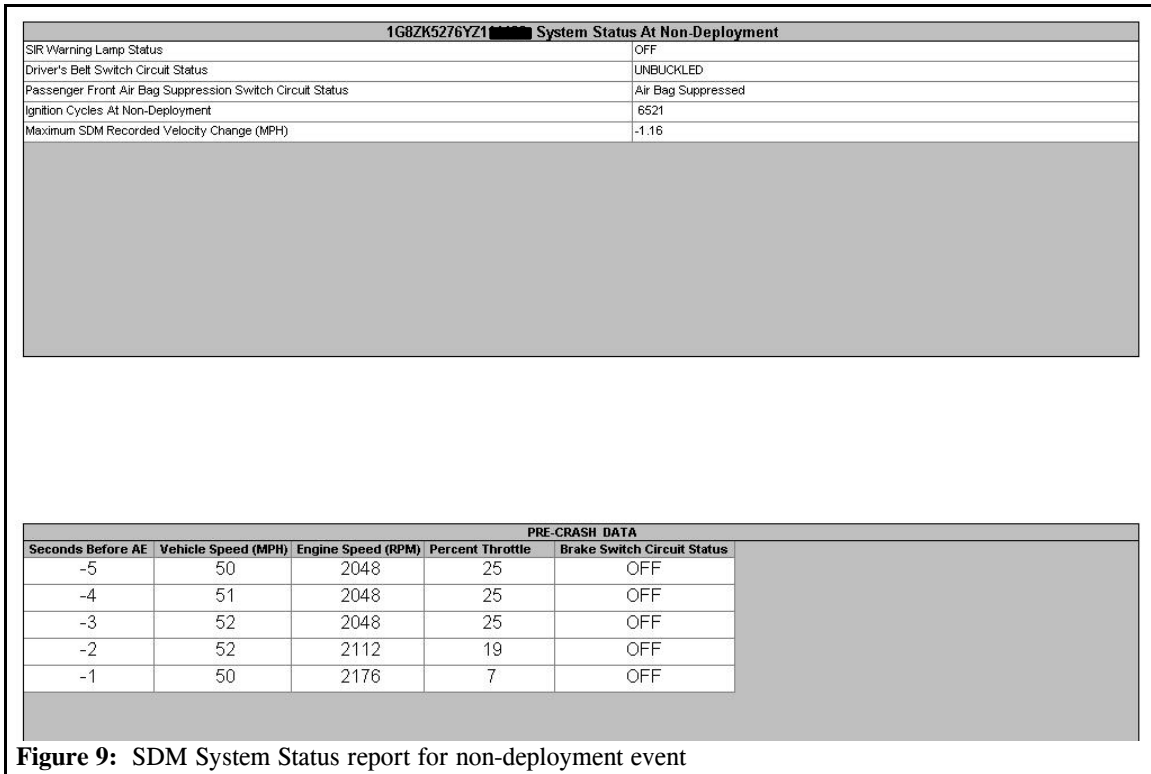


Figure 9: SDM System Status report for non-deployment event

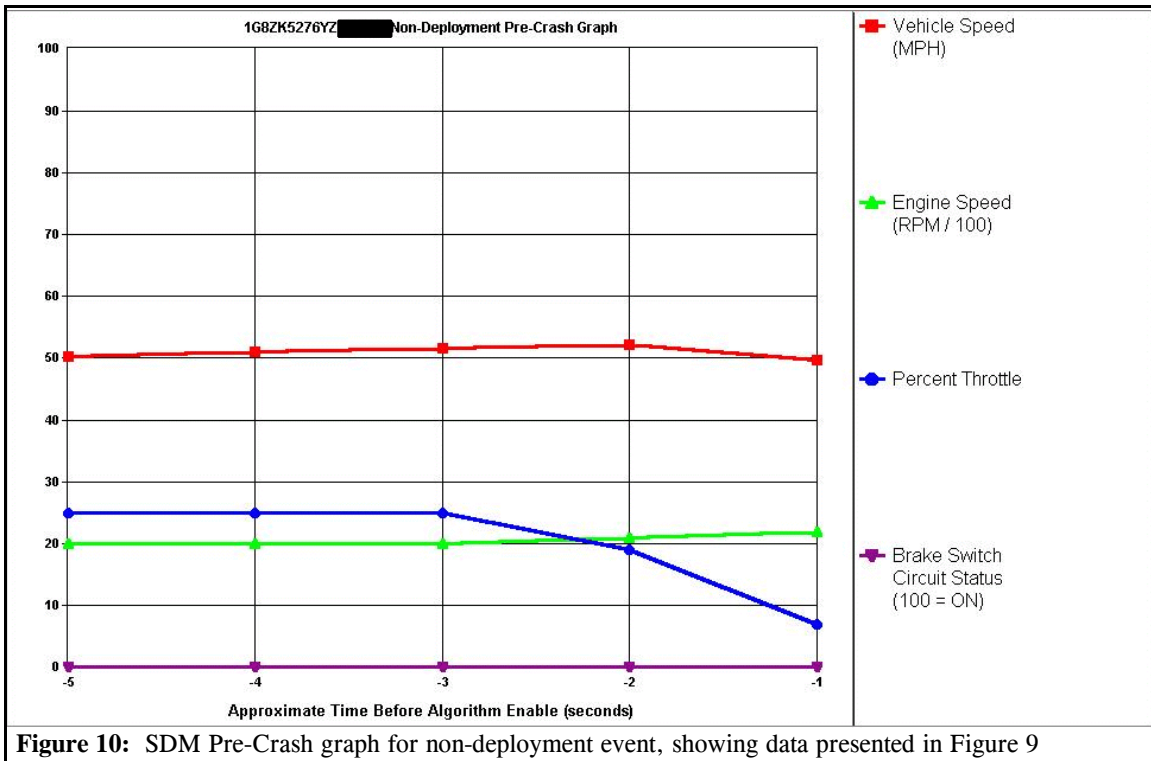


Figure 10: SDM Pre-Crash graph for non-deployment event, showing data presented in Figure 9

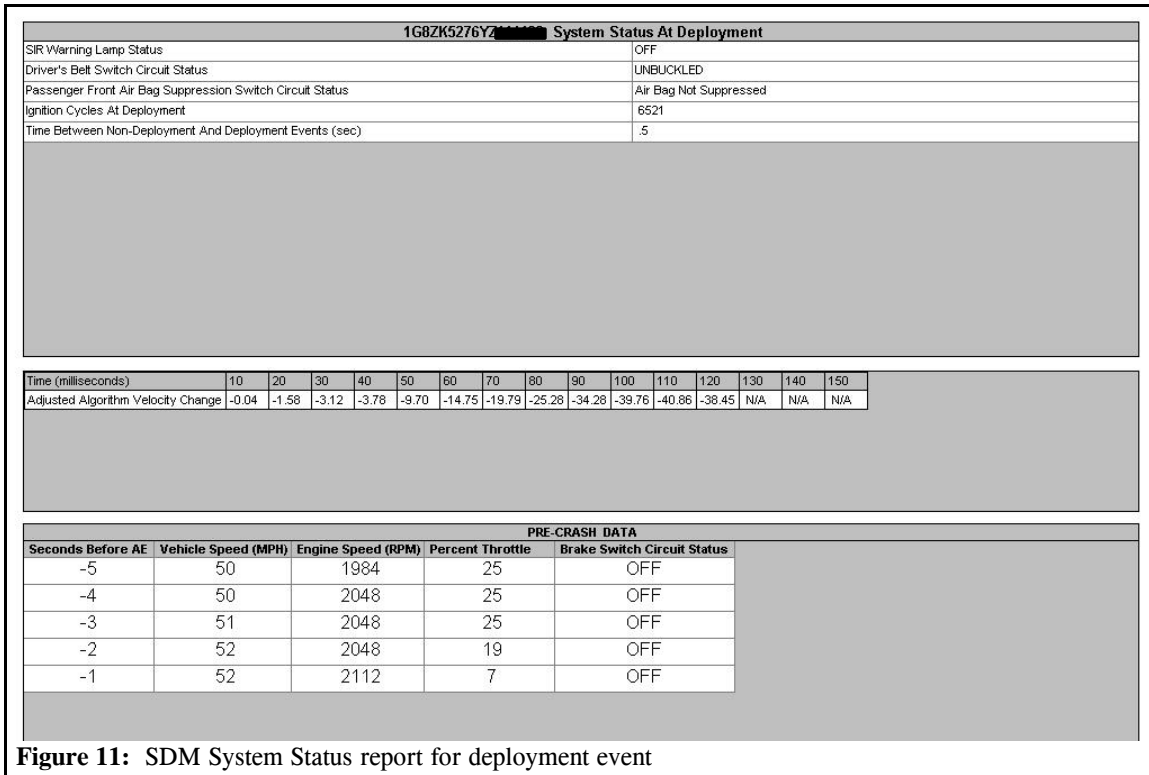


Figure 11: SDM System Status report for deployment event

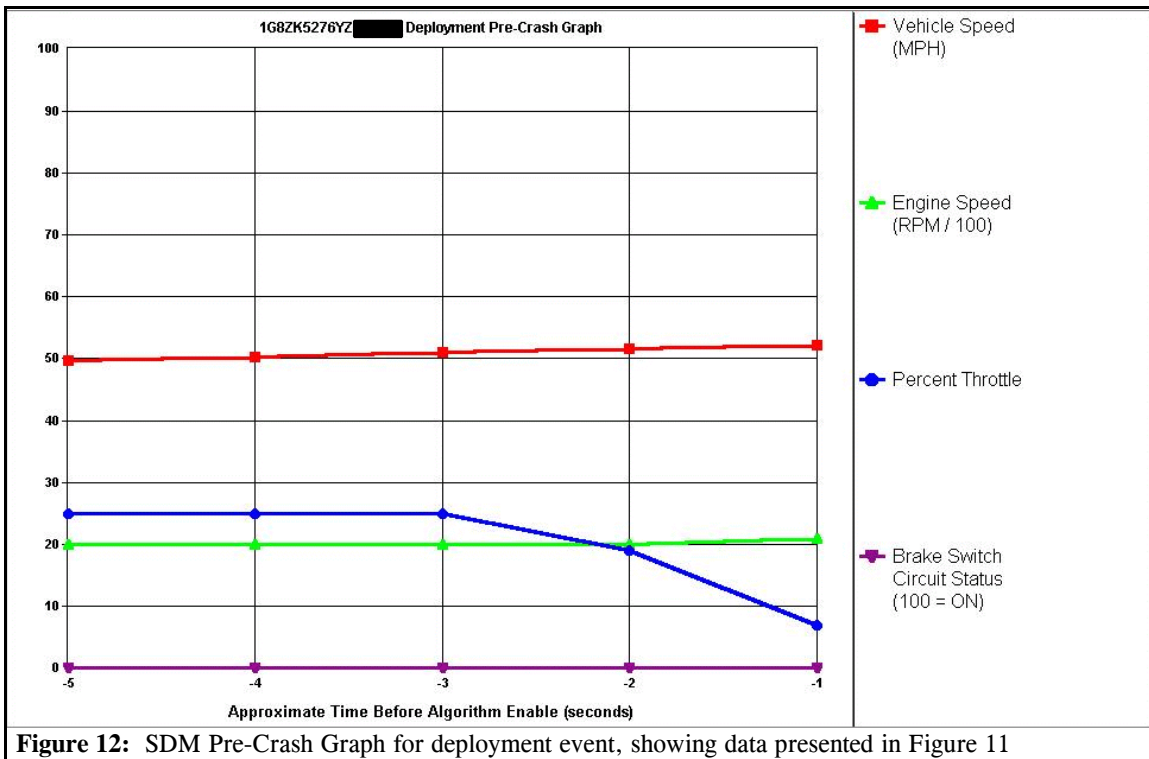


Figure 12: SDM Pre-Crash Graph for deployment event, showing data presented in Figure 11

