TRANSPORTATION SCIENCES
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REMOTE REDESIGNED AIR BAG RELATED ADULT PASSENGER FATALITY INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

NASS/SCI COMBO CASE NO. 00-12-091A

VEHICLE - 1999 BUICK PARK AVENUE

LOCATION - STATE OF MICHIGAN

CRASH DATE - MAY 2000

Contract No. DTNH22-94-D-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 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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15. *Supplementary Notes* Remote investigation of an offset frontal crash that resulted in the deployment of the redesigned frontal air bag system in a 1999 Buick Park Avenue. The 91-year-old female front right passenger died as a result of her injuries.			
16. *Abstract* This remote investigation focused on a 1999 Buick Park Avenue sedan that was equipped with redesigned air bags for the driver and front right positions. The Buick Park Avenue impacted a 1989 Chevrolet Corsica in a head-on configuration. The impact was sufficient to deploy the redesigned frontal air bag system in the Park Avenue. The Buick Park Avenue was occupied by 73-year-old male driver, a 91-year-old female front right passenger, and a 69-year-old female and a 72-year-old male seated in the left and right rear outboard positions, respectively. All of the occupants were restrained except the front right passenger. Pre-crash braking displaced the unrestrained front right passenger forward into the path of the redesigned front right passenger's air bag. At impact, the frontal air bag system deployed and the restrained occupants loaded the manual lap and shoulder belts. The driver sustained a shoulder sprain and minor contusions and lacerations. The front right passenger was struck by the deploying front right passenger's air bag which resulted in bilateral rib fractures with a flail chest, and a right lung contusion. She loaded the lower instrument panel and glove box door which resulted in a left mid-shaft femur fracture, a right comminuted intertrochanteric femur fracture, and upper and lower extremity lacerations, contusions, and abrasions. The rear left occupant sustained seat belt-related contusions and abrasions. The rear right occupant sustained anterior rib fractures, a sternum fracture, left tibia fracture, lumbar spine fracture, and seat belt-related abrasions. All occupants were transported by ambulance to a local trauma center for treatment. The 91-year-old front right passenger of the Park Avenue expired five hours after the crash.			
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LOCATION - STATE OF MICHIGAN
CRASH DATE - MAY 2000

BACKGROUND

This remote investigation focused on a 1999 Buick Park Avenue sedan **(Figure 1)** that was equipped with redesigned air bags for the driver and front right positions. The Buick Park Avenue impacted a 1989 Chevrolet Corsica in a head-on configuration. The impact was sufficient to deploy the redesigned frontal air bag system in the Park Avenue. The Buick Park Avenue was occupied by 73-year-old male driver, a 91-year-old female front right passenger, and a 69-year-old female and a 72-year-old male seated in the left and right rear outboard positions, respectively. All of the occupants were restrained except the front right passenger. Pre-crash braking displaced the unrestrained front right passenger forward into the path of the redesigned front right passenger's air bag.

Figure 1. 1999 Buick Park Avenue

At impact, the frontal air bag system deployed and the restrained occupants loaded the manual lap and shoulder belts. The driver sustained a shoulder sprain and minor contusions and lacerations. The front right passenger was struck by the deploying front right passenger's air bag which resulted in bilateral rib fractures with a flail chest, and a right lung contusion. She loaded the lower instrument panel and glove box door which resulted in a left mid-shaft femur fracture, a right comminuted intertrochanteric femur fracture, and upper and lower extremity lacerations, contusions, and abrasions. The rear left occupant sustained seat belt-related contusions and abrasions. The rear right occupant sustained anterior rib fractures, a sternum fracture, left tibia fracture, lumbar spine fracture, and seat belt-related abrasions. All occupants were transported by ambulance to a local trauma center for treatment. The 91-year-old front right passenger of the Park Avenue expired five hours after the crash.

This crash was selected for investigation by the National Automotive Sampling System (NASS) as CDS case number 00–12-091A. The crash occurred in May 2000. Initial notification of this crash was made to the Veridian Special Crash Investigations team following a NASS CDS case review. The NASS PSU performed the vehicle inspection and scene inspection. The National Highway Transportation Safety Administration (NHTSA) assigned a case review and report preparation to the Veridian Special Crash Investigation (SCI) team on February 20, 2001.

SUMMARY

Crash Site

The crash occurred on an undivided two-lane secondary roadway during daylight hours. The police report listed the National Weather Service information which stated that at the time of the crash, it was cloudy with a temperature of 11 degrees Celsius (52 degrees Fahrenheit), and the wind was from the south at a speed of 14 km/h (9 mph). Light rain was falling and the asphalt road surface was wet. The north/south roadway consisted of one travel lane in each direction separated by a broken yellow centerline. The roadway profile was straight and level. The outboard edges of the roadway were bordered by white fog lines and dirt/gravel shoulders. The roadside environment consisted of residential lawn areas, private driveways, and trees. The posted speed limit for the roadway was 89 km/h (55 mph).

Pre-Crash

The 19-year-old female driver of the 1989 Chevrolet Corsica was operating the vehicle northbound on the two-lane roadway in rain conditions behind several uninvolved vehicles **(Figure 2)**. According to a witness, traffic ahead of the Corsica had slowed due to a slow-moving truck that had entered the roadway. The driver of the Corsica lost control of the vehicle as she attempted to slow for the traffic ahead. The Corsica traveled across the centerline into the southbound lane, and into the path of the Buick Park Avenue. It was unknown if the driver of the Corsica attempted any avoidance maneuvers.

Figure 2. Northbound approach for the Corsica

The 73-year-old male driver of the Buick Park Avenue was operating the vehicle southbound on the two-lane roadway **(Figure 3)**. When he detected the Chevrolet Corsica encroaching into the southbound lane, he applied the brakes in an attempt to avoid the collision.

Figure 3. Southbound approach for the Park Avenue

Crash

The front area of the Buick Park Avenue impacted the front area of the Chevrolet Corsica. Based on factors such as vehicle weight, number of occupants, and damage patterns, it appears that the Buick was the dominant vehicle. The impact occurred in the southbound lane. The NASS researcher identified the heading angles to be 190 degrees and 0 degrees for the Park Avenue and Corsica, respectively. The resultant directions of force were in the 12 o'clock sectors for both vehicles. The damage algorithm of the WinSMASH program computed total velocity changes of 49.4 km/h (30.7 mph) for the Park Avenue and 81.0 km/h (50.3 mph) for the Corsica. The longitudinal and latitudinal components for the Park Avenue were -48.7 km/h (-30.3 mph) and 8.6 km/h (5.3 mph), respectively. The longitudinal and latitudinal components for the Corsica were -79.8 km/h (-49.6 mph) and -14.1 (-8.7 mph), respectively. The Corsica was deflected rearward and began to rotate clockwise (CW). The NASS researcher identified a secondary impact to the Corsica from the front area of the Park Avenue, evidenced by sideswipe damage on the left rear quarter panel of the Corsica. The Buick deflected off of the Corsica,

departed the west roadside, and came to rest on the west shoulder facing south. The Corsica traveled back across the northbound travel lane as it continued to rotate CW, and departed the right roadside into a drainage ditch. It came to rest facing east in the ditch.

Post-Crash

The occupants of the Buick Park Avenue were removed from the vehicle by rescue personnel and transported by ambulance to a local trauma center. The 91-year-old female front right passenger expired five hours after the crash. The remaining occupants of the Park Avenue were admitted for treatment. The driver of the Chevrolet Corsica had no vital signs at the scene. She was transported by ambulance to a local trauma center and was pronounced dead upon arrival.

VEHICLE DATA - 1999 Buick Park Avenue

The 1999 Buick Park Avenue was identified by the Vehicle Identification Number (VIN): 1G4CW52K3X4 (production sequence omitted). The Park Avenue was a four-door sedan equipped with front wheel drive, an automatic transmission, and a 3.8 liter, 6 cylinder engine. The Park Avenue was also equipped with a tilt steering wheel which was in the full-up position during the NASS vehicle inspection. The front seating was configured with a split bench seat with separate back cushions. The front center position had a folding arm rest that also served as a seat back for a center seated occupant. The front outboard seats were equipped with adjustable head restraints. The driver's head restraint appeared to be in the mid position and the front right head restraint between the mid and fully lowered positions. The front outboard seating positions were equipped with seat-integrated manual 3-point lap and shoulder belts. The top outboard aspects of the seat backs were equipped with integrated height adjusters for the shoulder belts. A lap belt was available for the front middle seating position. The rear seat was a fixed bench, and was equipped with manual 3-point lap and shoulder belts for the outboard positions and a lap belt for the middle position. An integrated arm rest folded forward from the rear center seating position.

VEHICLE DAMAGE

Exterior Damage - 1999 Buick Park Avenue

The 1999 Buick Park Avenue sustained severe damage as a result of the impact with the Chevrolet Corsica **(Figure 4)**. The direct contact damage began at the front left bumper corner and extended 79 cm (31") across the frontal plane. The combined direct and induced damage involved the entire frontal width of the vehicle and measured 132 cm (52"). The maximum crush measured 90 cm (35") and was located at the front left corner at C1. The entire bumper fascia, grille, and headlights were separated from the vehicle. The bumper beam was crushed rearward on the left side. The hood was buckled rearward, and direct contact abrasions were visible on the left leading aspect of the hood. The left front wheel was restricted and the tire was deflated. Due to the crush on the left side of the vehicle, the left wheelbase was shortened by 21 cm (8"). The leading edge of the left front fender was crushed rearward and the rear edge was

Figure 4. Damage to the 1999 Buick Park Avenue

deformed by rescue personnel. The left roof side rail was buckled at the left B-pillar and the left front door was removed by rescue personnel. The Collision Deformation Classification for the initial impact with the Corsica was 12-FYEW-3. Six crush measurements were taken by the NASS researcher at the level of the bumper beam, and were as follows: C1 = 75 cm (30"), C2 = 71 cm (28"), C3 = 65 cm (26"), C4 = 46 cm (18"), C5 = 23 cm (9"), C6 = 0 cm.

Interior Damage - *1999 Buick Park Avenue*

Figure 5. Interior view of the 1999 Buick Park Avenue

Interior damage to the 1999 Buick Park Avenue was moderate and attributed to occupant contact and compartment intrusion **(Figure 5)**. The windshield glazing was fractured from impact forces. The left lower instrument panel was displaced from impact forces and the rigid plastic knee bolster was deformed from occupant contact. The left quarter area of the steering wheel rim was deformed forward 2 cm (1") from occupant loading. The left toe pan intruded longitudinally 15 cm (6") and the roof intruded vertically 9 cm (4") into the driver's seating position. The driver's foot controls were slightly displaced. The driver's sun visor and rear view mirror were displaced from occupant contact. The glove compartment door was scuffed from occupant contact. The cover on the left aspect of the driver's seat back over the integrated seat belt was separated from the seat back. The left and middle aspects of the rear seat cushion became separated and displaced forward from the rear seat anchors.

Exterior Damage - *1989 Chevrolet Corsica*

Figure 6. Damage to the 1989 Chevrolet Corsica

The 1989 Chevrolet Corsica sustained severe damage as a result of the impact with the Buick Park Avenue **(Figure 6)**. The direct contact damage began at the front left bumper corner and extended 104 cm (41") across the entire frontal plane. The combined direct and induced damage involved the entire frontal width of the vehicle. The front bumper was fractured in the center and partially separated from the vehicle on the right side. The left side of the front bumper and left front fender were crushed rearward to the left A-pillar. The maximum crush was located at the front left bumper corner at C1 and measured 114 cm (45"). The hood was buckled rearward and the displaced slightly to the left. The right fender and right front wheel were displaced toward the center of the vehicle. The left wheel was restricted and deflated, and was crushed rearward behind the bumper. The left front door was buckled outward. The roof and both A-pillars were removed by rescue personnel. The Collision Deformation Classification for the frontal impact with the Buick Park Avenue was 12-FDEW-5. Six crush measurements were taken by the NASS researcher at the bumper level and were as follows: C1 = 114 cm (41"), C2 = 114 cm (41"), C3 = 111 cm (44"), C4 = 104 cm (41"), C5 = 67 cm (26"), C6 = 47 cm (19").

Direct damage was also identified on the left rear quarter panel area. The direct contact began at the left rear bumper corner and extended 61 cm (24") forward. The direct contact consisted of longitudinal abrasions and transfers along the trim line and on the quarter panel from a secondary sideswipe with the Buick Park Avenue. The combined direct and induced damage for this contact measured 102 cm (40") from the left rear bumper corner forward. The CDC for the second impact was 11-LBES-1.

REDESIGNED AIR BAG SYSTEM - ***1999 Buick Park Avenue***

The 1999 Buick Park Avenue was equipped with redesigned air bags for the driver and front right passenger positions that deployed as a result of the impact with the Chevrolet Corsica. The driver's air bag was housed in the center of the steering wheel with symmetrical I-configuration module cover flaps **(Figure 7)**. Each cover flap measured 11 cm (4") in width and 9 cm (4") in height. The redesigned driver's air bag measured 63 cm (25") in diameter in its deflated state and was tethered by two internal straps. The air bag was vented by two ports located at the 11 and 1 o'clock positions.

Figure 7. Redesigned driver's air bag

The redesigned front right passenger's air bag deployed from the mid-instrument panel area with a single cover flap design hinged at the bottom aspect **(Figure 8)**. The cover flap was rectangular in shape and measured 37 cm (15") in width and 15 cm (6") in height. The redesigned front right passenger's air bag measured 60 cm (24") in width and 32 cm (13") in height in its deflated state. The air bag was tethered by one internal strap and vented by two ports located at the 9 and 3 o'clock positions. A makeup transfer was identified on the lower right aspect from the unrestrained front right passenger.

Figure 8. Redesigned front right passenger's air bag

OCCUPANT DEMOGRAPHICS - 1999 Buick Park Avenue

Driver

Age/Sex:	73-year-old male
Height:	183 cm (72")
Weight:	86 kg (190 lb)
Seat Track Position:	Mid-track
Manual Restraint Use:	3-point manual lap and shoulder belt
Usage Source:	Vehicle inspection, injury data
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local trauma center and admitted overnight

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Right shoulder sprain	Minor (751020.1,1)	Shoulder belt webbing
Multiple contusions, NFS	Minor (990400.1,9)	Unknown
Left elbow abrasion	Minor (790202.1,2)	Left side interior door surface (fling injury from air bag deployment)

*Injury source: Emergency Room records

Driver Kinematics

The 73-year-old male driver of the Buick Park Avenue was reportedly seated in an upright attitude and restrained by the available integrated 3-point manual lap and shoulder belt. The driver was probably braced prior to impact as he applied the brakes and attempted to avoid the collision. At impact, and the redesigned frontal air bag system deployed. The expansion of the driver's air bag displaced the driver's left arm to the left which resulted in a left elbow abrasion. The driver loaded the integrated manual restraint and the redesigned driver's air bag which mitigated contact with the steering wheel assembly. He loaded through the driver's air bag and deformed the left aspect of the steering wheel rim 2 cm (1"). He sustained a left shoulder sprain as a result of loading to the shoulder belt. According to the hospital records, he sustained multiple contusions, although the locations were not specified. His knees struck the rigid plastic knee bolster as evidenced by bolster deformation and a complaint of knee pain. The driver was removed from the vehicle by rescue personnel and transported by ambulance to a local trauma center. He was treated and admitted overnight.

Front Right Passenger

Age/Sex:	91-year-old female
Height:	158 cm (62")
Weight:	64 kg (140 lb)
Seat Track Position:	Between mid-track and full-rear positions
Manual Restraint Use:	Unrestrained
Usage Source:	Vehicle inspection, injury data
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local trauma center and expired five hours following the crash

Front Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Bilateral rib fractures with flail chest	Critical (450266.5,3)	Front right passenger's air bag
Right lung contusion	Serious (441403.3,1)	Front right passenger's air bag
Right comminuted intertrochanteric femur fracture with leg laterally rotated	Serious (851810.3,1)	Indirect - energy translated through femur from glove compartment door contact
Left open mid-shaft femur fracture, laterally displaced 1 - 1.5 shaft diameters with angulation	Serious (851814.3,2)	Indirect - energy translated through femur from glove compartment door contact
Right hand contusion, thumb area	Minor (790402.1,1)	Right interior door surface, air bag-related fling injury
Bilateral forearm lacerations	Minor (790600.1,3)	Front right passenger's air bag cover flap
Right knee abrasion	Minor (890202.1,1)	Glove compartment door

*Injury source: Emergency Room records

Front Right Passenger Kinematics

The 91-year-old female front right passenger was seated in an upright attitude and was not restrained by the available integrated 3-point manual lap and shoulder belt. Her arms may have been extended forward in an effort to brace. Pre-crash braking placed her out of position forward into the path of the redesigned front right passenger's air bag. At impact, she initiated a forward trajectory and loaded the glove

compartment door with her knees which resulted in a right knee abrasion. The energy translated through the femurs from the glove compartment strike resulted in a right comminuted intertrochanteric femur fracture with the leg laterally rotated, and a left open mid-shaft femur fracture with angulation. The redesigned frontal air bag system deployed and the cover flap opened against the medial aspects of her arms which resulted in bilateral forearm lacerations. The expansion of the air bag displaced the front right passenger's arms laterally, and her right hand was projected into the interior door surface which caused a contusion on the right hand near the thumb. The air bag expanded against her chest which caused bilateral rib fractures with a flail chest and a right lung contusion. According to the Emergency Room report, the physicians suspected a possible aortic laceration based on persistent mediastinal widening and a possible subluxation of C4 and C5 based on a limited study of front right passenger's cervical spine. Due to the front right passenger's condition, the family elected to forego additional testing to confirm these potential injuries.

The front right passenger was found under the right instrument panel area by rescue personnel. Her entire body was reportedly trapped in the floor pan area. The Emergency Room records stated that her extrication from the vehicle took twenty minutes and that she was unresponsive at the scene. She was transported by ambulance to a local trauma center where she expired five hours following the crash.

Rear Left Passenger

Age/Sex:	69-year-old female
Height:	158 cm (62")
Weight:	64 kg (140 lb)
Seat Track Position:	Fixed
Manual Restraint Use:	3-point manual lap and shoulder belt
Usage Source:	Vehicle inspection, injury data
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local trauma center and admitted for two days

Rear Left Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Lower left abdominal contusion	Minor (590402.1,8)	Lap belt webbing
Abrasion - left aspect of neck	Minor (390202.1,2)	Shoulder belt webbing
Chest contusion, whole region	Minor (490402.1,0)	Shoulder belt webbing
Bilateral knee abrasions	Minor (890202.1,3)	Front left seat back

*Injury source: Emergency Room reports, NASS interview

Rear Left Passenger Kinematics

The 69-year-old rear left passenger was seated in an upright attitude and restrained by the available 3-point manual lap and shoulder belt. At impact, she initiated a forward trajectory and struck her knees against the front left seat back resulting in bilateral knee abrasions. She loaded the manual restraint which resulted in a lower left abdominal contusion and an abrasion on the left aspect of her neck. She stated in an interview that she also sustained a chest contusion from the shoulder belt webbing. She was removed from the vehicle by rescue personnel and transported by ambulance to a local trauma center. She was admitted for two days.

Rear Right Passenger

Age/Sex:	72-year-old male
Height:	183 cm (72")
Weight:	86 kg (190 lb)
Seat Track Position:	Fixed
Manual Restraint Use:	3-point manual lap and shoulder belt
Usage Source:	Vehicle inspection, injury data
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local trauma center and admitted for eight days

Rear Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Comminuted fracture of the proximal left tibia	Serious (853408.3,2)	Right front seat back support
Fractures of left ribs 3 - 8	Serious (450230.3,2)	Shoulder belt webbing
Positive loss of consciousness, NFS, awake upon admission	Moderate (160406.2,0)	Impact force - head motion
Comminuted fracture of the sternum	Moderate (450804.2,4)	Shoulder belt webbing
L1 fracture of the transverse process on the left	Moderate (650620.2,8)	Rebound into rear seat back
L2 fracture of the transverse process on the left	Moderate (650620.2,8)	Rebound into rear seat back
L3 fracture of the transverse process on the left	Moderate (650620.2,8)	Rebound into rear seat back

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
L4 fracture of the transverse process on the left	Moderate (650620.2,8)	Rebound into rear seat back
Left chest abrasion	Minor (490202.1,2)	Shoulder belt webbing
Abrasion on the lower left back area	Minor (690202.1,2)	Lap belt webbing

*Injury source: Emergency Room reports, Discharge Summary

Rear Right Passenger Kinematics

The 72-year-old male right rear passenger stated in the NASS interview that he was seated and leaning to the left. He was restrained by the available 3-point manual lap and shoulder belt. At impact, he initiated a forward trajectory and struck the rigid rear aspect of the front right lower seat cushion with his lower left leg. He sustained a comminuted fracture of the proximal left tibia. He loaded the manual restraint which resulted in fractures of left ribs 3 - 8, a comminuted fracture of the sternum, a left chest abrasion, and an abrasion on the lower left back area. He rebounded rearward into the seat back which resulted in transverse process fractures of L1 - L4 on the left side. He also sustained positive loss of consciousness as a result of the impact forces but was awake upon admission to the trauma center. He was removed from the vehicle by rescue personnel and transported by ambulance to a local trauma center. He was admitted for eight days.