

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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NASS/SCI COMBINED DRIVER AIR BAG FATALITY INVESTIGATION

CALSPAN CASE NO. 1998-04-004B

VEHICLE - 1993 BUICK CENTURY CUSTOM WAGON

LOCATION - NEW JERSEY

CRASH DATE - JANUARY, 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 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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<p>17. <i>Abstract</i></p> <p>This remote investigation focused on the fatal injury mechanisms of an unrestrained 71 year old female driver, involved in a single vehicle crash. The vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of a driver air bag that deployed as a result of an impact with a fire hydrant. The driver had a reported height and weight of 157 cm (62 in) and 64 kg (140 lb). She was seated unrestrained in a forward to mid seat track position due to her stature. The Buick was being operated westbound at an approximate speed of 72 km/h (45 mph), as reported by a trailing witness. Immediately prior to the crash, the driver failed to negotiate the left curve and the Buick departed the right side of the roadway. The impact probably disoriented the driver and the 12 o'clock direction of the impact force caused the unrestrained driver to exhibit a forward trajectory. The driver disengaged the brakes.</p> <p>The vehicle then traveled parallel to the road approximately 27.0 m (88.5 ft) and struck a fire hydrant located 2.5 m (8.2 ft) north of the curb edge with the left front corner of the vehicle. The 12 o'clock direction of the impact force displaced the driver further forward and in contact with driver air bag module located in the center of the steering wheel. The driver loaded and compressed the steering column and the fire hydrant impact caused the driver air bag to deploy. The position of her chest and head over the top of the air bag module impeded the normal path of the deploying air bag. The deployment of the air bag caused massive chest trauma. The results of the autopsy indicated the driver sustained multiple bilateral rib fractures with bilateral hemothoraces (AIS 5), a lacerated thoracic aorta (AIS 5) and other minor injuries.</p>			
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TABLE OF CONTENTS

BACKGROUND 1

SUMMARY 1

AIR BAG VEHICLE 3

SUPPLEMENTAL MANUAL RESTRAINT SYSTEM 4

DRIVER INJURIES 5

DRIVER KINEMATICS 6

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BACKGROUND:

This remote investigation focused on the fatal injury mechanisms of an unrestrained 71 year old female driver, involved in a single vehicle crash. The subject was driving a 1993 Buick Century Custom Wagon. The Buick mounted a curb and traveled off the right side of the road, striking a fire hydrant and rotating into a utility pole. The vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of a driver air bag that deployed as a result of the impact with the fire hydrant. The National Highway Traffic Safety Administration (NHTSA) was informed of the crash by a NASS research team on February 3, 1998. NHTSA assigned a remote investigation of this crash to the Special Crash Investigations Team at Calspan the same day. The crash was subsequently selected for investigation by the NASS system.

SUMMARY

This single vehicle crash occurred in the afternoon hours of January, 1998. At the time of the crash, it was daylight and the roads were dry; the weather was not a factor. The crash occurred at the end of a left curve for westbound traffic in a straight and level section of a two lane east/west county road (refer to Figure 1). At the approximate end of the curve, a two lane road intersects from the north. There was a shoulder and barrier curb bordering the north edge of the roadway. The speed limit in the area of the crash was 72 km/h (45 mph).

The driver of the Buick was a 71 year old female with a reported height and weight of 157 cm (62 in) and 64 kg (140 lb). She was seated unrestrained in a forward to mid seat track position due to her stature. The Buick was being operated westbound at an approximate speed of 72 km/h (45 mph), as reported by a trailing witness. Immediately prior to the crash, the driver failed to negotiate the left curve and the Buick departed the right side of the roadway. As the vehicle entered the mouth of the intersecting road, the driver recognized her error and applied the brakes, evidenced by a 4.2 m (13.7 ft) skid mark of the right front tire. The sudden brake application locked the right front tire and the vehicle skidded into and then impacted and mounted the barrier curb. The inspection of the scene located two impacts to the curb from the vehicle's respective front tires. The Buick's right front rim was deformed and the tire deflated in the curb impact. The impact probably disoriented the driver and the 12 o'clock direction of the impact force caused the unrestrained driver to exhibit a forward trajectory. The driver disengaged the brakes.

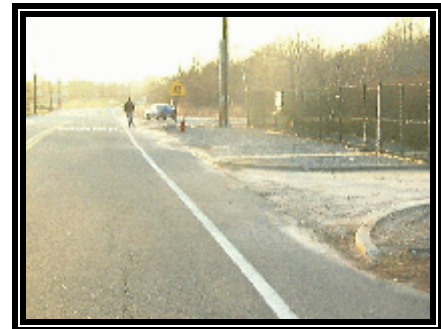


Figure 1: Pre-crash trajectory view.

The vehicle then traveled parallel to the road approximately 27.0 m (88.5 ft) and struck a fire hydrant located 2.5 m (8.2 ft) north of the curb edge with the left front corner of the vehicle. The 12 o'clock direction of the impact force displaced the driver further forward and in contact with driver air bag module located in the center of the steering wheel. The driver loaded and compressed the steering column and the fire hydrant impact caused the driver air bag to deploy. The position of her chest and head over the top of the air bag module impeded the normal path of the deploying air bag. The NASS inspection identified specific areas of interaction between the driver, the module cover flaps and the air bag membrane. The deployment of the air bag caused massive chest trauma. Approximately 1.5 seconds elapsed from the time the Buick struck the curb to the fire hydrant impact. In that interval, the disoriented driver did not have sufficient time to perceive and react to the impending crash.

The Collision Deformation Classification(CDC) of the hydrant impact as determined by the NASS inspection was 12-FLEN-01. The direct contact damage began 2.0 cm (0.8 in) inboard of left front bumper corner and extended right 22.0 cm (8.7 in). The maximum engagement of the front bumper with the hydrant occurred at C2, located 31.6 cm (12.4 in) inboard of the left front corner (refer to Figure 2). The crush profile measured during the inspection was: C1=10.0 cm (3.9 in), C2=17.0 cm (6.7 in), C3=7.0 cm (2.8 in), C4=2.0 cm (0.8 in), C5=0, C6=0. The left side wheelbase was foreshortened 7.0 cm (2.8 in) and the left front fender buckled rearward. The A-pillars were cut and the windshield removed during the rescue operations. The total delta V of the Buick computed by the barrier model of the SMASH program was 14.5 km/h (9.0 mph). The delta V was of sufficient magnitude to cause the deployment of the Supplemental Restraint System. Note, the delta V reported was enhanced by the SCI team from the EDCS reported delta V value of 16.9 km/h (10.0 mph)



Figure 2: Left front view of the Buick Century Wagon.

The impact sheared the fire hydrant casing. However, the vehicle's suspension snagged the hydrant's internal piping and the Buick's momentum caused it to rotate counterclockwise about the hydrant. The Buick rotated approximately 45 degrees, disengaged from the hydrant and continued a westbound trajectory and in the process initiated a right side leading roll. The Buick then impacted a utility pole located 5.0 m (16.4 ft) north of the curb edge and 5.6 m (18.4 ft) west of the fire hydrant. The right rear quarterpanel of the vehicle struck the utility pole resulting in a CDC of 00-RBAN-03 (refer to Figure 3). (Note, the SCI team revised the CDC extent zone to 03, from the EDCS



Figure 3: Right side view of the Buick.

reported CDC of 00-RBAN-02.) The nature of the damage indicated the vehicle had rolled approximately 30 degrees at the time of the impact. The vehicle then rebounded and completed the one-quarter turn coming to rest on its right side and in contact with a utility pole, Figure 4.



Figure 4: View of final rest.

The driver responded to the right side impact and rollover by moving toward the right side of the vehicle, where she was found. She was pronounced dead at the crash scene, 23 minutes post-crash. The cause of death, indicated in the police report, was ruled massive chest trauma. An autopsy was performed. The results of the autopsy indicated the driver sustained multiple bilateral rib fractures with bilateral hemothoraces (AIS 5), a lacerated thoracic aorta (AIS 5) and other minor injuries.

AIR BAG VEHICLE

The 1993 Buick Century Wagon was identified by the VIN of 1G4AH85N0P (production sequence deleted). The vehicle's power train consisted of a 3.3 liter, V6 MFI engine linked to a 3-speed automatic transmission. (The 2.2 liter, 4-cylinder engine reported in the EDCS was revised based on the VIN.) The odometer reading was 111,673 km (69,392 miles) at the time of inspection.

The vehicle was equipped with a Supplemental Restraint System that consisted of a driver air bag and 3-point automatic seat belts in the front outboard seat positions. The front belts were door mounted with a fixed D-ring mounted to the upper rear aspect of the window frame. The lap and shoulder belts consisted of two separate webbings with two retractors mounted in the base of each door. The webbings attached at the fixed latch plate. The left front restraint was found in the retracted position at inspection. There were no signs on the webbing or the hardware surfaces that the restraint was in-use during the crash. The police report coded the driver as unrestrained. An interview with the family of the deceased indicated, the driver was found on the right front seat, slumped to the right. The driver's final rest location, kinematic pattern and the interior damage to the Buick all support the conclusion that the driver was unrestrained.

Passenger compartment integrity was maintained in the crash, with the exception of the right rear second window glazing and backlight which disintegrated in the impact with the utility pole. The doors remained closed through the collision sequence. Vehicle inspection revealed the left rear and right rear doors were jammed shut due to deformation. The intrusion into the rear cargo area, due to the pole impact, measured at the lower edge of the right rear second window frame was 15 cm (6 in).

The front seats in the Buick were configured in a split bench with reclining backs. The left front seat was positioned between forward and mid track. The seat back was slightly reclined and the adjustable head rest was in the full down position. There were no seat performance failures. The horizontal distance from the center of the steering wheel hub to the seat back was 54 cm (21 in). The center arm rest was down and exhibited signs of occupant contact. It was deformed to the right. The driver side (left) knee bolsters were rigid and exhibited no signs of occupant contact.

The tilt steering column was adjusted between the center and full down positions. It was a non-telescoping column. There was no steering wheel rim deformation. However, the steering column exhibited signs of significant interaction between the driver and the steering wheel hub. The steering column was compressed completely forward off the shear capsules (approximately 5 to 8 cm (2 to 3 in)), with the tilt and transmission levers in contact with instrument panel (Figures 5 and 6).



Figure 5: Left view of the steering column.

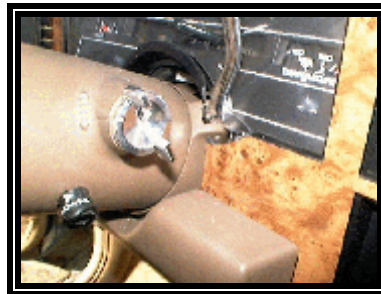


Figure 6: Right view of the steering column.

SUPPLEMENTAL RESTRAINT SYSTEM

The driver air bag module was designed in the typical manner and housed in the center of the steering wheel and the air bag had deployed as designed from the H-configuration module. The module cover flaps were symmetrical and measured 20.0 cm x 5.0 cm (7.9 in x 2.0 in) width by height. The deflated air bag measured 50 cm (20 in) in diameter. The bag was tethered and had two vent ports on the back side on the bag located in the 3 and 9 o'clock sectors. It should be noted that in Figure 7, the steering wheel was rotated clockwise approximately 90 degrees, such that the 9 o'clock sector of the rim was vertical.



Figure 7: Driver air bag.

There were two distinct areas of interaction between the occupant and the SRS identified during the NASS inspection. The cover flaps opened at the designated tear seams, however the flaps exhibited heavy blue fabric transfers and were covered with faint blue fibers. The transfers were located on the center and right aspects of both the upper and lower flaps. These fibers transferred from the driver's blue sweater to the cover flaps during the deployment sequence. The interview with the driver's family confirmed that the

driver was wearing a blue sweater. On the air bag's peripheral seam, in the 3 o'clock sector, a black transfer 25 cm (10 in) in length was identified. This transfer was caused by friction heating between the inside surface of the cover flaps and the membrane of the air bag in the early stages of the deployment. The existence of these interactions indicate the driver's chest was on top of the air bag module at the beginning of the deployment sequence. The driver's forward position and forward trajectory impeded the normal egress of the air bag from the module.



Figure 8: Blue fabric transfers on the upper cover flap.

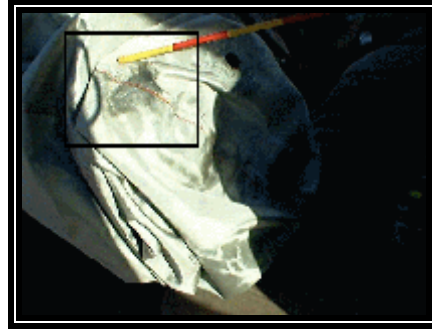


Figure 9: Black transfer in the 3 o'clock sector of the air bag's peripheral seam.

DRIVER INJURIES

Injury	Severity (AIS 90)	Injury Mechanism
Thoracic Aortic Laceration	Critical (420216.5,4)	Deploying driver air bag
Multiple rib fractures with hemothoraces	Critical (450222.5,3)	Deploying driver air bag
Fractured Sternum	Moderate (450804.2,4)	Deploying driver air bag
Pericardial Laceration	Moderate (441602.2,4)	Deploying driver air bag
Anterior neck abrasion	Minor (390202.1,5)	Deploying driver air bag
Anterior mid-chest abrasion	Minor (490202.1,4)	Deploying driver air bag/ cover flap
Right shoulder contusion	Minor (790202.1,1)	Inertial contact - right side interior
Multiple facial abrasions	Minor (290202.1,2,8)	Deploying driver air bag

DRIVER KINEMATICS

The female driver of the vehicle was 71 years old with a reported height/weight of 157 cm (62 in) and 64 kg (140 lb). She was seated with a presumably normal posture, unrestrained by the vehicle's automatic restraint system. The left front seat was adjusted to a forward to mid track position, consistent with her stature. At impact with the barrier curb, the driver was displaced forward in response to the 12 o'clock direction of force. It is probable that the driver became disoriented. Her forward trajectory positioned the driver in close proximity to the driver air bag module located in the center of the steering wheel. Upon impact with the fire hydrant, the 12 o'clock direction of the impact forces caused the driver to contact the air bag module and load the steering column with her chest. This kinematic pattern placed the driver's upper chest and head over the top of the air bag module at the time of deployment.

As the deployment initiated, the cover flaps rotated open against the driver's chest evidenced by the blue fabric transfers to the cover flaps from her clothing. The mid aspect of her chest was abraded in the contact. The air bag began to expand and unfold out of the module, however the driver's position over the top of the module impeded its egress. This impedance caused the friction heating between the cover

flaps and air bag membrane evidenced by the black transfers on the bag's periphery. The air bag expanded into the driver's chest causing massive chest trauma and the aortic laceration. The air bag's continued expansion abraded the anterior aspect of the driver's neck. The driver then began to accelerate rearward.

As the driver rebounded, the vehicle began to rotate counterclockwise about the hydrant and the vehicle's rear axle began to elevate and rollover to the right. Relative to the vehicle, this dynamic pattern displaced the rebounding driver toward the left side of the left front seat and the left B-pillar. The vehicle rotated approximately 45 degrees, disengaged with the hydrant and continued its westbound trajectory. In the process, it was rolling to its right. The right rear quarterpanel of the vehicle then contacted the utility pole. The 3 o'clock direction of the impact force and quarter turn roll displaced the driver into the center arm rest and to right side of the vehicle where she was found. The right shoulder contusion probably occurred when the driver was displaced to the right side of the vehicle.