

**TRANSPORTATION SCIENCES  
CRASH RESEARCH SECTION**

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**ONSITE SIDE IMPACT OCCUPANT PROTECTION INVESTIGATION**

**VERIDIAN CASE NO: CA99-019**

**VEHICLE: 1998 MERCEDES BENZ C280**

**LOCATION: VIRGINIA**

**CRASH DATE: JUNE, 1999**

**Contract No. DTNH22-94-07058**

**Prepared for:  
U.S. Department of Transportation  
National Highway Traffic Safety Administration  
Washington, DC 20590**

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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.

## TECHNICAL REPORT STANDARD TITLE PAGE

|  |   |   |                         |
|--|---|---|-------------------------|
| <p>1. <i>Report No.</i><br/>CA99-19</p>  | <p>2. <i>Government Accession No.</i></p>                           | <p>3. <i>Recipient's Catalog No.</i></p>  |                         |
| <p>5. <i>Title and Subtitle</i><br/>On-site Side Impact Occupant Protection Investigation<br/>Vehicle - 1998 Mercedes Benz C280<br/>Location - Virginia</p>  |   | <p>4. <i>Weights</i></p>  |                         |
|  |   | <p>6. <i>Report Date:</i><br/>May 2000</p>  |                         |
| <p>8. <i>Author(s)</i><br/>Crash Research Section</p>  |   | <p>7. <i>Performing Organization Code</i></p>   |                         |
|  |   | <p>9. <i>Performing Organization Report No.</i></p>   |                         |
| <p>10. <i>Performing Organization Name and Address</i><br/>Transportation Sciences<br/>Crash Research Section<br/>Veridian Engineering<br/>P.O. Box 400<br/>Buffalo, New York 14225</p>  |   | <p>11.<br/><i>Work Unit No.</i><br/>CO1115 0233-(0000-9999)</p>                                     |                         |
|  |   | <p>12. <i>Contract or Grant No.</i><br/>DTNH22-94-D-07058</p>                                       |                         |
| <p>13. <i>Sponsoring Agency Name and Address</i><br/>U.S. Department of Transportation<br/>National Highway Traffic Safety Administration<br/>Washington, DC 20590</p>   |   | <p>14. <i>Type of Report and Period Covered</i><br/>Technical Report<br/>Crash Date: June, 1999</p> |                         |
|  |   | <p>15. <i>Sponsoring Agency Code</i></p>  |                         |
| <p>16. <i>Supplementary Notes:</i></p>   |   |   |                         |
| <p>17. <i>Abstract</i></p> <p>This on-site investigation focused on a single vehicle run-off road/roll-over driver fatality. The crash involved a 1998 Mercedes-Benz C280 occupied by a 50 year old female driver and a 62 year old female front right passenger. The Mercedes was equipped with a Supplemental Restraint System that consisted of dual frontal air bags and dual door mounted side impact air bags. The vehicle was also equipped with a manual 3-point lap and shoulder belt system with emergency tensioning retractors (ETR). The door mounted side impact air bags and ETRs deployed as a result of the roll-over. The driver sustained a fatal closed head injury and was pronounced dead at the crash scene. The front right passenger reportedly sustained a fractured vertebra in her lower back and was transported to a local trauma center in serious condition.</p> |   |   |                         |
| <p>18. <i>Key Words</i><br/>Supplemental Restraint System<br/>Frontal air bags<br/>Side impact air bags<br/>Tripped rollover<br/>Closed head injury</p>  |   | <p>19. <i>Distribution Statement</i><br/>General Public</p>   |                         |
| <p>20. <i>Security Classif. (of this report)</i><br/>Unclassified</p>  | <p>21. <i>Security Classif. (of this page)</i><br/>Unclassified</p> | <p>22. <i>No. of Pages</i><br/>9</p>  | <p>23. <i>Price</i></p> |

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**VERIDIAN CASE NO: CA99-019**  
**VEHICLE: 1998 MERCEDES BENZ C280**  
**LOCATION: VIRGINIA**  
**CRASH DATE: JUNE, 1999**

***BACKGROUND***

This on-site investigation focused on a single vehicle run-off road/roll-over driver fatality. The crash involved a 1998 Mercedes-Benz C280 occupied by a 50 year old female driver and a 62 year old female front right passenger. The Mercedes was equipped with a Supplemental Restraint System that consisted of dual frontal air bags and dual door mounted side impact air bags. The vehicle was also equipped with a manual 3-point lap and shoulder belt system with emergency tensioning retractors (ETR). The door mounted side impact air bags and ETRs deployed as a result of the roll-over. The driver sustained a fatal closed head injury and was pronounced dead at the crash scene. The front right passenger reportedly sustained a fractured vertebra in her lower back and was transported to a local trauma center.

The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) was informed of the crash on June 16, 1999 by the local police reconstruction unit responsible for the crash. NHTSA in-turn assigned an investigation of the crash to the Special Crash Investigation team at Veridian/Calspan the same day. Cooperation with the local police authorities was established and the Mercedes was placed in the police impound pending SCI inspection. Onsite investigation of the crash took place June 22, 1999.

***SUMMARY***

This single vehicle crash occurred during the daylight hours in June, 1999. At the time of the crash, it was daylight and the weather was not a factor. At the crash scene, the roadway was a four-lane north/south divided state route. A depressed grass median (Vee shaped cross-section) approximately 13 m (40 ft) wide separated the northbound and southbound lanes. There was a sweeping right curve and negative grade for the northbound traffic. The measured radius of the curve was approximately 335 m (1,100 ft). The northbound grade was an estimated -5%. The speed limit in the area of the crash was 89 km/h (55 mph). **Figure 1** is a northbound trajectory view at the crash scene taken during the police investigation.



**Figure 1:** On-scene trajectory view of the Mercedes.

The crash occurred in the following manner. The Mercedes-Benz was northbound in the in-board lane of the road at a reconstructed speed of approximately 97 km/h (60 mph). As the Mercedes entered the right curve, the vehicle drifted to the right of the lane divider due to driver inattention/distraction. A non-contact vehicle reportedly moved to the right into the breakdown lane in order to give the Mercedes a wide berth. The startled driver of the Mercedes realized her error and attempted to return the vehicle to the outboard lane, however she over-steered the vehicle counterclockwise. The rear wheels of the vehicle lost traction as a result of the abrupt steering maneuver and the Mercedes started to rotate counterclockwise. Police investigation identified two yaw marks approximately 36 m (120 ft) long attributed to the right side tires of the Mercedes, Figure 1. The marks began approximately 0.3 m (1.0 ft) outboard of the center lane divider and extended northeastward into the median. The mark's radius of curvature measured approximately 103 m (337 ft). Critical speed calculations of the yaw marks indicated a travel speed of approximately 97 km/h (60 mph).

The Mercedes departed the northbound lanes in a counterclockwise yaw. Upon entering the median, the vehicle had rotated approximately 145 degrees (relative to its initial direction of travel). The vehicle's rotation diminished as it traversed an angled trajectory through the depressed median. Two tire tracks through the median were identified during the scene inspection. The nature of the tracks indicated the Mercedes was sliding laterally, **Figure 2**. As the vehicle began traveling up the median's back slope, its left side tires began to lift. The vehicle entered the southbound lanes of the roadway with the right side rims impacting the raised pavement edge. The Emergency Tensioning Retractors (ETR) (i.e. seat belt pretensioner) may have been activated by this impact. The impact also tripped the Mercedes and initiated a right side leading lateral roll. Two impacts to the pavement edge were identified by the police and SCI scene inspections, **Figure 3**. The vehicle was traveling approximately 64 km/h (40 mph) at the initiation of the tripped rollover.



**Figure 2:** View of the marks through the median.



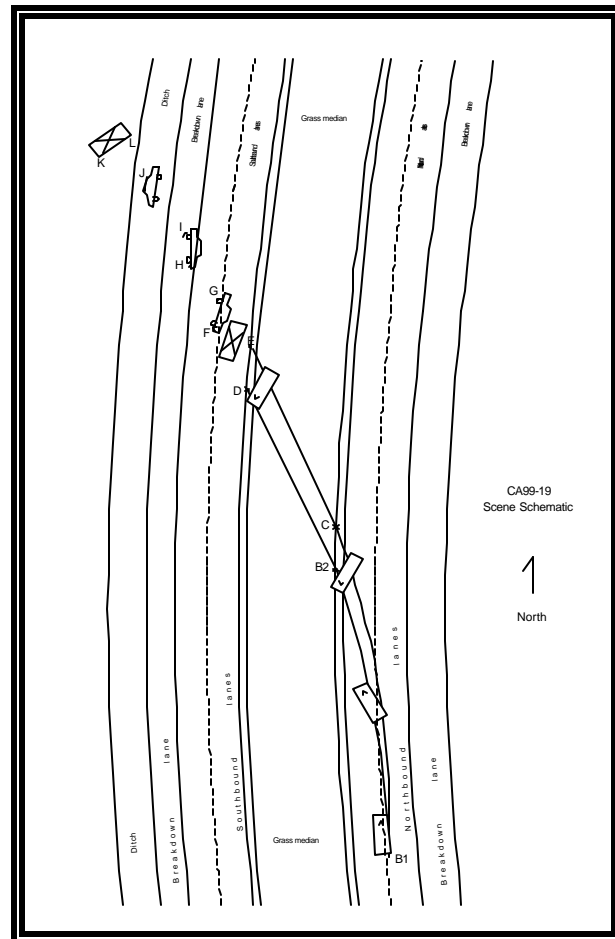
**Figure 3:** View of the rim impacts to the pavement edge.

The Mercedes vaulted and rolled approximately 2 quarter turns (180 degrees) and impacted the pavement with the left front corner of the roof. The roof crushed down impacting the driver's head and resulted in the driver's fatal closed head injury. The vehicle then rolled 1 quarter turn (270 degrees total) with the left side rims impacting the pavement immediately outboard of the southbound centerline. Two rim gouges identified this impact, **Figure 4**. The left side impact air bag deployed due to this impact.



**Figure 4:** View of the left rim gouges.

The vehicle continued to roll approximately 4 quarter turns with the left side rims impacting the pavement (a second time) in the southbound breakdown lane. The Mercedes then rolled 3 additional quarter turns impacting the back slope of the ditch bordering the southbound lanes with its right side. An impression of the right A pillar and roof line into the back slope of the ditch was identified during inspection of the scene. The right side impact air bag deployed at this time. The Mercedes then rolled up the back slope and came to rest on its roof. In total, the vehicle rolled 10 quarter turns (2-1/2 rolls) over a distance of approximately 31 m (103 ft). **Figure 5** is a schematic of the rollover crash event.



**Figure 5:** Crash Schematic.

The driver of the vehicle was a 50 year old female. She was restrained by the vehicle's 3-pt. manual lap and shoulder belt system. The impact of the vehicle's roof with the pavement in the first roll crushed the roof down a minimum of approximately 20 cm (8 in). The driver's head was impacted by the roof as evidenced by blood spatters on the headliner directly above the left front seat. She was pronounced dead at the scene. The Medical Examiner reported that the driver suffered a closed head injury with a possible skull fracture. Cerebral spinal fluid taken from the driver was bloody, indicative of an intracranial injury. A broken left humerus was also identified during the examination. No autopsy

was performed. The front right passenger was a restrained 62 year old female. She reportedly was removed from the vehicle by a passer-by. She reportedly suffered a fractured vertebra in her lower back and was transported to a local trauma center in serious but stable condition.

### ***AIR BAG VEHICLE***

The 1998 Mercedes Benz C280, 4 door sedan, was identified by the Vehicle Identification Number (VIN): WDBHA29G7WA (production sequence deleted). The vehicle's power train consisted of a 2.8 liter, V-6 engine linked to a 5-speed automatic transmission. The vehicle's standard equipment included power steering, traction control and a 4-wheel disc anti-lock braking system with brake assist. The manual restraint system consisted of 3-point manual lap and shoulder belts for the 4 outboard passengers. The front seat belt were equipped with Emergency Tensioning Retractors. The Supplemental Restraint System consisted of frontal air bags for the driver and front right passenger and side impact air bags mounted in the interior panel of the front doors. The electronic odometer was inoperative at the time of the inspection. The vehicle's mileage could not be determined.

### ***Exterior Damage***

The 1998 Mercedes Benz C280 sustained damage consistent with a lateral 2 ½ revolution lateral rollover crash event and is depicted in **Figures 6 and 7**. The primary vehicle damage was to the left front aspect of the roof resultant to its impact with the ground. The left A, B and C-pillars deformed and were displaced laterally to the right. The residual vertical deformation measured approximately 20 cm (8 in). Dynamically, the vertical deformation was greater and crushed the left aspect of the roof down to the level of the left front head rest, **Figure 8**. The rightward lateral displacement measured approximately 15 cm (6 in). The windshield was fractured. The backlight and all side glazings disintegrated in the event. The left front door was jammed shut due to deformation. All other doors remained closed during the crash and were operational. The Collision Deformation Classification (CDC) of the damage was 00-TPDO-4. The left A, B and C-pillars were cut during the extrication of the driver. Additional minor body damage occurred during the process of up-righting the vehicle.



**Figure 6:** Left front three-quarter view of the Mercedes Benz C280.



**Figure 7:** Right front three-quarter view of the Mercedes Benz C280.





**Figure 8:** Interior view of the magnitude of roof deformation.

The vehicle's front and back planes sustained only minor damage indicative that the roll was purely lateral. The longitudinal dimensions of the vehicle were unchanged. The right and left side planes of the vehicle exhibited scratches and abrasions oriented in two different directions. The scratches were primarily vertical (relative to the vehicle's yaw axis) but were biased both to the front and rear of the vehicle. The different orientation of the scratches indicated that the respective side planes contacted the ground at least twice. Three orientations of scratch/abrasions were identified on the right roof edge. The nature of the body damage was consistent with the rollover sequence.

All four tires and aluminum rims were damaged and revealed evidence of ground contact. The right front and right rear tires were debanded and the rims were fractured. The coil spring of the right rear suspension was displaced from the assembly. These damages occurred during impact with the southbound lane's pavement edge and were the trip mechanism of the rollover. Grass/dirt and debris were identified in the rims and related to the vehicle's trajectory through the median. The exposed edges of the left side rims were abraded about their full circumference. The rims were also fractured. These damages related to the rim gouges in the pavement identified during the police and SCI investigations.

### ***Interior Damage***

The interior damage of the Mercedes Benz consisted of the deployment of the side impact bags and the driver's contact with the roof. The driver's head contact resulted from the vehicle's inverted ground impact and the resultant roof deformation (refer to Figure 8). Bloody transfers to the headliner directly above the left front seat identified this contact, **Figure 9**. The area measured approximately 18 cm x 23 cm (7 in x 9 in) and was located approximately 25 cm (10 in) aft of the windshield header and 18 cm (7 in) left of the left roof rail.



**Figure 9:** View of the head contact to the headliner.

### ***Manual Restraint System***

The manual restraint system in the front seats of the 1998 Mercedes Benz C280 4 door sedan consisted of a 3-point lap and shoulder belt with Emergency Tensioning Retractors (ETR) (i.e. pretensioner) with belt force limiters. The anchors of the front seat restraint were fixed to and moved with the seat. The webbing retractor was located in the B-pillar. The D-ring was adjustable. The ETR's of the front left seat and front right seat had fired during the crash. The retractors of both belts were locked at inspection.

The front left restraint webbing was cut during the extrication of the driver. Inspection of the left D-ring indicated it was adjusted to the full down position. The webbing was gathered and trapped in its forward aspect. Inspection of the webbing identified a transfer caused by an interaction with the latchplate hardware. This transfer was located 66 cm (26 in) from the webbing anchor. Examination of the latchplate revealed a corresponding transfer to the hardware, as well as evidence of historical use. The evidence identified during the SCI inspection confirmed the driver was restrained by the manual belt system during the crash.

The front right D-ring was adjusted to the full down position. The belt webbing was gathered and wedged in the D-ring, similar to the front left webbing. Transfer marks were identified on the webbing and on the latchplate's hardware. Evidence of historical use was also identified. All the evidence identified during the inspection confirmed the front right passenger was restrained during the crash.

### ***Supplemental Restraint System***

The Mercedes's Supplemental Restraint System consisted of frontal air bags for the driver and front right passenger and side impact air bags mounted in the interior panels of the front doors. The deployment of the frontal air bags were controlled by a single point sensing control module mounted to the transmission tunnel under the center console. Two satellite sensors mounted to a cross-member under the front seats aided in lateral crash detection and signaled the control module to deploy the side impact air bags. The driver air bag was mounted in the typical manner in the center hub of the steering wheel. The front right air bag was a mid-mount design located in the right aspect of the instrument panel. The frontal air bags did not deploy during the crash.

The side impact air bag module was located above the arm rest in the upper aft aspect of the door, **Figure 10**. Both door mounted side impact air bags deployed as a result of the multiple rollover crash event. The bag deployed from the longitudinal center seam of the door's interior trim panel. The bag was trapezoidal in shape and measured approximately 51 cm by 30 cm (20 in by 12 in), width by height. There was no contact evidence to either side impact air bag. The following nomenclature identified the left and right side impact air bag, respectively:



**Figure 10** View of the right side impact air bag.

|                          |                           |
|--------------------------|---------------------------|
| Left side impact air bag | Right side impact air bag |
| PA 6.6 003101929611      | PA 6.6 003101932703       |
| 002897249107557          | 00289724910725587         |

***OCCUPANT DEMOGRAPHICS***

|                              | <b>Driver</b>                 | <b>Front Right Passenger</b>                           |
|------------------------------|-------------------------------|--|
| Age/Sex:                     | 50 year old/female            | 62 year old/female                                     |
| Height/Weight:               | (63 in)/unknown               | unknown  |
| Restraint Use:               | 3-point lap and shoulder belt | 3-point lap and shoulder belt                          |
| Usage Source:                | SCI and police inspection     | SCI and police inspection                              |
| Medical Condition/Treatment: | fatality                      | fractured lumbar vertebra/transported to trauma center |

***DRIVER INJURY***

The Medical Examiner listed Head Trauma as the driver's cause of death. In an interview, he indicated the driver sustained a probable skull fracture as a result of contact with the roof. Blood was identified in the cerebral spinal fluid indicative of an intra-cranial injury. Multiple facial lacerations and a fractured left humerus were also identified in the external examination. A full autopsy was not required.

| <b>Injury</b>                     | <b>Injury Severity (AIS 90)</b> | <b>Injury Mechanism</b>                       |
|-----------------------------------|---------------------------------|---|
| Probable skull fracture (NFS)     | Moderate (150000.2,9)           | Intruding roof/ground contact during rollover |
| Intra-cranial injury (NFS)        | Serious (121299.3,9)            | Intruding roof/ground contact during rollover |
| Multiple facial lacerations (NFS) | Minor (290600.1,9)              | Disintegrated glass                           |

|                             |                          |  |
|-----------------------------|--------------------------|--|
| Left humerus fracture (NFS) | Moderate<br>(752600.2,2) | Left interior door panel during rollover |
|-----------------------------|--------------------------|--|

***DRIVER KINEMATICS***

The driver of the Mercedes was a 50 year old female. She was restrained and seated in a mid-to-forward seat track position consistent with her stature. Upon impact with the raised pavement edge, it was probable the restraint system’s Emergency Tensioning Retractors (ETR) activated. However, there was no information available regarding the timing of the ETR firing. The ETR’s removed the slack from the belt system and tightened the webbing about the occupants.

The pavement edge impact tripped the vehicle and it initiated a right lateral roll. The centrifugal force caused the sudden rapid lateral rotation caused the driver to initiate a vertically upward and leftward trajectory. The driver loaded the manual restraint evidenced by the aforementioned transfers. As the vehicle became inverted the driver was suspended from the seat belts. Her head was at or above the elevation of the head rest, in-close proximity to the roof. The left front corner of the vehicle’s roof impacted the ground after 2 quarter turns. The left aspect of the roof crushed down to the level of the left head rest, a static measurement of approximately 20 cm (8 in), and impacted the driver’s head. Her fatal closed head injury occurred at this time. Laboratory tests of ETR systems in rollover crashes has determined that the occupant’s vertical excursion is reduced approximately 7 cm to 10 cm (3 in to 4 in). This level of effectiveness would not have significantly affected the driver outcome.

The vehicle’s roll continued with the left rims impacting pavement as evidenced by the two rim gouges near the centerline of the southbound lanes. The left side impact air bag deployed. The driver responded to the left impact by contacting the left door panel and deployed bag. This contact resulted in the fracture of her left humerus. As the vehicle continued to roll, the driver remained in contact with seat belts and flailed about the front interior. The vehicle came to rest on its roof, after completing 2-1/2 rolls.

***FRONT RIGHT PASSENGER INJURY***

| <b>Injury</b>         | <b>Injury Severity (AIS 90)</b> | <b>Injury Mechanism</b>                                       |
|-----------------------|---------------------------------|---|
| Lumbar fracture (NFS) | Moderate (650616.2,8)           | Right interior door panel upon ground contact during rollover |

***FRONT RIGHT PASSENGER KINEMATICS***

The 62 year old female front right passenger in the Mercedes was restrained and seated in a mid-to-forward seat track position consistent with her stature. Upon impact with the raised pavement edge, the restraint system’s Emergency Tensioning Retractors (ETR) (i.e pretensioner) probably activated. The ETR’s removed the slack from the belt system and tightened the webbing about the occupants.

The vehicle tripped upon impact with the pavement edge and rolled laterally right. The rapid rotation displaced the front right passenger upward and leftward. She was in contact with the manual restraint and the restraint helped to maintain her position within the front occupant compartment. Her extremities may have flailed due to the rotation. The vehicle contacted the ground several times during the initial 2 rolls. The passenger would have loaded the restraint and or seat cushion as the vehicle suddenly decelerated during the contact. After completing 2-1/4 rolls, the right side of the Mercedes impacted the back slope of the ditch. The right side impact air bag deployed. The front right passenger moved to the right in response to the deceleration. She impacted the deployed air bag and interior door panel with her hip and right side. This contact was the probable cause of her lower back injury. The vehicle then rolled onto its roof and came to rest with the occupant suspended from the seat belt.