TRANSPORTATION SCIENCES
CRASH DATA RESEARCH CENTER

Veridian Engineering
Buffalo, New York 14225

ON-SITE SIDE IMPACT OCCUPANT PROTECTION INVESTIGATION

VERIDIAN CASE NO. CA01-018

VEHICLE: 2000 MERCEDES BENZ E320 STATION WAGON

LOCATION: MICHIGAN

CRASH DATE: JANUARY 2001

Contract No. DTNH22-94-07058

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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 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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17. *Abstract*

This on-site investigation focused on the performance of the side impact protection system in a 2000 Mercedes Benz E320 station wagon. The Mercedes was equipped with frontal and door-mounted side impact air bags for the front seated occupants. The outboard rear positions were also protected by door-mounted side impact air bags. Head protection curtain bags were installed in the roof. The front 3-point lap and shoulder belts were equipped with Emergency Tensioning Retractors (ETR) and belt force limiters. The left side impact air bags and the left head protection curtain deployed as a result of an intersection crash with a 1993 Chevrolet C3500 Chassis with a utility body. The 46 year old female driver of the Mercedes was restrained at the time of the impact and not injured. The 37 year old restrained male driver of the Chevrolet was not injured.

This crash was identified during the weekly sample of local police agencies conducted by the Primary Sampling Unit 11 (PSU-11) of the National Automotive Sampling System (NASS). The crash was not selected for investigation by NASS. The NASS Zone Center 1 forwarded notification of the crash to the Crash Investigations Division of the National Highway Traffic Safety Administration (NHTSA). NHTSA subsequently assigned an on-site investigation of the crash to the Special Crash Investigations team at Veridian Engineering. The vehicle was located at a repair facility and was available for inspection.

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BACKGROUND

This on-site investigation focused on the performance of the side impact protection system in a 2000 Mercedes Benz E320 station wagon. The Mercedes was equipped with frontal and door-mounted side impact air bags for the front seated occupants. The outboard rear positions were also protected by door-mounted side impact air bags. Head protection curtain bags were installed in the roof. The front 3-point lap and shoulder belts were equipped with Emergency Tensioning Retractors (ETR) and belt force limiters. The left side impact air bags and the left head protection curtain deployed as a result of an intersection crash with a 1993 Chevrolet C3500 Chassis with a utility body. The 46 year old female driver of the Mercedes was restrained at the time of the impact and not injured. The 37 year old restrained male driver of the Chevrolet was not injured.

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SUMMARY

Crash Site

This two-vehicle crash occurred during the morning hours of January, 2001. At the time of the crash, it was daylight and the weather was not a factor. The road surfaces were dry. The crash occurred at the angular four-leg intersection of a two lane north/south road and a two-lane northeast/southwest road in a rural setting. There were no obstructions in the bordering quadrant of the intersection that would have effected the visibility between the intersecting traffic. A stop sign and a flashing red signal for traffic on the north/south road controlled the intersection. A flashing yellow traffic signal regulated the northeast/southwest traffic flow. The speed limit in the area of the crash was 89 km/h (55 mph). **Figure 1** is a southwest view depicting the configuration of the intersection.

Figure 1: Southwest view into the intersection.

Pre-crash

The 1993 Chevrolet C3500 was north-eastbound driven by a 37 year old restrained male. He was operating the vehicle in the course of his employment for a utility company. The Chevrolet was towing a two-wheel work trailer. The 2000 Mercedes Benz was northbound driven by a 46 year old female. She was restrained by the vehicle's 3-point lap and shoulder belt system. The driver of the Mercedes reportedly came to a stop the intersection. The driver then accelerated forward into the path of the Chevrolet. It was her intension to pass straight through the intersection and continue north. The driver indicated to the police she thought the intersection was a 4-way stop and believed the Chevrolet was slowing to stop and/or turn right. It was probable the Chevrolet was braking prior to the crash.

Crash

The crash occurred when the right aspect of the Chevrolet's front plane struck the left side plane of the Mercedes immediately aft of the left rear axle. The principle directions of force were 12 o'clock and 9 o'clock for the Chevrolet and Mercedes, respectively. The force of the impact rearward of the Mercedes' center-of-gravity caused it to rotate counterclockwise as it slid to rest. The Mercedes came to rest facing northwest within the intersection. The Chevrolet came to rest in close proximity to the Mercedes in the north-eastbound lane. The respective velocity changes for the Mercedes and Chevrolet calculated by the Damage Only algorithm of the WINSMASH model were 14.2 km/h (8.8 mph) and 9.3 km/h (5.8 mph). These calculations appear to understate the severity of the crash, based on SCI experience.

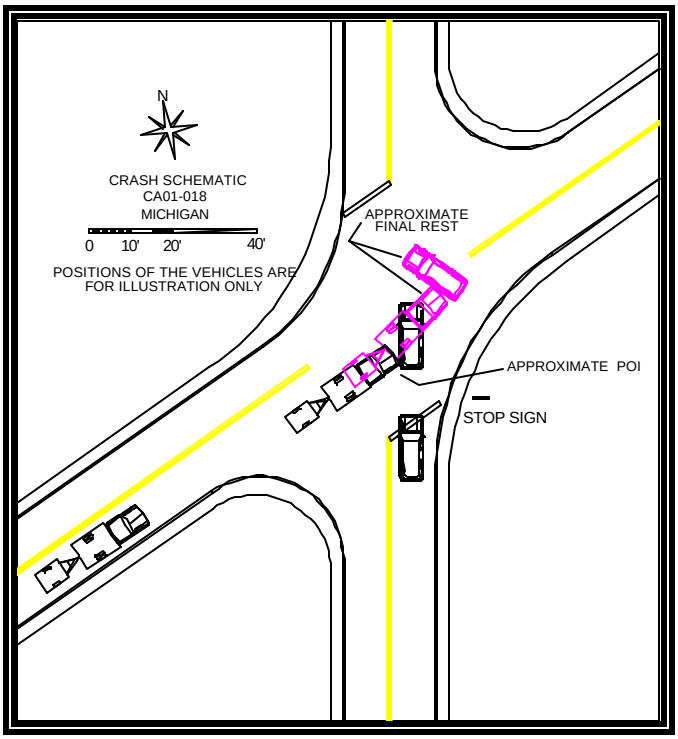

Figure 2: Crash schematic.

The impact was of sufficient magnitude to warrant the deployment of the Mercedes side impact protection system. The left side impact air bags deployed from the front and rear doors. The left head protection curtain deployed from the roof rail. The Chevrolet was manufactured prior to the requirement for automatic occupant protection. There were no injuries in this crash and neither driver requested medical attention.

2000 MERCEDES BENZ E320 STATION WAGON

The 2000 Mercedes Benz E320 station wagon was identified by the Vehicle Identification Number (VIN):

WDBJH82J0YX (production sequence deleted). The 4-door station wagon was equipped with a 3.2 liter/V-6 engine linked to a 5-speed automatic transmission. Traction and stability control systems were standard equipment. The brakes were a 4-wheel disc/anti-lock brake system. The seating system of the station wagon was configured to carry seven passengers and consisted of two front bucket seats, a 3-passenger split bench second row seat and a 2-passenger/rear facing fold down third row seat in the cargo area. The third row seat was folded down at the time of the inspection. The vehicle was manufactured in Germany in August 1999. The vehicle's electronic odometer read 22,342 km (13,883 miles) at the time of the inspection.

Exterior Damage

The vehicle's exterior left side damage consisted of 143.5 cm (56.5 in) of induced and direct contact damage, **Figures 3 and 4.** The direct contact damage began 39.9 cm (15.7 in) forward of the left rear axle and extended to the left corner of the rear bumper. The vertical height of the damage measured 97 cm (38 in) consistent with the front profile of the Chevrolet.. The residual lateral crush profile measured at the trim elevation was as follows: C1=2.5 cm (1.0 in), C2=12.2 cm (4.8 in), C3=15.2 cm (6.0 in), C4=15.5 cm (6.1 in), C5=5.8 cm (2.3 in), C6=1.5 cm (0.6 in). The maximum crush was 15.5 cm (6.1 in) at C4. A pattern of minor scratches to the painted exterior surface was noted on the aft aspect of the left front door and center aspect of the left rear door. This scratch pattern was linked to probable contact with the front plane of the Chevrolet during the later stages of the impact as the Mercedes rotated counterclockwise to rest. There was no change in the wheelbase dimensions. The Collision Deformation Classification (CDC) was 09-LBEW-2.

Figure 3: Left side of the Mercedes Benz.

Figure 4: Close-up of the left rear quarterpanel damage.

The Damage Only algorithm of the WINSMASH model calculated a total velocity change (delta V) for the Mercedes of 14.2 km/h (8.8 mph). The longitudinal and lateral components were 3.7 km/h (2.3 mph) and 13.7 km/h (8.5 mph), respectively. In this contractor's opinion, this calculation underestimated the crash severity. A total delta V in the range of 24 km/h (15 mph) was more representative of the crash severity based on SCI experience. The delta V was probably underestimated due to the nature of the vehicle's structure and the impact orientation. The left rear tire and wheel were in the region of direct

contact and absorbed a portion of the impact energy. In addition, the spare tire was located in a compartment on the interior side of the left rear quarterpanel, directly opposite the impact. The spare tire also absorbed the impact energy and transmitted a portion of that energy in the floor pan of the cargo area, **Figure 5**. The energy absorbed by these components was not accounted for in the WINSMASH analysis, resulting in an underestimated calculation.

Figure 5: Damage to the spare tire compartment.

Interior Damage

The interior damage to the vehicle consisted of the minor intrusion [<2.5 cm (<1 in)] of the spare tire into the rear cargo area and the deployment of the vehicle's left side impact air bags and head protection curtain. The intrusion of the spare tire was caused by the exterior force of the impact on the left rear quarterpanel. Refer to **Figure 5** above. There was no interior damage identified that was associated to any occupant interior contacts.

The leather upholstered 10-way powered driver seat was adjusted to a mid track position and measured 9.1 cm (3.6 in) forward of full rear. The total seat track adjustment measured 25 cm (10 in). The tilt 4-spoke steering wheel rim was adjusted to the center position and was mounted on a telescoping steering column. The telescoping adjustment measured 1.2 cm (0.5 in) aft of full forward. There was no contact to or deformation of the steering wheel rim, consistent with the lateral direction of the impact force.

1993 CHEVROLET C3500 PICK-UP TRUCK

The 1993 Chevrolet C3500 pick-up truck was identified by the Vehicle Identification Number (VIN): 1GBJC34K6PE (production sequence deleted). The 2-wheel drive, 1 ton Chassis Cab was manufactured by General Motors in December 1992 as an incomplete vehicle. The vehicle manufacture was completed in February 1993 by the utility company. The vehicle had a gross vehicle weight rating (GVWR) of 4,990 kg (11,000 lb) and was configured with a 344.2 cm (135.5 in) wheelbase. The power train consisted of a 5.7 liter/V-8 engine linked to a 4-speed automatic transmission. The service brakes were power assisted front disc/rear drum brakes. It was not ABS equipped. **Figure 6** is the right front view of the damaged Chevrolet. A the time of the crash the vehicle was towing a work trailer, **Figure 7**.

Exterior Damage

The combined direct and induced damage extended across the full 174 cm (68.5 in) frontal end-width of the Chevrolet. The width of the direct contact damage measured 77 cm (30.3 in) and began 9 cm (3.5 in) right of center extending to the right front bumper corner. The crush profile measured along the front bumper was as follows: C1=1.0 cm (0.4 in), C2=1.0 cm (0.4 in), C3=4.0 cm (1.6 in), C4=7.0 cm (2.8 in), C5=14.0 cm (5.5 in), C6=30.0 cm (11.8 in). The energy of the impact was managed primarily by the frame and bumper structure of the vehicle. The right front fender buckled rearward and the right door was restricted. There was no measurable change in the wheelbase dimensions. The Collision Deformation Classification was 12-FREW-2. The delta V calculated by the Damage Only algorithm of the WINSMASH model was 9.3 km/h (5.8 mph). In this contractor's opinion, this calculation was underestimated as well. A delta V estimate in the range of 16 km/h (10 mph) was more appropriate based on SCI experience.

Figure 6: Right front view of the Chevrolet.

Figure 7: View of the work trailer.

2000 MERCEDES BENZ E320 STATION WAGON

Manual Restraint System

The vehicle's manual restraint system consisted of 3-point lap and shoulder belts for all seven seat positions. The restraints for the front seat positions were equipped with Emergency Tensioning Retractors (ETRs) and belt force limiters. The driver's belt was stowed in the retractor and operational upon inspection. The ETR did not fire during the lateral crash event. (This component is deployed as a result of an above-threshold longitudinal crash event.) The left front D-ring was adjusted to a mid position. Inspection of the latch plate yielded evidence of historical use consistent with the age of the vehicle. The webbing revealed no direct evidence related to this crash.

Automatic Restraint System

The Mercedes was equipped with a total of eight air bags consisting of a driver and front right passenger air bags, four side impact air bags mounted in the respective side doors of the vehicle and two head protection curtains mounted in the respective side roof rails. The left side impact air bags and left head protection curtain properly deployed as a result of the above-threshold lateral impact.

Figure 8 and 9 are views of the side impact air bags that deployed from the front left door and rear left door, respectively. The respective door-mounted air bags were mounted in the upper aft aspect of the door and located in equivalent positions. The left front and left rear air bags were identical. The leather trimmed upholstery split along a 38 cm (15 in) seam allowing for the deployment of the air bag. The air bag was designed to offer thoracic protection and was trapezoidal in shape. The deflated bag measured 46 cm (18 in) in length. The height of the bag measured 20 cm (8 in) at its forward aspect and the height expanded to 28 cm (11 in) over its length. It was not externally vented. The single noted difference between the respective bags was the method of tethering. The front side impact bag was tethered by two straps separated approximately 14.0 cm (5.5 in) apart. The rear left side impact bag was tethered by a single 20 cm (8 in) long strap. Refer to **Figures 8 and 9**. No contact evidence was noted on the face of the respective bags. The following nomenclature was embossed on bag's fabric: PA66 ASCI. A bar code bearing the following numbers identified the device: 8882 99226304. The air bags were manufactured by Automotive Safety Components International, Johnson Controls.

Figure 8: Front left side impact air bag.

Figure 9: Rear left side impact air bag.

The force of the impact also caused the deployment of the left head protection curtain from the left roof rail. **Figures 10 through 12** are views of the deployed head protection curtain. The headliner separated, along its length, from the upper interior trim allowing the curtain to deploy vertically down. The curtain provided approximately 161.3 cm (65.5 in) of coverage across the vehicle's left side glass. This coverage measured approximately 61 cm (24 in) forward of the B-pillar ending near the forward aft of the left front glazing. The coverage extended approximately 100.3 cm (39.5 in) rearward of the B-pillar, across the left rear glazing and ending immediately rear of the C-pillar. The forward aspect

Figure 10: Left view depicting the coverage of the head protection curtain.

of the curtain was fastened to the mid aspect of the A-pillar by a 30 cm (12 in) long tether strap. The strap attached to the A-pillar approximately 15 cm (6 in) above the instrument panel. The rear aspect of the curtain was fastened to the left roof rail between the C- and D-pillars by a 46 cm (18 in) long tether strap. The vertical dimension of the deflated curtain measured 31.2 cm (12.3 in).

Figure 11: Right interior view of the head protection curtain.

Figure 12: View of the rearward aspect of the head protection curtain.

The curtain was designed with a distinct vertical chambered pattern, refer to Figure 12. This pattern provided the occupant protection when inflated, as well as providing some rigidity to the curtain and helped to maintain its shape. The curtain was not externally vented. A gas cylinder located in the C-pillar provided the means for inflation. The curtain was an estimated 3-5 cm (1-2 in) thick when inflated The head protection curtain was supplied by Autoliv GMBH and was identified by the following nomenclature:

S210 565 120016
01204A
99135
A470
Bar Code: 1125199232006241

Figure 13 is a view of a contact pattern and scuff identified on the outboard side of the curtain and the interior surface of the glazing, respectively. The contact pattern was triangular in shape and measured 14.0 cm by 15.2 cm (5.5 in by 6 in), length by height. The center of the contact was located 23 cm (9 in) rearward of the tether strap. The contact consisted of a pattern of dirt transferred to the curtain during its contact with the interior surface of the glazing. A 5 cm (2 in) scuff was observed on the glazing immediately above the contact pattern. The scuff was located 38.9 cm (15.3 in) forward of the aft edge of the door and 7.1 cm (2.8 in) below the top edge of the glazing.

Figure 13: View of the contact pattern identified on the exterior surface of the curtain.

These contact patterns resulted from the driver's head responding to the lateral direction of the impact force and contacting the interior surface of the curtain. The driver was not injured in the crash event. It was probable the head protection curtain mitigated any potential injury.

DRIVER DEMOGRAPHICS

Age/Sex:	46 year old/Female
Height/Weight:	Unknown, refused cooperation
Manual Restraint Use:	3-point lap and shoulder
Usage Source:	SCI inspection/police report
Medical Treatment:	None, not injured.

DRIVER KINEMATICS

The 46 year old female driver of the vehicle was seated in a presumed upright posture with her seat adjusted to a mid-track position. She was restrained by the vehicle's 3-point lap and shoulder belt system. Upon impact, the Mercedes' side impact protection consisting of side impact air bags in the left doors and the left head protection curtain deployed. The driver responded to the 9 o'clock direction of the impact by moving laterally to the left. Although her position was probably maintained by the structures and manual restraint, she probably contacted the deployed door-mounted side impact air bag with her left flank. The unrestrained inertia of the head caused her neck to bend laterally resulting in head contact to the deployed head protection curtain. The head contact was identified by a contact pattern on the outboard surface of the curtain, as the curtain's outboard surface contacted the left front glazing. The deployed head protection curtain mitigated the driver's contact to the left front glazing and prevented possible head injury. The driver was not injured in the event.