TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

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INFLATABLE SIDE IMPACT OCCUPANT PROTECTION INVESTIGATION

VERIDIAN CASE NO: CA99-020

VEHICLE: 1999 BMW M COUPE

LOCATION: NEW YORK

CRASH DATE: JULY 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

1. *Report No.* CA99-020	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
		4. Weights	
5. *Title and Subtitle* Inflatable Side Impact Occupant Protection Investigation Vehicle - 1999 BMW M Coupe Location - New York		6. *Report Date*: September, 2000	
		7. *Performing Organization Code*	
8. *Author(s)* Crash Research Section		9. *Performing Organization Report No.*	
10. *Performing Organization Name and Address* Transportation Sciences Crash Research Section Veridian Engineering P.O. Box 400 Buffalo, New York 14225		11. *Work Unit No.* CO1115 0235-(0000-9999)	
		12. *Contract or Grant No.* DTNH22-94-D-07058	
13. *Sponsoring Agency Name and Address* U.S. Department of Transportation National Highway Traffic Safety Administration Washington, DC 20590		14. *Type of Report and Period Covered* Technical Report Crash Date: July, 1999	
		15. *Sponsoring Agency Code*	
16. *Supplementary Notes*:			

17. *Abstract*

This on-site investigation focused on a single vehicle run-off road/rollover crash that involved a 1999 BMW M coupe. The vehicle was occupied by a 25 year old male driver and a 25 year old male front right passenger. The vehicle's manual restraint system consisted of an integrated 3-point manual restraint system equipped with pre-tensioners and belt force limiters. The BMW was also equipped with a Supplemental Restraint System(SRS) that consisted of dual frontal air bags and dual door mounted side impact air bags. The seat belt pre-tensioners, dual frontal air bags and the right side impact air bag deployed as a result of the rollover crash. Both occupants of the vehicle were restrained by the 3-point manual belts during the crash sequence. The driver reportedly sustained a minor laceration to his hand and a bloody nose and the right front passenger was reportedly uninjured.

18. *Key Words* Supplemental Restraint System Frontal air bags Side impact air bags Air bag deployment Tripped rollover		19. *Distribution Statement* General Public	
20. *Security Classif. (of this report)* Unclassified	21. *Security Classif. (of this page)* Unclassified	22. *No. of Pages* 9	23. *Price*

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BACKGROUND

This on-site investigation focused on a single vehicle run-off road/rollover crash that involved a 1999 BMW M coupe. The vehicle was occupied by a 25 year old male driver and a 25 year old male front right passenger. The vehicle's manual restraint system consisted of an integrated 3-point manual restraint system equipped with pretensioners and belt force limiters. The BMW was also equipped with a Supplemental Restraint System(SRS) that consisted of dual frontal air bags and dual door mounted side impact air bags. The seat belt pretensioners, dual frontal air bags and the right side impact air bag deployed as a result of the rollover crash. Both occupants of the vehicle were restrained by the 3-point manual belts during the crash sequence. The driver reportedly sustained a minor laceration to his hand and a bloody nose and the right front passenger was reportedly uninjured.

The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) was informed of the crash on July 6,1999 by the Special Crash Investigation team at Veridian/ Calspan. NHTSA subsequently assigned an on-site investigation of the crash to the Veridian SCI team. The vehicle was located at the tow yard near the crash site and was inspected within a week of the crash. An insurance representative for the vehicle was present during the SCI inspection.

SUMMARY

This single vehicle crash occurred during the early morning hours of July 1999 in a rural resort area of New York State. At the time of the crash, it was dark, without street lights, and the weather was not a factor. The westbound approach to the crash scene was a straight two lane chip stone and tar roadway, without lane markings, **Figure 1**. The approach had a positive 3% grade to a hillcrest located 51 m (166 ft) from the area of the crash. The road was a straight for approximately 3 km (2 miles) leading into the area of the crash. The road then descended from the crest at negative 3% and curved to the left 90 degrees. The radius of the curve measured 19 m (62 ft). The road surface changed to dirt and gravel 12 m (39 ft) before the hillcrest. The vertical curvature of the roadway obscured the location of the curve from the driver's vision. A swallow embankment, small trees and brush bordered the right (north) shoulder of the road. The speed limit in the area of the crash was 89 km/h (55 mph).

Figure 1: Westbound trajectory view approaching the hillcrest.

The BMW was driven by a 25 year old male and was traveling westbound at a high rate of speed. The front right passenger was a 25 year old male. Both occupants were restrained by the vehicle's manual belt system. The driver and passenger were on vacation from out-of-state and were unfamiliar with the road. As the vehicle crested the hill and descended into the crash scene, the driver initiated a late counterclockwise steering maneuver in an attempt to negotiate the left curve, **Figure 2**. Due to the vehicle's speed and abrupt steer input, the rear tires of the vehicle lost traction and the vehicle began to rotate counterclockwise off the road. The vehicle rotated approximately 30 degrees relative to its initial direction and the vehicle's right side tires slid into the earthen embankment. As the vehicle climbed the embankment's back slope, the right side tires of the vehicle began to furrow. At the top of the embankment, the vehicle encountered a line of small trees and brush. The front right corner of the BMW impacted and uprooted a 15 cm (6 in) dia. tree. The force of the impact caused the deployment of the vehicle's seat belt pre-tensioners and dual frontal air bags.

Figure 2: Westbound trajectory view approximately 15 m (50 ft) from the roadside departure.

Coincident to the frontal impact, the right corner of the rear bumper side-swiped and snagged a 30 cm (12 in) dia tree. The force of these impacts tripped the vehicle and initiated the right side lateral roll. The vehicle rolled one quarter turn and its right side impacted the ground. The force of the impact caused the deployment of the right side impact air bag. The vehicle then rolled an additional quarter turn (2 quarter turns in total) while sliding through the brush and sideswiping several small trees. The BMW came to rest on its roof facing northward. The final rest of the vehicle measured approximately 18 m (60 ft) from the point of the roadside departure. Refer to **Figures 3 and 4**. **Figure 5** is a schematic of the crash scene.

Several individuals, at a residence east of the crash scene, heard the BMW pass-by the house at a high speed. Due to the vehicle's speed, they anticipated the crash was about to occur and quickly ran toward the scene. Witnesses were on-scene within 30 to 60 seconds. By that time the driver was out of the vehicle and the passenger was in the process of getting out. Reportedly, the driver sustained a small laceration to his hand and had a bloody nose. The right front passenger was not injured. The police investigation determined the driver's Blood Alcohol Content (BAC) was above the legal limit at the time of the crash.

Figure 3: View of the point of roadside departure.

Figure 4: Look back from the BMW's final rest position, 18 m (60 ft) from the road edge.

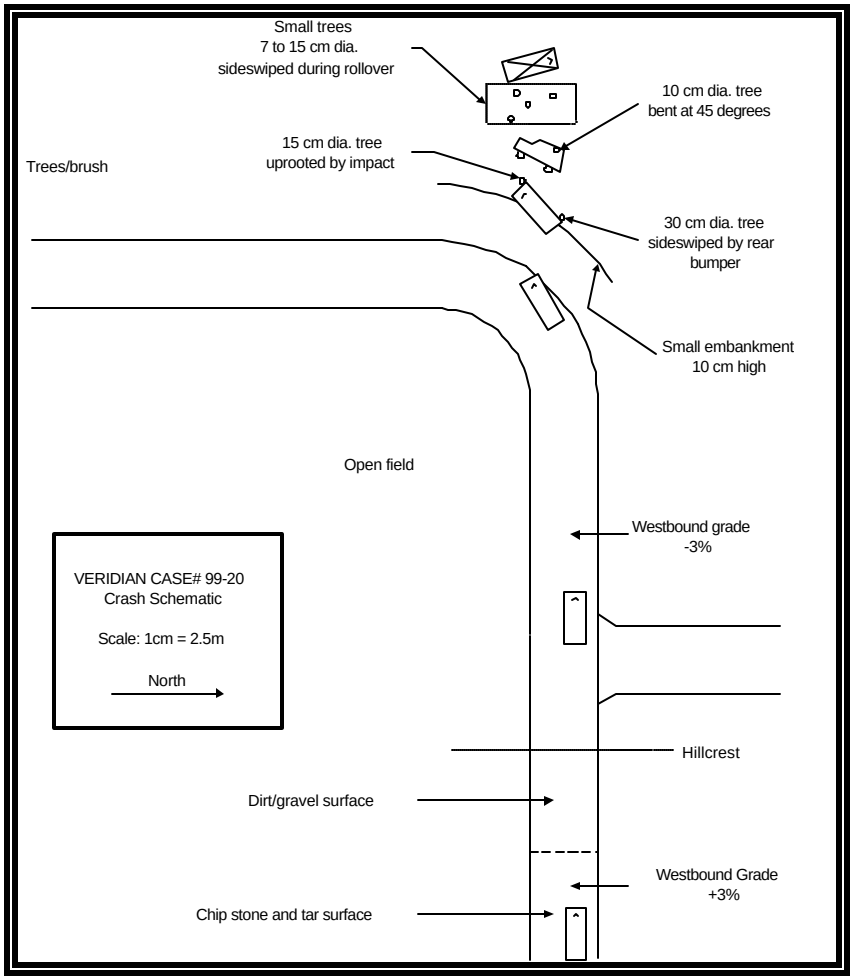

Figure 5: Schematic of the crash scene.

1999 BMW M COUPE

The 1999 BMW M Coupe was identified by the Vehicle Identification Number (VIN): WBSCM9338XL (production sequence deleted). The vehicle was designed as a high performance, rear-wheel drive, 2-door coupe. The power train consisted of a 3.2 liter/in-line 6 cylinder engine linked to a 5 speed manual transmission. The braking system consisted of vacuum assisted 4-wheel disc brakes with ABS (Anti-lock Brake System). The vehicle's date of manufacture was 8/98 and was reportedly leased by the driver in June 1999. The electronic odometer was in-operative at the time of the inspection.

Exterior Damage

The contact damage to the BMW was consistent with an impact to the frontal right corner area and a 2 quarter turn roll-over. Refer to **Figures 6 and 7**. The impact to the front right corner occurred outboard of the right end of the front bumper. Inspection of the vehicle's front bumper system revealed the rigid bumper reinforcement was manufactured from a formed aluminum section and was attached to energy absorbing devices (EAD's). The EAD's were mounted to the vehicle's under-frame. Abrasions on the bodies of the respective EAD's indicated the bumper system compressed approximately 1.9 cm (3/4 in) and returned to its original position through full restitution. The bumper fascia was fractured and displaced. The profile of the front bumper was not deformed by the impact. The overall length of the BMW was unchanged. The force of the impact was absorbed primarily by the structures of the right front suspension/wheel and fender. The right front tire was debeaded and the right side wheelbase was foreshortened 19.1 cm (7.5 in). The left side wheelbase dimension was unchanged. The nature of the frontal vehicular damage was beyond the analytical scope of the WINSMASH model. Forensic analysis of the damage based on SCI experience indicated the delta V of this impact was approximately 19-24 km/h (12-15 mph). The Collision Deformation Classification (CDC) of the impact was 01-FREN-01. This impact coupled with the furrowing of the right side tires were the main tripping mechanisms of the rollover.

Figure 6: Left side view of the 1999 BMW M Coupe.

Figure 7: Right side view of the BMW.

The right side of the BMW sustained sideswiping type damage from contact with several small trees as it departed the roadside and due to contact with the ground. The scratches and abrasions were directed longitudinally rearward. There was rearward deformation of the leading edge of the right door and wooden debris were lodged in the area, refer to Figure 7. The right door remained operational. The right corner of the rear bumper snagged a tree during the initial stages of the roadside departure. This snagging was evidenced by the rearward

displacement of the bumper reinforcement and the EAD bumper mount. The rear bumper system was attached to EADs (similar to the design of the front bumper system). The right EAD was pulled free from its frame attachment by this contact.

Inspection of the right side tires and alloy rims revealed evidence of the vehicle's lateral trajectory. The grass/dirt and debris were identified in the both of the rims and tire beads. These debris were deposited as the vehicle entered the roadside ditch and began to furrow. Inspection of the left side tires and rims was unremarkable.

The left side of the BMW revealed minor roll-over damage that occurred as the vehicle neared final rest. The left rear quarterpanel (Figure 6) buckled inward. Its surface was scratched and abraded by ground contact. The scratches were oriented primarily in the longitudinal direction. The glazing of the left rear window had disintegrated. The vehicle probably rolled up onto the quarterpanel in the latter stages of the rollover and then settled back onto its roof at rest. The left side outboard mirror was displaced from its mount and had dented the exterior panel of the left door. The damage to the door probably occurred during the process of up-righting the vehicle. The door was still operational.

The center forward aspect of the roof (windshield header) was crushed down approximately 5 cm (2 in) and the upper aspect of the windshield was fractured. These damages occurred during contact with a fallen tree near the vehicle's final rest location. The respective locations of the upper A and B-pillars were not disturbed. Damage to the remainder of the roof consisted primarily of scratches and abrasions oriented in the longitudinal direction. Numerous debris were embedded in the area surrounding the sun roof. These damages occurred during the recovery of the vehicle by the tow operator. Reportedly, the vehicle was pulled from its final rest location to the road edge while still on its roof. The vehicle was then up-righted and towed from the scene. The CDC of the rollover damage was 00-TPDO-2.

Manual Restraint System

The manual restraint system in the 1999 BMW M Coupe consisted of integrated 3-point lap and shoulder belts with pretensioners and belt force limiters. The in-board anchors of the restraints were fixed to and moved with the seat. The webbing retractor was located in the mid-aspect of the B-pillar. The D-ring was adjustable. The pre-tensioners were incorporated into the tether stalk of the inboard buckles. The police investigation determined both occupants were restrained.

The front left restraint webbing was found in the stowed position. Inspection of the latch plate revealed little evidence of historical use, however this was consistent with the age of the vehicle. Evidence of belt use, in the form of webbing transfers, were found on the plastic surface of the latch plate's hardware. Additionally as the webbing was exposed from the retractor during its inspection, a 8.1 cm (3.2 in) section of the dirt was identified on the belt. The dirt was located 49.5 to 58.4 cm (19.5 to 23.0 in) above the stop button and would have been over the central aspect of the driver's chest. The dirt could not have gotten on the webbing if it had been retracted during the crash. The evidence identified during the SCI inspection confirmed the driver was restrained by the manual belt system during the crash.

The front right webbing was also found stowed within the retractor at inspection. A transfer mark8 cm (3 in) in length was identified on the webbing. The transfer was located 36.8 to 44.4 cm (14.5 to 17.5 in) above the stop button. A corresponding fabric transfer was identified on the plastic surfaces of the latch plate hardware. Inspection of the restraint confirmed the front right occupant was also restrained in the crash.

Supplemental Restraint System

The BMW's Supplemental Restraint System (SRS) consisted of frontal air bags for the driver and front right passenger and two door-mounted side impact air bags. A seat occupancy sensor mat was incorporated into the cushion of the front right seat. The seat was considered occupied if the sensor mat was loaded with a force of 20 lbs. or more. If the seat was not occupied, the logic of the SRS suppressed deployment of the front right passenger air bag under certain conditions. The SRS was controlled by a single point control module located under the center console. The frontal air bags deployed as a result of the frontal impact and the right side impact air bag deployed during ground contact in the roll-over.

The driver air bag was located in the typical manner in the center hub of the steering wheel rim, **Figure 8.** Note, the steering wheel was rotated approximately 180 degrees counterclockwise at inspection. The air bag measured 61 cm (24 in) in diameter in its deflated state and was not tethered. The bag was vented by a single 2.8 cm (1.1 in) port located in the 12 o'clock sector on the back side of the bag. Multiple blood spatters were located throughout the 4 to 8 o'clock sectors on the face of the bag. There was no direct contact evidence identified on the air bag. The following nomenclature identified the driver air bag:

Figure 8: Driver air bag. Note, the steering wheel is rotated 180 degrees CCW.

Bar Code Label	Embossed on Bag Fabric
P365136466 TT8023884	P565136466 PA66 11-09-98 935574 BBNB006.2 TAKATA/EEC 8023884

The front right passenger air bag deployed from a top-mount configuration located in the right aspect of the instrument panel, **Figure 9**. The module cover flap was trapezoidal in shape, measured 33 cm (13 in) wide and tapered to 25 cm (10 in) over its 18 cm (7 in) height. The flap was tethered by a single 5 cm (2 in) wide strap. The cover flap contacted and fractured the windshield during the deployment sequence. The face of the passenger air bag measured 48 cm by 36 cm (19 in by 14 in), width by height, and extended 46 cm (18 in) rearward of the module. It was tethered by two 15 cm (6 in) wide straps sewn to the face of the bag. The bag was vented by a 8 cm (3 in) diameter vent port located on the outboard side panel. Black vinyl transfers were noted on the face of the air bag and were linked to contact with the interior surface of the module cover flap. There was no evidence of direct contact from the front right passenger to the air bag. The following nomenclature was located on two bar code labels attached to the module:

Figure 9: View of the front right passenger air bag.

4184114797
TRW-VSSI
30310165 A

TYP P3-11-PS-BMW
TRW VSSI

The right side impact air bag, **Figure 10**, was located in the central aspect of the door immediately above the arm rest. The module cover flap measured 24.1 cm by 10.7 cm (9.5 in by 4.2 in), width by height, and hinged on its lower edge. The bag deployed through a 18 cm by 8 cm (7 in by 3 in) opening in the trim panel. The side impact air bag measured 46 cm by 30 cm (18 in by 12 in), width by height, in its deflated state. There was no contact evidence on the air bag The following manufacturer's information identified the air bag:

Herst: Autoliv International
Side Bag Module
122025
BAM-PT1-0644

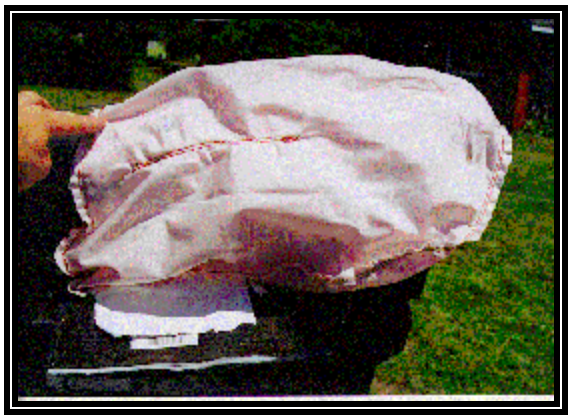

Figure 10: View of the right side impact air bag.

OCCUPANT KINEMATICS AND INJURY

The driver and front right passenger were both 25 year old males. They were from out-of-state and on vacation in a resort community, near where the crash occurred. Neither individual was familiar with the road. Alcohol was cited in the police report as a factor in the crash.

The vehicle was traveling westbound at a high rate of speed. Both the driver and front right passenger were seated in a rear track position and restrained by the vehicle's manual seat belt system. As the BMW crested hill, the driver realized the road curved sharply left and abruptly initiated a 180 degree counterclockwise steer. The speed of the vehicle coupled with the sharp steering maneuver caused the rear tires to lose traction and the BMW began to rotate counterclockwise and travel off the road. The vehicle rotated approximately 30 degrees relative to its initial travel direction and had begun to furrow. The occupants responded to this maneuver and the vehicle's dynamics by initiating a forward and rightward trajectory as the vehicle decelerated. Upon impact with tree at the brush line, the seat belt pre-tensioners and frontal air bag system deployed. The pre-tensioner removed the slack from the belt system and cinched the belt webbings down about the occupants. The occupants were kept within the occupant seat by the webbing's tension. The "in-position" occupants probably had little interaction with the frontal air bags.

The frontal right impact tripped the vehicle and caused the right lateral rollover. The right side impact with the ground caused deployment of the right side impact air bag. The occupants moved rightward (relative to the vehicle) in response to the deceleration of the impact and gravitational forces. The front right occupant probably contacted the inflated side impact air bag. This contact did not produce any injuries. The vehicle then rolled an additional quarter turn and came to rest on its roof. During the dynamics of the roll the occupants probably flailed about the interior but remained in contact with the seats due to an effective restraint system. At rest, the occupants were suspended upside down and held in place by the seat belts.

Witnesses in the vicinity of the crash site saw the BMW pass-by at a high rate of speed. They heard and then responded to the crash. They arrived within 1 minute of the crash. Upon their arrival, the driver was already out of the BMW and the passenger was just in the process of exiting the vehicle. Reportedly the driver had a minor laceration to his hand and a bloody nose. The front right passenger was not injured. The police report indicated neither party was injured nor transported to a hospital.