

**TRANSPORTATION SCIENCES  
CRASH DATA RESEARCH CENTER**

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**VERIDIAN REMOTE ADVANCED OCCUPANT PROTECTION SYSTEM/SIDE  
IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION  
SCI TECHNICAL SUMMARY REPORT**

**NASS/SCI COMBO CASE NO. 02-04-076E**

**VEHICLE – 2001 BMW 525i**

**LOCATION - STATE OF NEW JERSEY**

**CRASH DATE – OCTOBER 2002**

Contract No. DTNH22-01-C-17002

Prepared for:

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National Highway Traffic Safety Administration  
Washington, D.C. 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 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.

## TECHNICAL REPORT STANDARD TITLE PAGE

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| <i>16. Abstract</i><br>This remote investigation focused on the performance of the Advanced Occupant Protection System (AOPS) and the side impact inflatable occupant protection system present in a 2001 BMW 525i sedan. The AOPS included dual-stage "smart" frontal air bags and safety belt pretensioners. The side impact inflatable occupant protection system included side impact air bags and a Head Protection System (HPS). The BMW was involved in a run-off-road crash that involved a left side impact to a wood fence and a wood utility pole, and a subsequent frontal impact with a tree. The impacts resulted in the deployment of the driver's air bag, both side impact air bags, and both HPS. A 17-year-old male driver was the sole occupant of the vehicle and was restrained by the manual 3-point lap and shoulder belt. He sustained small lacerations behind the left ear, left shoulder abrasion, left chest abrasion, left abdomen abrasion, left lower leg contusion, a right hip contusion, and a thoracic spine strain. He was transported by ambulance to a local hospital where he was treated for his injuries and released. |                                                             |                                                                                              |                  |
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IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION  
SCI SUMMARY TECHNICAL REPORT  
NASS/SCI COMBO CASE NO. 02-04-076E  
SUBJECT VEHICLE – 2001 BMW 525i  
LOCATION - STATE OF NEW JERSEY  
CRASH DATE - NOVEMBER 2002**

***BACKGROUND***

This remote investigation focused on the performance of the Advanced Occupant Protection System (AOPS) and the side impact inflatable occupant protection system present in a 2001 BMW 525i sedan. The AOPS included dual-stage “smart” frontal air bags and safety belt pretensioners. The side impact inflatable occupant protection system included side impact air bags and a Head Protection System (HPS). The BMW (**Figure 1**) was involved in a run-off-road crash that involved a left side impact to a wood fence and a wood utility pole, and a subsequent frontal impact with a tree. The impacts resulted in the deployment of the driver’s air bag, both side impact air bags, and both HPS. A 17-year-old male driver was the sole occupant of the vehicle and was restrained by the manual 3-point lap and shoulder belt. He sustained small lacerations behind the left ear, left shoulder abrasion, left chest abrasion, left abdomen abrasion, left lower leg contusion, a right hip contusion, and a thoracic spine strain. He was transported by ambulance to a local hospital where he was treated for his injuries and released.



**Figure 1. Damaged 2001 BMW 525i**

This crash was identified by the National Automotive Sampling System (NASS) PSU 04 during the weekly sampling of Police Accident Reports (PARs). This crash was selected as CDS Case No. 02-04-076E. The NASS PSU performed the vehicle inspection and scene inspection. Due to the presence of the AOPS and deployment of the side impact inflatable protection system in the 2001 BMW 525i, NHTSA assigned the tasks of case review and report preparation to the Veridian SCI team.

***SUMMARY***

***Crash Site***

This single-vehicle crash occurred during the nighttime hours of October 2002 in the state of New Jersey. At the time of the crash rain was falling and the asphalt roadway surface was wet. The north/south roadway consisted of one travel lane in each direction separated by a double-yellow centerline and bordered by asphalt shoulders. The west roadside was also bordered by a concrete curb. The roadway was level and had exhibited a southbound right curve at the crash site. There were no traffic controls present at the crash site and the posted speed limit was 64 km/h (40 mph). The roadside environment consisted of trees and private residences.

### ***Pre-Crash***

The 17-year-old male driver of the 2001 BMW 525i was operating the vehicle southbound on the two-lane roadway on approach to the right curve (**Figure 2**). Police reported the pre-crash travel speed to be 72 km/h (45 mph). As the BMW entered the curve, the driver lost control of the vehicle due to the wet roadway surface. The vehicle initiated a clockwise (CW) yaw across the centerline and the northbound lane, and departed the opposite roadside near the apex of the curve (**Figure 3**). Scuff marks were present on the roadside from the BMW's tires between the point of roadside departure and the impact with the utility pole. The driver stated that he did not apply the brakes and did not attempt any steering inputs to attempt to regain control of the vehicle. It was not known if the BMW's traction control system engaged.



**Figure 2. Southbound approach for the BMW 525i**



**Figure 3. Close-up of crash site**

### ***Crash***

The left side of the BMW struck a wood fence with the left rear aspect. The damage was concentrated on the rear aspect of the left rear quarter panel. Due to the yielding nature of the wood fence, the BMW continued through the fence in the CW yaw. The vehicle struck a wood utility pole with the left rear door area which resulted in moderate left side damage to the BMW and deployed the left and right side impact air bags and the left and right HPS. The pole impact reversed the vehicle's rotation as the BMW's center of gravity was forward of the pole at impact. The BMW rotated approximately 90 degrees in a rapid counterclockwise (CCW) direction around the pole and subsequently struck a tree with the front aspect. The damage algorithm of the WinSMASH program calculated a delta-V of 24 km/h (15 mph) based on the documented frontal crush profile. The tree impact resulted in the moderate frontal damage to the vehicle and was sufficient to deploy the frontal air bag system. The BMW rotated approximately 270 degrees off of the tree in a CCW direction while it traveled back across the roadway. The vehicle came to rest in a lateral orientation straddling the centerline.

### ***Post-Crash***

The 17-year-old male driver of the BMW 525i exited the vehicle under his own power. He was transported by ambulance to a local hospital where he was treated for his injuries and released.

### ***VEHICLE DATA – 2001 BMW 525i***

The 2001 BMW 525i was identified by the Vehicle Identification Number (VIN): WBATT43421G (production sequence omitted). The odometer reading was unknown due to lack of power to the vehicle at the time of the inspection. The vehicle was a four-door sedan equipped

with a 3.0 liter, 6 cylinder engine, a 5-speed manual transmission, power four-wheel disc brakes with anti-lock, alloy wheels, a traction control system, power steering, and a tilt/telescoping steering wheel. The BMW was configured with Continental Contitouring Contact P225/55R16 tires for each wheel.

The seating was configured with front bucket seats and a rear bench seat. The driver's seat was equipped with an 8-way power adjustment. Each seating position was configured with an adjustable head restraint.

## **VEHICLE DAMAGE**

### **Exterior Damage – 2001 BMW 525i**

The BMW 525i sustained moderate left side damage as a result of the fence and utility pole impacts (**Figure 4**). The direct damage for the fence impact was located on the left rear quarter panel. The maximum lateral crush was 5 cm (2") for the impact with the fence. The Collision Deformation Classification (CDC) for the fence impact was 10-LBEW-1. The direct damage for the utility pole impact began 45 cm (18") rear of the left B-pillar and extended 45 cm (18") rearward along the left rear door. Pocketing in the sheet metal and wood transfers from the pole were present on the left rear door. The left rear wheel was displaced laterally and the left aspect of the rear bumper fascia was separated. The right rear wheel was displaced as a result of the rapid CCW rotation around the pole. The direct contact involved the entire vertical height of the vehicle. The combined direct and induced damage began at the left B-pillar and measured 90 cm (35") rearward along the left rear door and left rear quarter panel. Due to the overlapping damage from the multiple left side impacts, a single crush profile was documented by the researcher. It should be noted that the crush profile and damage locators were adjusted after Zone Center review and did not coincide with the case photographs of the crush contour gauge. The maximum lateral crush on the left rear door measured 33 cm (13"). The CDC for the utility pole impact was 09-LPAW-3.



**Figure 4. Left side damage to the BMW 525i**

The BMW sustained moderate frontal damage as a result of the impact with the tree (**Figure 5**). The direct damage began 110 cm (43") inboard of the front left bumper corner and extended along the front bumper 50 cm (20") to the front right corner. The bumper fascia sustained abrasions and fractures from contact with the tree. Direct contact abrasions and tree debris were also present on the right aspect of the hood. The hood was buckled rearward and the right front fender was crushed rearward. The combined direct and induced damage measured 160 cm (63") across the entire frontal plane. Six crush measurements were documented by the NASS researcher along the front



**Figure 5. Frontal damage to the BMW 525i**



bumper and were as follows: C1 = 15 cm (6”), C2 = 16 cm (6”), C3 = 22 cm (9”), C4 = 31 cm (12”), C5 = 32 cm (13”), C6 = 24 cm (9”). The CDC for the frontal impact with the tree was 12-FZEW-2.

### **Interior Damage – 2001 BMW 525i**

The 2001 BMW 525i sustained moderate interior damage as a result of the multiple impacts (**Figures 6 and 7**). The left rear door was jammed shut at the time of the vehicle inspection. The windshield was fractured from impact forces. The left rear, right front, and backlight glazing was disintegrated from impact forces. The right toe pan intruded longitudinally, and lateral intrusions included the left roof side rail, left door, and left C-pillar. The knee bolster was scuffed on the left aspect from contact with the driver’s left leg. The interior panel of the left front door had been removed at the time of the vehicle inspection. The NASS researcher reported that the rear left head restraint was damaged as a result of the impact with the utility pole. It was separated from the rear seat back at the time of the vehicle inspection. The driver’s safety belt webbing exhibited scuffs on the shoulder portion of the belt.



**Figure 6. View across the front seating positions**



**Figure 7. View across the rear seating positions showing intrusions**

### **MANUAL RESTRAINT SYSTEMS – 2001 BMW 525i**

The 2001 BMW 525i was configured with manual 3-point lap and shoulder belts for each seating position in the vehicle. Adjustable D-rings were present for the driver and front right passenger positions and both D-rings were adjusted to the full-down position at the time of the vehicle inspection. The driver’s safety belt was configured with an Emergency Locking Retractor (ELR) and a sliding latch plate. The remaining seating positions in the vehicle were configured with switchable ELR/Automatic Locking Retractors (ALR) and sliding latch plates.



## **ADVANCED OCCUPANT PROTECTION SYSTEM (AOPS) – 2001 BMW 525i**

### **Frontal Air Bag System**

The 2001 BMW 525i was equipped with dual-stage, “smart”, frontal air bags for the driver and front right passenger positions. The driver’s air bag deployed as a result of the frontal impact with the tree. The driver’s air bag deployed from the steering wheel hub that was configured with asymmetrical H-configuration module cover flaps. The upper flap measured 16 cm (6”) in width and 11 cm (4”) in height. The lower flap measured 14 cm (6”) in width and 7 cm (3”) in height. The driver’s air bag (**Figure 8**) measured 58 cm (22”) in diameter and was vented by a single circular port at the 12 o’clock aspect on the rear of the air bag. The air bag was not tethered. The NASS researcher reported no occupant contact evidence on the air bag.



**Figure 8. View of deployed driver's air bag**

The front right passenger’s air bag was housed in a top-mount module on the right instrument panel. The front right passenger’s air bag did not deploy in this crash.

### **Safety Belt Pretensioners**

The front seat safety belts were configured with buckle pretensioners that activated as a result of the frontal impact. The post-crash measurement of the buckle pretensioners was not reported.

### **Side Impact Occupant Protection System**

#### **Side Impact Air Bag System**

The 2001 BMW 525i was equipped with door-mounted side impact air bags for both front seating positions. Both side impact air bags deployed as a result of the crash. The side impact air bags deployed in a lateral direction from the interior door panels above the arm rests. The cover flaps were in the shape of parallelograms and were hinged at the bottom aspects. The side air bags offered thorax protection and measured 50 cm (20”) in length and 22 cm (9”) in height. Each side air bag was tethered by one internal strap. The deployed driver’s side air bag is shown in **Figure 9**.



**Figure 9. Door-mounted driver's side air bag**

**Head Protection System (HPS)**

The 2001 BMW 525i was equipped with a HPS that consisted of inflatable tubular structures for both front seated occupants that deployed as a result of the crash. The HPS deployed vertically from the A-pillars and roof side rails and were positioned diagonally across the side windows when fully inflated (**Figure 10**). Both HPS were tethered at the lower aspect of the A-pillars and at the roof side rails between the B- and C-pillars. The HPS cover flaps measured 150 cm (59”) in length and 10 cm (4”) in width. Each HPS air bag measured 120 cm (47”) in length and 16 cm (16”) in diameter. The NASS researcher did not identify any occupant contact to the HPS.



**Figure 10. View of driver's HPS**

**OCCUPANT DEMOGRAPHICS – 2001 BMW 525i**

**Driver**

Age/Sex: 17-year-old male  
 Height: 168 cm (66”)  
 Weight: 50 kg (110 lb)  
 Seat Track Position: Full-forward at the time of the vehicle inspection  
 Manual Restraint Use: Manual 3-point lap and shoulder belt  
 Usage Source: Vehicle inspection, injury data  
 Eyewear: Contact lenses  
 Type of Medical Treatment: Transported by ambulance to a local hospital, treated for his injuries, and released

**Driver Injuries**

| <b>Injury</b>                                                                  | <b>Injury Severity (AIS 90/Update 98)</b> | <b>Injury Mechanism</b> |
|--------------------------------------------------------------------------------|-------------------------------------------|-------------------------|
| Lower left flank (abdomen) abrasion (medically reported as a ‘seat belt mark’) | Minor (590202.1,2)                        | Lap belt webbing        |
| Thoracic spine strain                                                          | Minor (640478.1,7)                        | Impact forces           |
| Left shoulder abrasion                                                         | Minor (790202.1,2)                        | Shoulder belt webbing   |
| Small lacerations behind left ear*                                             | Minor (190602.1,2)                        | Flying glass            |
| Mid-left chest abrasion*                                                       | Minor (490202.1,2)                        | Shoulder belt webbing   |
| Right hip contusion*                                                           | Minor (890402.1,1)                        | Lap belt webbing        |
| Left anterior lower leg contusion*                                             | Minor (890402.1,2)                        | Knee bolster            |

Injury source: Emergency Room Records, \*Interview

### **Driver Kinematics**

The 17-year-old driver was seated in an upright posture. He stated in the interview that his right hand was positioned at 12 o'clock on the steering wheel rim and his left hand was on his lap. He was restrained by the manual 3-point lap and shoulder belt. Although the seat track position was in the full-forward position at the time of the vehicle inspection, the driver stated that the seat was adjusted to the full-rear track position at the time of the crash.

The driver initiated a somewhat lateral trajectory to the left as the vehicle initiated the CW yaw. Due to the yielding nature of the fence impact, the driver was probably displaced slightly, but remained in position as a result of the restraint use. At impact with the utility pole, the left side air bag and left HPS deployed. Although there was no right side impact to the vehicle, the right side air bag and HPS also deployed. The driver initiated a lateral trajectory to the left and loaded the manual restraint, driver's side impact air bag and the left HPS. The HPS mitigated driver contact with the left front glazing. He sustained small lacerations behind the ear from flying glass. The driver was redirected to the right as the vehicle reversed its rotation around the pole. The vehicle continued a short distance and struck a tree with the front aspect. At impact with the tree, the buckle safety belt pretensioners fired and the driver's air bag deployed. The driver initiated a forward trajectory in response to the frontal impact force. He loaded the manual restraint, which remained taught as a result of the activated buckle pretensioner. He sustained a left flank abrasion, right hip contusion, left shoulder abrasion, and a mid-left chest abrasion as a result of loading the safety belt webbing. His left leg struck the outboard aspect of the knee bolster, which resulted in a left anterior lower leg contusion. The driver also sustained a thoracic spine strain as a result of impact forces. He exited the vehicle under his own power and was transported by ambulance to a local hospital. He was treated for his injuries and released.

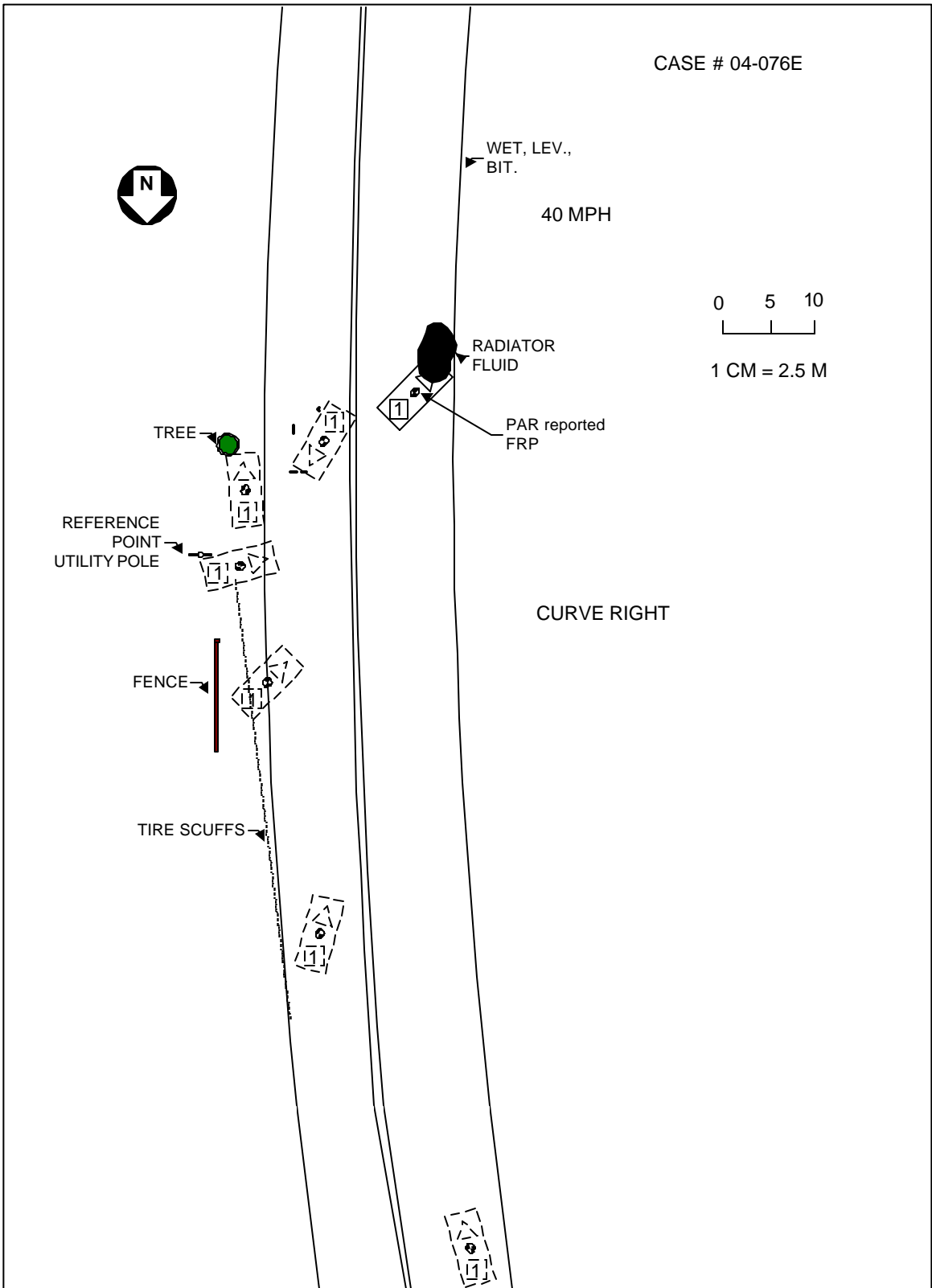


Figure 11. NASS scene schematic