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VERIDIAN REMOTE ADVANCED OCCUPANT PROTECTION SYSTEM INVESTIGATION
SCI TECHNICAL SUMMARY REPORT

NASS/SCI COMBO CASE NO. 02-43-212E

VEHICLE – 2002 BMW 325i

LOCATION - STATE OF NORTH CAROLINA

CRASH DATE – SEPTEMBER 2002

Contract No. DTNH22-01-C-17002

Prepared for:

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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.

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16. Abstract

This remote investigation focused on the performance of the Advanced Occupant Protection System (AOPS) in a 2002 BMW 325i. The safety system included dual stage frontal air bags and safety belt pretensioners for the front occupants. The BMW was also equipped door panel mounted side impact air bags and a Head Protection System (HPS) that consisted of front roof side rail mounted tubular air bags. In addition, the BMW was equipped with an Event Data Recorder (EDR) that was removed by the NASS researcher and sent to BMW for data recovery. The 2002 BMW 325i was occupied by a restrained 37-year-old female driver, a 25-year-old female front right occupant, a 19-month-old male in the rear left, and a 23-year-old female in the rear right. The BMW 325i **(Figure 1)** was involved in a moderate severity intersection crash with a 1995 Nissan 240SX. The front of the 2002 BMW impacted the left side of the 1995 Nissan. The impact with the 1995 Nissan was sufficient to actuate the driver's and front right passenger's safety belt buckle pretensioners and deploy both stages of the frontal air bags. The driver sustained a superior thoracic spine strain. The front right occupant sustained a right facial contusion, right facial abrasion, central chest contusion and a minor closed head injury. The rear left occupant was reported as restrained in a child safety seat (CSS) and was not injured. The CSS was not inspected by the NASS researcher. The driver and two adult passengers were transported to a hospital for treatment. The child occupant was reportedly not injured or transported. The rear right occupant sustained police reported "B" type injuries and was transported to a hospital for treatment; however, no medical records have been received. The driver of the Nissan sustained police reported "B" type injuries and was transported to a local hospital for treatment. The driver of the Nissan's injuries consisted of a right lower extremity contusion, cervical spine strain, left side pelvis fracture, anterior displaced pelvis fracture, left side one rib fracture, and a posterior sacroilium fracture. The front right occupant of the Nissan was police reported as not injured.

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VERIDIAN REMOTE ADVANCED OCCUPANT PROTECTION SYSTEM INVESTIGATION
SCI SUMMARY TECHNICAL REPORT
NASS/SCI COMBO CASE NO. 02-43-212E
SUBJECT VEHICLE – 2002 BMW 325i
LOCATION - STATE OF NORTH CAROLINA
CRASH DATE - SEPTEMBER 2002

BACKGROUND

This remote investigation focused on the performance of the Advanced Occupant Protection System (AOPS) in a 2002 BMW 325i. The safety system included dual stage frontal air bags and safety belt pretensioners for the front occupants. The BMW was also equipped door panel mounted side impact air bags and a Head Protection System (HPS) that consisted of front roof side rail mounted tubular air bags. In addition, the BMW was equipped with an Event Data Recorder (EDR) that was removed by the NASS researcher and sent to BMW for data recovery. The 2002 BMW 325i was occupied by a restrained 37-year-old female driver, a 25-year-old female front right occupant, a 19-month-old male in the rear left, and a 23-year-old female in the rear right. The BMW 325i **(Figure 1)** was involved in a moderate severity intersection crash with a 1995 Nissan 240SX. The front of the 2002 BMW impacted the left side of the 1995 Nissan. The impact with the 1995 Nissan was sufficient to actuate the driver's and front right passenger's safety belt buckle pretensioners and deploy both stages of the frontal air bags. The driver sustained a superior thoracic spine strain. The front right occupant sustained a right facial contusion, right facial abrasion, central chest contusion and a minor closed head injury. The rear left occupant was reported as restrained in a child safety seat (CSS) and was not injured. The CSS was not inspected by the NASS researcher. The driver and two adult passengers were transported to a hospital for treatment. The child occupant was reportedly not injured or transported. The rear right occupant sustained police reported "B" type injuries and was transported to a hospital for treatment; however, no medical records have been received. The driver of the Nissan sustained police reported "B" type injuries and was transported to a local hospital for treatment. The driver of the Nissan's injuries consisted of a right lower extremity contusion, cervical spine strain, left side pelvis fracture, anterior displaced pelvis fracture, left side one rib fracture, and a posterior sacroilium fracture. The front right occupant of the Nissan was police reported as not injured.

Figure 1. 2002 BMW 325i

This crash was identified by the National Automotive Sampling System (NASS) PSU 43 during the weekly sampling of Police Accident Reports (PARs). This crash was selected and researched as CDS Case No. 02-43-212E. The NASS PSU performed the vehicle and scene inspections. Due to the deployment of the AOPS in the 2002 BMW 325I and the

presence of a CSS, NHTSA assigned the tasks of case review and report preparation to the Veridian SCI team.

SUMMARY

Crash Site

This two-vehicle crash occurred during the daylight hours of September 2002 in the state of North Carolina. At the time of the crash, there were no adverse weather conditions and the asphalt road surface was dry. The crash occurred at a four-leg intersection, which connected an interstate off-ramp to a three-lane divided north/south roadway. The north and southbound lanes were separated by a depressed grass median. The northbound roadway was configured with two lanes for through traffic and a left turn lane. The north/south roadway was straight and level. The westbound roadway was a two-lane interstate off-ramp with a right turn lane separated by a concrete gore on the north edge and a yellow fog line and a grassy road edge on the south. The off- ramp was straight and level at the intersection. Traffic flow through the intersection was controlled by a stop sign for westbound traffic. The posted speed limit for the roadways was 72 km/h (45 mph).

Vehicle Data – 2002 BMW 325i

The 2002 BMW 325i was identified by the Vehicle Identification Number (VIN): WBAET37402 (production sequence omitted). The odometer reading was 12,271 km (7,625 miles) at the time of the inspection. The vehicle was a four-door sedan that was equipped with a 2.5-liter, six-cylinder engine, four-wheel disc brakes with ABS, rear wheel drive and a five-speed automatic transmission. The tires on the BMW were Continental Conti-Touring Contact radials, size P205/55R16. The 2002 BMW was configured with front bucket seats with adjustable head restraints. The second row was configured with a bench seat and adjustable head restraints for the outboard positions. The driver's seat was equipped with power adjustments for track and recline adjustments.

1995 Nissan 240SX

The 1995 Nissan 240SX was identified by the Vehicle Identification Number (VIN): JN1AS44D2S (production sequence omitted). The odometer reading was 178,921 km/h (111,176) at the time of the inspection. The vehicle was a two-door coupe that was equipped with 2.4 liter, four-cylinder engine, with rear wheel drive and a four speed automatic transmission. The front tires on the Nissan were Continental Conti-touring Contact radials, size P205/55R16. The rear tires on the Nissan were Goodyear Eagle HP radial, size P205/55R16. The Nissan was configured with front bucket seats and adjustable head restraints. The second row was configured with a bench seat and no head restraints.

Pre-Crash

The 37-year-old female driver of the 2002 BMW 325i was operating the vehicle northbound in the left through lane on approach to the intersection **(Figure 2)**. A 25-year-old female front right occupant, a 19-month-old male in the rear left, and a 23-year-old female in the rear right also occupied the 2002 BMW 325i. The driver of the 1995 Nissan was operating the vehicle westbound on approach to the intersection **(Figure 3)**. The

driver of the Nissan failed to detect the BMW and accelerated forward directly into the path of the BMW. It was unknown if the driver of the Nissan came to a complete stop before entering the intersection. There was no physical evidence at the crash site. The police reported travel speed for the BMW was 72 km/h (45 mph) and 16 km/h (10 mph) for the Nissan. The NASS scene schematic is included as **Figure 15** of this report.

Figure 2. BMW's approach to the intersection.

Figure 3. Nissan's approach to the intersection.

Crash

The full frontal aspect of the BMW impacted the left passenger compartment area of the Nissan **(Figure 4)**. The impact resulted in moderate severity damage to the front aspect of the BMW and was sufficient to fire the front safety belt buckle pretensioners and deploy the front left and front right frontal air bags. The WINSMASH program was used to calculate the delta V for this impact. The total delta V for the BMW was 33.0 km/h (20.5 mph). The longitudinal and lateral components were -31.0 (19.3 mph) and -11.0 (6.8 mph) respectively. The total delta V for the Nissan was 40.0 km/h (24.8 mph). The longitudinal and lateral components were -20.0 (12.4 mph) and 35.0 km/h (21.7 mph) respectively. The EDR did not record a delta V for this impact.

Figure 4. Area of impact.

Post-Crash

The BMW rotated slightly counter clockwise (CCW) and came to rest in the intersection northwest of the area of impact. The Nissan rotated approximately 35 degrees and came to rest northwest of the area of impact in the intersection. The BMW's driver and two adult occupants were injured and transported to a local hospital for treatment. The child occupant was reported as not injured or transported. The driver of the Nissan was injured and transported to a local hospital for treatment. The front right passenger of the Nissan was reportedly not injured or transported.

Vehicle Damage

Exterior – 2002 BMW 325i

The 2002 BMW 325i sustained moderate severity frontal damage as a result of the intersection type crash with the 1995 Nissan 240SX **(Figure 5)**. The direct contact damage width was 153 cm (60.2”) and extended from bumper corner to bumper corner. The damage also consisted of the longitudinal displacement of the hood, left and right front fenders. The front left headlight and left aspect of the center grille were disintegrated. Six crush measurements were documented along the front bumper fascia and were as follows: C1= 25.0 cm (9.8”) C2= 17.0 cm (6.7”) C3= 9.0 cm (3.5”) C4= 7.0 cm (2.8”) C5= 9.0 cm (3.5”) C6= 7.0 cm (2.8”). The Collision Deformation Classification for the frontal impact to the BMW was 01-FDEW-2. The four doors remained closed and operational and all glazing remained intact.

Figure 5. Front damage, BMW.

Interior – 2002 BMW 325I

The 2002 BMW 325I sustained minor interior damage as a result of the crash. The damage consisted of occupant contacts to the interior **(Figures 6 and 7)**. There was no intrusion into the passenger compartment. The occupant contacts consisted of a make-up transfer to driver’s air bag, an imprint from the driver’s abdomen on the front safety belt, an imprint from the front right occupant’s abdomen on the front safety belt, and the rear of the front right seat back and head restraint was scuffed from contact by the rear right occupant.

Figure 6. Driver's facial contact to air bag.

Figure 7. Front left safety belt contact.

Exterior – 1995 Nissan 240SX

The 1995 Nissan 240SX sustained moderate severity left side damage **(Figure 8)** as result of the impact with the BMW. The damage consisted of lateral displacement of the

left front fender, door, and rear quarter panel. The direct damage began 8 cm (3.2") aft of the left front axle and extended rearward 164 cm (64.6"). The combined direct and induced damage was 280 cm (110"). Six crush measurements were documented along the left side and were as follows: C1=0.0 cm, C2 =28.0 cm (11.0), C3= 54.0 cm (21.3"), C4= 50.0 cm (19.7"), C5= 13.0 cm (5.1"), C6= 0.0 cm. The Collision Deformation Classification for this impact was 10-LYEW-4. The windshield was in place and cracked. The left front and left rear glazing were disintegrated at impact. The left front door was jammed closed by deformation.

Figure 8. Left side damage of Nissan.

Manual Restraint Systems – 2002 BMW 325i

The 2002 BMW 325i was equipped with manual 3-point lap and shoulder belts for each seating position. The front safety belts were equipped with buckle pretensioners, which actuated as a result of the crash **(Figures 9 and 10)**. The driver's safety belt was configured with a sliding latch plate and a belt-sensitive Emergency Locking Retractor (ELR). The front right safety belt was configured with a sliding latch plate and switchable ELR/Automatic Locking Retractor (ALR). The rear outboard safety belts were configured with sliding latch plates and ELR/ALR retractors. The rear center safety belt was configured with a locking latch plate. The driver and front right passenger utilized their safety belts. The rear right occupant did not utilize her safety belt. The rear left safety belt was used with an unknown type child safety seat.

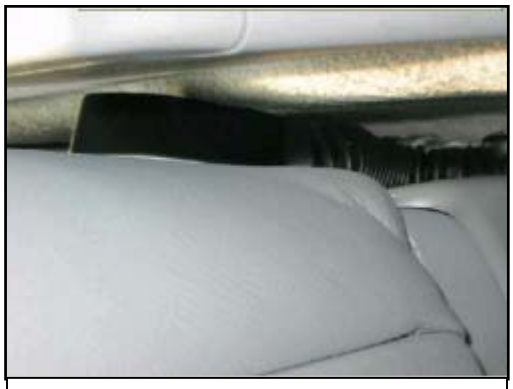

Figure 9. Actuated front left safety belt pretensioner.

Figure 10. Actuated front right safety belt pretensioner.

Advanced Occupant Protection System - 2002 BMW 325i

The 2002 BMW 325i was equipped with dual-stage frontal air bags for the driver and front right passenger positions. The driver and front right frontal air bag deployed as a result of the impact with the Nissan **(Figures 11 & 12)**. The deployment was recorded by the EDR as a stage two deployment. The front left air bag deployed from the center of the steering wheel hub. The front left air bag module was designed with "H"

configuration asymmetrical cover flaps. The top flap was measured as 15.0 cm (5.9”) in width and 9.0 cm (3.5”) in height. The lower flap was measured as 14.0 cm (5.5”) in width and 8.0 cm (3.1”) in height. The front left air bag was not tethered and was vented by one vent port at the 12 o’clock position.

The front right air bag deployed from the top of the instrument panel and was configured with a single cover-flap. The cover flap was measured as 49.0 cm (19.3”) in width and 19.0 cm (7.5”) in height. The front right air bag was not tethered and was vented by two vent ports at the 11 and 1o’clock positions on the air bag side panels.

Figure 11. Front left air bag.

Figure 12. Front right air bag.

Event Data Recorder (EDR) 2002 BMW 325i

The 2002 BMW 325i was equipped with an Event Data Recorder (EDR). The EDR was removed from the vehicle by the NASS researcher and was forwarded by NHTSA to BMW for download. The EDR data was electronically forwarded to NHTSA, then to the SCI team where it was evaluated and compiled into this summary report. The data stored in the control unit was not complete because parts of the stored data were deleted after the crash. The EDR recorded a Stage Two deployment with Stage Two deploying 5 ms after Stage One. The EDR also indicated that the driver and front right passenger safety belts were buckled at the time of air bag deployment and the front right seat was occupied. The data also indicated that the front safety belt pretensioners fired and the Battery Safety Terminal (BST) was triggered. The EDR did not record deployment times for the pretensioners or the BST. The EDR also recorded twelve fault codes, however, these faults were unknown.

Side Impact Air Bag System - 2002 BMW 325i

The 2002 BMW 325i was equipped with door panel mounted side impact air bags for the driver and front right positions **(Figure 13)**. The BMW was also equipped with a Head Protection System (HPS). This system included tubular shaped air bags that were mounted in the left and right roof side rails. The vehicle sustained a frontal impact, therefore the side air bag system did not deploy in this crash.

Figure 13. Front left door panel mounted side air bag.

Occupant Demographics – 2002 BMW 325i

Driver

Age/Sex:	37-year-old female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Full Rear
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a local hospital where she was treated and released.

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Superior thoracic spine strain	Minor (640478.1,7)	Impact force

Injury source: Emergency room records, post-ER records

Driver Kinematics

The 37-year-old female driver of the 2002 BMW 325i was seated in a presumed upright driving posture and was restrained by the manual 3-point lap and shoulder belt. The seat track was in the full rear position. At impact, the driver's safety belt pretensioner fired and the front left air bag deployed. The restrained driver initiated a forward trajectory and loaded the safety belt and contacted the frontal air bag with her face. Her forward motion and restraint loading resulted in flexion of the upper right torso. As a result of this impact-induced motion, the driver sustained a thoracic spine strain. The driver was transported by ambulance to a hospital where she was treated and released.

Front Right Passenger

Age/Sex:	25-year-old female
Height:	Unknown
Weight	Unknown
Seat Track Position:	Mid to rear
Manual Restraint Use:	Manual 3-point lap and shoulder belt
Usage Source:	Vehicle Inspection
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a local hospital and treated for her injuries.

Front Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Right facial contusion	Minor (290402.1,1)	Deployed front right air bag
Right facial abrasion	Minor (290202.1,1)	Deployed front right air bag
Central chest contusion	Minor (490402.1,4)	Deployed front right air bag
Minor concussive injury	Minor (160402.1,0)	Deployed front right air bag

Front Right Passenger Kinematics

The 25-year-old female front right passenger was seated in a presumed upright posture and restrained by the 3-point manual lap and shoulder belt. The seat track was in the mid to rear position. At impact, the front right safety belt pretensioner fired and the front right air bag deployed. The restrained passenger initiated a forward trajectory and loaded the safety belt causing the central chest contusion. The passenger also contacted the deployed front right air bag causing the right facial contusion, right facial abrasion, and the minor closed head injury. The passenger was transported by ambulance to a hospital where she was treated and released.

Rear Left Passenger

Age/Sex:	19-month-old male
Height:	Unknown
Weight:	Unknown
Manual Restraint Use:	Unknown type CSS secured by the 3-point lap and shoulder belt
Usage Source:	Vehicle Inspection and Police report
Eyewear:	Unknown
Type of Medical Treatment:	Not injured

Rear Left Passenger Kinematics

The 19-month-old male passenger was seated in a presumed upright posture in a CSS that was restrained by the vehicle's lap and shoulder belt. At impact, the restrained child passenger initiated a forward trajectory loading the harness of the CSS. The child passenger was police reported as not injured.

Rear Right Passenger

Age/Sex:	23-year-old female
Height:	Unknown
Weight:	Unknown
Manual Restraint Use:	None used
Usage Source:	Vehicle inspection
Eyewear:	Unknown
Type of Medical Treatment:	Transported by ambulance to a local hospital and treated for her injuries.

Rear Right Passenger Kinematics

The 23-year-old female passenger was seated in the rear right position in a presumed upright posture and not restrained. At impact, the passenger initiated a forward trajectory and loaded the rear of the front right seatback and head restraint **(Figure 14)** evidenced by scuffing to these components. The passenger was police reported as injured and transported for medical treatment.

Figure 14. Rear right occupant contact to rear of front right seat back.

Figure 15. NASS Scene Schematic