

**TRANSPORTATION SCIENCES  
CRASH DATA RESEARCH CENTER**

Veridian Engineering  
Buffalo, NY 14225

**REMOTE ADVANCED OCCUPANT PROTECTION SYSTEMS INVESTIGATION  
SCI TECHNICAL SUMMARY REPORT**

**NASS/SCI COMBO CASE NO. 01-41-005K**

**VEHICLE - 2001 AUDI TT**

**LOCATION - STATE OF FLORIDA**

**CRASH DATE - JANUARY 2001**

Contract No. DTNH22-94-D-07058

Prepared for:

U.S. Department of Transportation  
National Highway Traffic Safety Administration  
Washington, D.C. 20590

## **DISCLAIMER**

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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

<p>1. <i>Report No.</i> 01-41-005K</p>	<p>2. <i>Government Accession No.</i></p>	<p>3. <i>Recipient's Catalog No.</i></p>	
<p>4. <i>Title and Subtitle</i> Veridian Remote AOPS Investigation Vehicle: 2001 Audi TT Location: State of Florida</p>		<p>5. <i>Report Date:</i> August 2001</p>	
		<p>6. <i>Performing Organization Code</i></p>	
<p>7. <i>Author(s)</i> Crash Data Research Center</p>		<p>8. <i>Performing Organization Report No.</i></p>	
<p>9. <i>Performing Organization Name and Address</i> Transportation Sciences Crash Data Research Center Veridian Engineering P.O. Box 400 Buffalo, New York 14225</p>		<p>10. <i>Work Unit No.</i> C01115.0344.(0000-0009)</p>	
		<p>11. <i>Contract or Grant No.</i> DTNH22-94-D-07058</p>	
<p>12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590</p>		<p>13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: January 2001</p>	
		<p>14. <i>Sponsoring Agency Code</i></p>	
<p>15. <i>Supplementary Notes</i> Remote investigation of an intersection crash that resulted in the deployment of the AOPS system in the Audi TT.</p>			
<p>16. <i>Abstract</i> This remote investigation focused on a 2001 Audi TT Roadster that was equipped with an Advanced Occupant Protection System (AOPS). The Audi was occupied by an unrestrained 32-year-old male driver. The Audi was involved in an intersection collision with a subsequent sideslap with a 1988 Pontiac Grand Am. The Audi's frontal impact resulted in the deployment of the driver's dual stage air bag and fired both frontal seat belt pretensioners. The driver of the Audi sustained a forehead abrasion from contact with the deployed driver's air bag. He also sustained a right knee laceration and contusion from contact with the knee bolster and the left aspect of the center console. The driver refused treatment at the scene.</p>			
<p>17. <i>Key Words</i> Dual Stage Air Bags                      Seat belt pretensioners Advanced Occupant Protection Systems      Side impact protection system</p>		<p>18. <i>Distribution Statement</i> General Public</p>	
<p>19. <i>Security Classif. (of this report)</i> Unclassified</p>	<p>20. <i>Security Classif. (of this page)</i> Unclassified</p>	<p>21. <i>No. of Pages</i> 8</p>	<p>22. <i>Price</i></p>

## TABLE OF CONTENTS

BACKGROUND .....	1
SUMMARY .....	1
Crash Site .....	1
Pre-Crash .....	2
Crash .....	2
Post-Crash .....	3
VEHICLE DATA - <i>2001 Audi TT</i> .....	3
VEHICLE DAMAGE .....	3
Exterior Damage - <i>2001 Audi TT</i> .....	3
Interior Damage - <i>2001 Audi TT</i> .....	4
Exterior Damage - <i>1988 Pontiac Grand Am</i> .....	4
ADVANCED OCCUPANT PROTECTION SYSTEM (AOPS) - <i>2001 Audi TT</i> .....	5
Retractor Seat Belt Pretensioners .....	5
Dual Stage Frontal Air Bag System .....	5
Side Impact Protection System .....	6
OCCUPANT DEMOGRAPHICS - <i>2001 Audi TT</i> .....	6
Driver .....	6
Driver Injuries .....	6
Driver Kinematics .....	6
NASS SCENE SCHEMATIC .....	8

**REMOTE REDESIGNED AIR BAG DEPLOYMENT INVESTIGATION  
SCI TECHNICAL SUMMARY REPORT  
NASS/SCI COMBO CASE NO. 01-41-005K  
VEHICLE - 2001 AUDI TT  
LOCATION - STATE OF FLORIDA  
CRASH DATE - JANUARY 2001**

***BACKGROUND***

This remote investigation focused on a 2001 Audi TT Roadster that was equipped with an Advanced Occupant Protection System (AOPS). The Audi was occupied by an unrestrained 32-year-old male driver. The Audi (**Figure 1**) was involved in an intersection collision with a subsequent sideslap with a 1988 Pontiac Grand Am. The Audi's frontal impact resulted in the deployment of the driver's dual stage air bag and fired both frontal seat belt pretensioners. The driver of the Audi sustained a forehead abrasion from contact with the deployed driver's air bag. He also sustained a right knee laceration and contusion from contact with the knee bolster and the left aspect of the center console. The driver refused treatment at the scene.



**Figure 1. Front and side damage to the 2001 Audi TT**

This crash was selected for investigation by the National Automotive Sampling System (NASS) as CDS case number 01-41-005K. The crash occurred in January 2001. Initial notification of this crash was made to the Veridian Special Crash Investigations team following a NASS CDS case review. The NASS PSU performed the vehicle inspection and scene inspection. Due to the presence of the Advanced Occupant Protection Systems, NHTSA assigned the tasks of case review and report preparation to the Veridian Special Crash Investigation (SCI) team on March 12, 2001.

***SUMMARY***

**Crash Site**

The crash occurred during daylight hours at an urban four-leg intersection of a east/west two-lane undivided roadway and a north/south four-lane arterial roadway with a center left turn lane. Both roadways were straight and had level grades. At the time of the crash, it was cloudy and the asphalt road surface was wet. Traffic flow through the intersection was controlled by stop signs for east/west traffic. The posted speed limit for both roadways was 56 km/h (35 mph). Both roadways were bordered by concrete curbs and sidewalks.

### Pre-Crash

The driver of the Audi TT was operating the vehicle northbound on the outboard lane on approach to the four-leg intersection (**Figure 2**) at a police-reported speed of 56 km/h (35 mph). The driver of the Pontiac Grand Am was operating the vehicle westbound on the two-lane roadway on approach to the four-leg intersection (**Figure 3**) at a police reported speed of 24 km/h (15 mph). The driver of the Grand Am disregarded the stop sign at the intersection and proceeded into the intersection across the path of the Audi. It was not known if either vehicle attempted any avoidance maneuvers.



**Figure 2. Northbound trajectory for the 2001 Audi TT**



**Figure 3. Westbound trajectory for the 1998 Pontiac Grand Am**

### Crash

The front area of the Audi impacted the left side area on the forward aspect of the Grand Am's left front door. Impact resulted in moderate damage to both vehicles. The directions of force were in the 12 and 9 o'clock sectors for the Audi and Grand Am, respectively. The NASS researcher could not measure a crush profile on the Audi since repairs were underway, therefore the Missing Vehicle routine of the WinSMASH program was used to generate estimated velocity changes of 24.9 km/h (15.5 mph) for the Audi and 30.1 km/h (18.7 mph) for the Grand Am. The longitudinal component of -24.9 km/h (15.5 mph) for the Audi was sufficient to deploy the frontal air bag system and both frontal seat belt retractor pretensioners.

The Audi rotated counterclockwise (CCW) direction as the Grand Am rotated in a clockwise (CW) direction. The two vehicles impacted in a sideslap configuration with directions of force in the 3 o'clock sector for the Audi and in the 9 o'clock sector for the Grand Am. The rear aspect of the Audi's left door impacted the left rear corner of the Grand Am.

The Audi continued to rotate in a CCW direction into the west leg of the intersection. It traversed a concrete driveway and came to rest on an asphalt parking lot on the southwest corner of the intersection. The Grand Am continued to rotate in a CW direction and traveled into the north leg of the intersection. It crossed the southbound travel lanes and traveled over the northwest concrete curb and impacted a breakaway signpost with the front area right of center. The Grand Am came to rest against the sign post on the northwest corner.

### **Post-Crash**

The 32-year-old male driver of the Audi exited the vehicle under his own power. He refused medical treatment at the scene. It was not known how the 73-year-old male driver exited the Grand Am. He was transported by ambulance to a regional trauma center where he was admitted for treatment. Both vehicles were towed from the scene.

### **VEHICLE DATA - 2001 Audi TT**

The 2001 Audi TT was identified by the Vehicle Identification Number (VIN): TRUUT28N811 (production sequence omitted). The vehicle was a two-door coupe with a power-retractable cloth soft convertible top. It was equipped with a turbocharged 1.8 liter, 4-cylinder engine, full-time all-wheel drive, a 6-speed manual transmission, four-wheel disc brakes with anti-lock, and 17 inch alloy wheels. The interior was configured with a manual tilt and telescoping steering column, and front bucket seats with folding backs, locking head restraints, and variable height adjustments. There was no rear seat in the Audi TT Roadster.

### **VEHICLE DAMAGE**

#### **Exterior Damage - 2001 Audi TT**

The 2001 Audi TT sustained moderate damage as a result of the primary impact with the Grand Am. At the time of the NASS vehicle inspection, the Audi was undergoing repairs and a crush profile could not be obtained. The crush appeared to be uniform across the frontal plane based on the NASS photographs (**Figure 4**). The bumper assembly, frontal trim, headlight assemblies, and both front fenders were separated from the vehicle, but it was not known if it was crash related or due to repair. The Audi appeared to have energy absorbing devices on the outboard sides for the front bumper system. The piston travel distances could not be determined. The hood was slightly buckled and uniformly displaced rearward. Due to the unknown extent of the damage, the Collision Deformation Classification (CDC) for this event was 99-F9999.



**Figure 4. Frontal damage to the 2001 Audi TT**

The Audi was involved in a secondary sideslap impact as the vehicles were deflected by the initial impact. The lateral impact to the right side door resulted in minor damage (**Figure 5**). The direct damage for this impact began 93 cm (37") forward of the right rear axle and extended forward 24 cm (9") along the right door. The combined direct and induced damage began 74 cm (29") forward of the right rear axle and extended 116 cm (46") forward along the side plane. The rear aspect of the right door sustained longitudinal



**Figure 5. Right side sideslap damage to the 2001 Audi TT**

abrasions and minor crush. The CDC for this secondary impact was 03-RPEN-1. The NASS researcher estimated a crush profile based on a visual inspection of the damage that was as follows: C1 = 0 cm, C2 = 1 cm (0.5"), C3 = 1 cm (0.5"), C4 = 0cm, C5 = 0 cm, C6 = 0 cm.

### **Interior Damage - 2001 Audi TT**

The interior damage to the Audi TT was minor and attributed to occupant contact. There were no measurable intrusions. At the time of the NASS vehicle inspection, the repair facility indicated that there had been no glazing damage. Probable occupant contacts included scuffs that were located on the lower left instrument panel and the left aspect of the center console. The rear view mirror was also displaced from probable occupant contact.

### **Exterior Damage -1988 Pontiac Grand Am**

The 1988 Pontiac Grand Am sustained moderate left side damage as a result of the primary impact with the Audi. The direct damage began 112 cm (44") forward of the left rear axle and extended forward 115 cm (45") along the side plane. The combined direct and induced damage began 101 cm (40") forward of the left rear axle and extended forward 215 cm (85"). Six crush measurements were taken at the mid-door level and were as follows: C1 = 3 cm (1"), C2 = 25 cm (10"), C3 = 39 cm (15"), C4 = 20 cm (8"), C5 = 9cm (4"), C6 = 0 cm.

The secondary sideslap impact resulted in minor deformation to the left rear quarter panel and left rear corner on the Grand Am (**Figure 7**). There was no measurable crush from the impact.

The Pontiac Grand Am sustained frontal damage from a third impact with a breakaway sign post. The direct damage began 40 cm (16") to the right of the front left bumper corner and extended laterally 12 cm (5"). The maximum crush for the third impact was 26 cm (10") and was located 48 cm (19") to the right of the front left bumper corner.



**Figure 6. Left side damage from the primary impact and frontal damage from the breakaway sign post**



**Figure 7. Sideslap damage to the 1988 Pontiac Grand Am**



### ***MANUAL RESTRAINT SYSTEM - 2001 Audi TT***

The 2001 Audi TT was equipped with 3-point lap and shoulder belts for the front outboard positions. The manual restraints consisted of continuous loop webbing, force limiters, sliding latch plates, and retractor pretensioners. Manual anchorage adjustments were also present.

### ***ADVANCED OCCUPANT PROTECTION SYSTEM (AOPS) - 2001 Audi TT***

#### **Retractor Seat Belt Pretensioners**

Each manual restraint was configured with retractor-mounted pretensioners. The NASS vehicle inspection identified both manual restraints as locked in the stowed position (**Figure 8**) due to the firing of the retractor pretensioners, which suggested that the manual belts were not utilized in the crash.



**Figure 8. Driver's manual restraint locked in stowed position**

#### **Dual Stage Frontal Air Bag System**

The 2001 Audi TT was equipped with frontal air bags with dual stage inflators for the driver and front right passenger positions. Based on the crash severity, the control module could deploy the air bags at different thresholds. The front right passenger's air bag was equipped with a deactivation switch that was housed in the glove box. The switch required the use of the vehicle's key to activate/deactivate the air bag. The NASS researcher could not gain access to the switch, however, the repair facility reported that the switch was in the "off" position.

The driver's air bag was housed in the center of the steering wheel. The cover flap had been removed from the module. The outline of the opening for the air bag measured 15 cm (6") in width and 14 cm (6") in height. The driver's air bag was cut away from the module at the time of the NASS vehicle inspection (**Figure 9**). Therefore it was unknown if the air bag sustained any damage or contacts. Based on the lack of restraint usage by the driver, the both stages of the air bag most likely deployed.



**Figure 9. Driver's air bag module**

The front right passenger dual stage air bag did not deploy as a result of the crash, reportedly as a result of its deactivated status.

### Side Impact Protection System

The 2001 Audi TT was equipped with seat back-mounted side impact head/torso air bags for the driver and front right passenger positions (**Figure 10**). The secondary sideslap impact did not produce a lateral delta-V high enough to reach the deployment threshold for the side air bag system.



**Figure 10. Driver's side air bag module**

### OCCUPANT DEMOGRAPHICS - 2001 Audi TT

#### Driver

Age/Sex: 32-year-old male  
 Height: 178 cm (70")  
 Weight: 82 kg (181 lb)  
 Seat Track Position: Between middle and full rear positions  
 Manual Restraint Use: Unrestrained  
 Usage Source: Vehicle inspection  
 Eyewear: Unknown  
 Type of Medical Treatment: Refused medical treatment at the scene

#### Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Probable Injury Mechanisms
Upper forehead abrasions	Minor (290202.1,7)	Driver's air bag
Right knee contusion	Minor (890402.1,1)	Center console
Right knee laceration	Minor (890602.1,1)	Center console

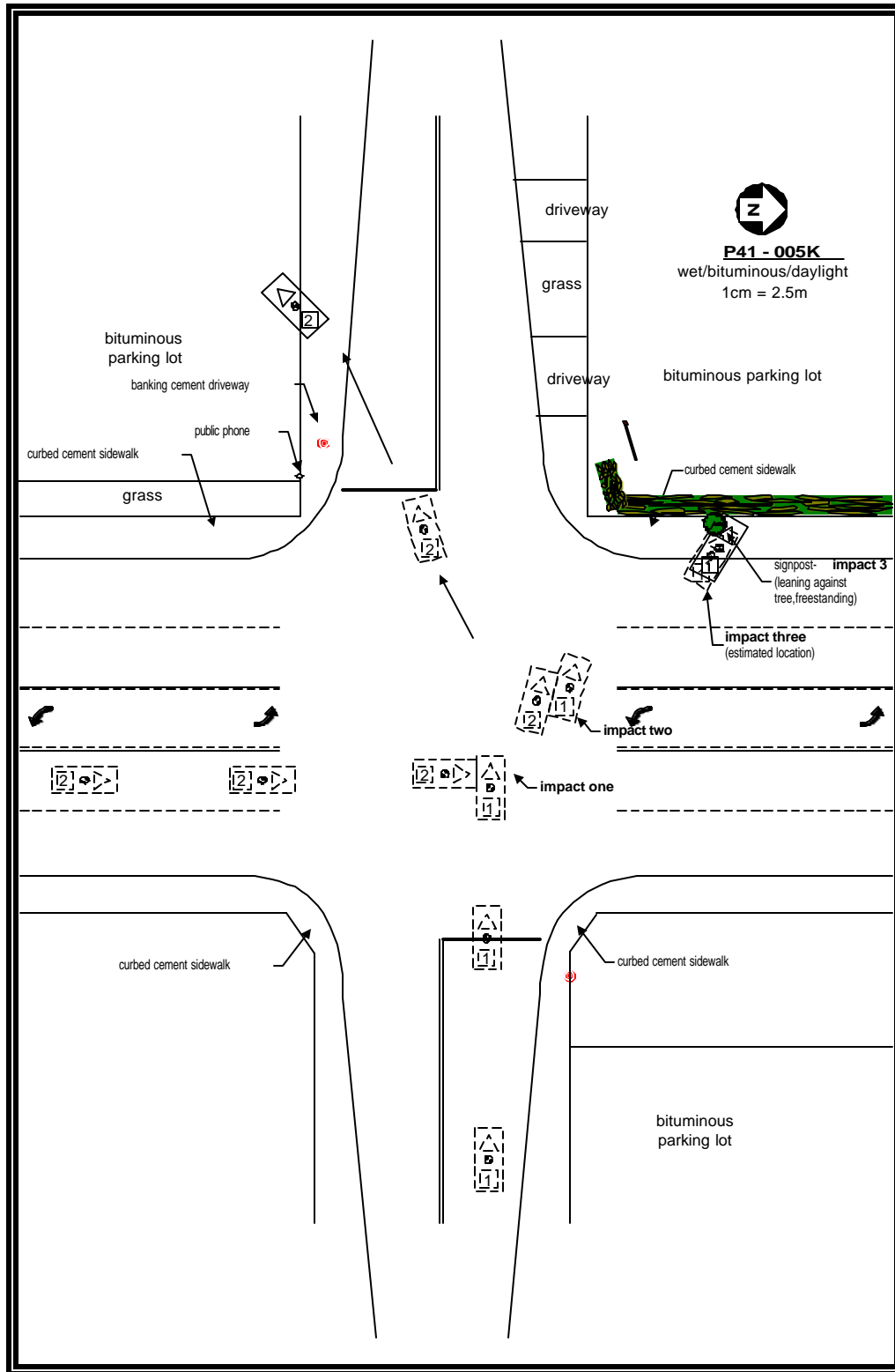
\*Injury source: Driver interview

#### Driver Kinematics

The 32-year-old male driver was presumed to have been seated in an upright posture. The police report listed the driver as restrained by the manual 3-point lap and shoulder belt. However, the NASS vehicle inspection identified both manual restraints as locked in the stowed position due to the firing of the retractor pretensioners, which suggested that they were not utilized in the crash. The reported injuries were obtained from a NASS interview and were not confirmed by medical records.

At impact, the driver's air bag deployed from the steering wheel. Since the driver was not restrained, the control module most likely deployed both the first and second stages of the air bag to provide additional protection to the unbelted driver. The driver initiated a forward trajectory and his knees struck the lower instrument panel and left aspect of the center console, evidenced by scuff marks. He sustained a right knee contusion and laceration as a result of the contact. He loaded the deployed air bag which resulted in upper forehead abrasions and was redirected to the left as the Audi rotated CCW and impacted the Grand Am

in a sideslap configuration. The driver exited the vehicle under his own power and refused medical treatment at the scene.



**Figure 11. NASS scene schematic**