

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

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**REDESIGNED AIR BAG SPECIAL STUDY (RABSS)
SCI TECHNICAL SUMMARY REPORT**

NASS RABSS CASE NO. 1998-09-804E

RABSS VEHICLE - 1998 VOLKSWAGEN BEETLE

LOCATION - STATE OF MARYLAND

CRASH DATE - OCTOBER, 1998

Contract No. DTNH22-94-D-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 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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<p>16. <i>Abstract</i> This investigation focused on a single vehicle crash involving a 1998 Volkswagen Beetle 2-door hatchback. The Volkswagen Beetle was equipped with redesigned frontal air bags that deployed as a result of a frontal collision with a guardrail. The Beetle was northbound on a multi-lane divided highway merging into traffic from the inboard on-ramp when a (non-contact) vehicle made an abrupt lane change in front of the Beetle. The driver of the Beetle steered right in avoidance and traveled across the six northbound lanes, subsequently exiting the right (east) pavement edge where the front right area struck a guardrail. Engagement continued as the right side impacted the guardrail before the vehicle came to rest on the east shoulder facing north. The impact resulted in moderate frontal damage to the vehicle. The 27 year old male driver was unrestrained (3-point manual lap and shoulder belt available) and seated in an upright posture with the seat track adjusted to the mid-to-rear position. At impact, he initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed driver air bag which resulted in multiple abrasions to the head and face. He also sustained abrasions to the anterior aspect of both forearms from contact by the expanding air bag. The lower extremities loaded the knee bolster, center instrument panel and (floor mounted) transmission lever as the left thigh and right abdomen contacted the lower portion of the steering wheel rim resulting in multiple abrasions and contusions. The driver rebounded into the seat back which resulted in a contusion to the right lower back and kidney. The unrestrained 19 year old female front right passenger was seated in an upright posture with the seat track adjusted to the mid-to-forward position. At impact, she initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed passenger air bag resulting in a small abrasion to the right facial area. The passenger also sustained a cervical strain which was probably a result of the sudden forward head movement as the body loaded the deployed air bag. Both occupants were transported to a local hospital for treatment and released.</p>			
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CRASH DATE - OCTOBER, 1998**

BACKGROUND

This investigation focused on a single vehicle crash involving a 1998 Volkswagen Beetle 2-door hatchback. The Volkswagen Beetle was equipped with redesigned frontal air bags that deployed as a result of a frontal collision with a guardrail. The Beetle was northbound on a multi-lane divided highway merging into traffic from the inboard on-ramp when a (non-contact) vehicle made an abrupt lane change in front of the Beetle. The driver of the Beetle steered right in avoidance and traveled across the six northbound lanes, subsequently exiting the right (east) pavement edge where the front right area struck a guardrail. Engagement continued as the right side impacted the guardrail before the vehicle came to rest on the east shoulder facing north. The impact resulted in moderate frontal damage to the vehicle. The 27 year old male driver was unrestrained (3-point manual lap and shoulder belt available) and seated in an upright posture with the seat track adjusted to the mid-to-rear position. At impact, he initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed driver air bag which resulted in multiple abrasions to the head and face. He also sustained abrasions to the anterior aspect of both forearms from contact by the expanding air bag. The lower extremities loaded the knee bolster, center instrument panel and (floor mounted) transmission lever as the left thigh and right abdomen contacted the lower portion of the steering wheel rim resulting in multiple abrasions and contusions. The driver rebounded into the seat back which resulted in a contusion to the right lower back and kidney. The unrestrained 19 year old female front right passenger was seated in an upright posture with the seat track adjusted to the mid-to-forward position. At impact, she initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed passenger air bag resulting in a small abrasion to the right facial area. The passenger also sustained a cervical strain which was probably a result of the sudden forward head movement as the body loaded the deployed air bag. Both occupants were transported to a local hospital for treatment and released.

This crash was initially selected for investigation by the National Automotive Sampling System (NASS) as case number 98-09-804E for the Redesigned Air Bag Special Study. The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) assigned the Special Crash Investigation (SCI) team at Veridian/Calspan the task of case review and final report preparation.

SUMMARY

Crash Site

This single vehicle crash occurred during the early morning hours of October, 1998. At the time of the crash, it was dark (street lighted) with rain conditions as the roads were wet. The crash occurred off the east pavement edge of the northbound six lane (asphalt) highway (see **Figure 11 - page 8**). The speed limit at the crash scene was 89 km/h (55 mph).

Pre-Crash

The 27 year old male driver of the 1998 Volkswagen Beetle was operating the vehicle northbound and was merging into traffic from the inboard on-ramp when a (non-contact) vehicle traveling in the adjacent right lane made an abrupt lane change (in front of the Beetle) to access the off-ramp. The driver of the Beetle steered right in avoidance and traveled across the northbound lanes towards the right (east) shoulder.

Crash

As the Volkswagen Beetle departed the right (east) pavement edge of the multi-lane highway, the front right area struck the guardrail (**Figure 1**) resulting in moderate damage. The impact induced deceleration was sufficient to deploy the Beetle's redesigned frontal air bag system. Although the impact was classified as a yielding object (out of scope), the damage algorithm of the WinSMASH program computed a (barrier equivalent) velocity change of 17.2 km/h (10.7 mph). The specific longitudinal component was -16.2 km/h (-10.1 mph). The Collision Deformation Classification (CDC) for this impact to the Beetle was 01-FREE-9. Engagement continued as the right side impacted the guardrail (with no separation of the contact damage) which resulted in moderate right side damage. The lateral displacement of the right door panel was sufficient to deploy the Beetle's side impact air bag system. The Beetle came to rest in close proximity to the point of impact facing north.



Figure 1. Guardrail impact area.

Post-Crash

Both occupants of the Volkswagen Beetle exited the vehicle under their own power. Treatment was rendered at the scene by fire department personnel and emergency medical technicians (EMT's). Both occupants were transported to a local hospital for treatment and released. The vehicle was towed from the scene.

RABSS VEHICLE

The 1998 Volkswagen Beetle was identified by the Vehicle Identification Number (VIN): 3VWBB61C6WM (production sequence deleted). The vehicle was a 2-door hatchback equipped with front wheel drive and a 2.0 liter, 4 cylinder engine. The police report listed an unspecified individual (other than the driver) as the owner of the vehicle. The vehicle's odometer reading was 18,388 km (11,426 miles) at the time of the crash. The seating was configured with front bucket seats and a folding (back) rear bench. The NASS researcher reported no cutoff switch for the redesigned passenger air bag. The interviewee reported no previous crashes or maintenance on the Beetle's air bag system (original equipment). No cell phone was present or in-use at the time of the collision.

VEHICLE DAMAGE

Exterior Damage

The Volkswagen Beetle sustained moderate frontal damage as a result of the impact with the guardrail (**Figure 2**). The direct contact damage began at the front right bumper corner and extended 15.0 cm (6.0 in) inboard. The impact deformed the full frontal width resulting in a combined direct and induced damage

length (Field L) of 135.0 cm (53.0 in). Six crush measurements were documented at the level of the bumper: C1 = 4.0 cm (1.6 in), C2 = 9.0 cm (3.5 in), C3 = 12.0 cm (4.7 in), C4 = 14.0 cm (5.5 in), C5 = 15.0 cm (5.9 in), C6 = 13.0 cm (5.1 in). Induced damage was noted to the hood which was displaced rearward from the impact force. The right front wheel/tire was deflated and restricted. Direct damage was noted to the right side of the vehicle which extended rearward to the B-pillar and shattered the side glazing (**Figure 3**). The windshield was fractured from exterior forces and the (interior) front right air bag module cover flap.



Figure 2. Frontal damage to the 1998 Volkswagen Beetle.



Figure 3. Right side damage to the 1998 Volkswagen Beetle.

Interior Damage

Interior damage to the Volkswagen Beetle identified through the NASS vehicle inspection was moderate and was attributed to occupant contact (**Figure 4**). No transfers or loading marks were noted to the available 3-point manual lap and shoulder belt systems. Blood spattering was documented on the right side of the redesigned driver air bag. No contacts were found on the passenger air bag or exterior surface of the driver or passenger air bag module cover flaps. Scuff marks were noted on the left and right door panels, left knee bolster (rigid plastic type) and glove compartment door. The transmission selector lever was displaced to the right. The radio and climate control components located at the center instrument panel were out of place. The windshield was fractured from the front right air bag module cover flap. The rearview mirror separated from the windshield (undamaged). No deformation was noted to the steering wheel rim which was placed to the full up position. The right instrument panel intruded rearward 5.0 cm (2.0 in) into the front right seating area. The right door panel intruded 3.0 cm (1.2 in) laterally into the front right seating position along with 5.0 cm (2.0 in) of lateral floorpan intrusion which deformed the seat back to a slightly forward position.

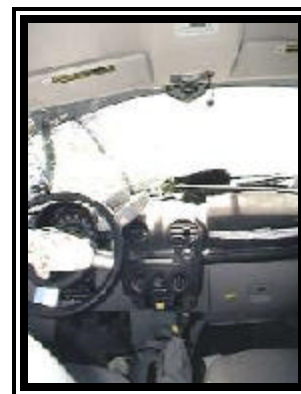


Figure 4. Interior view of the 1998 Volkswagen Beetle.

REDESIGNED AIR BAG SYSTEM

The 1998 Volkswagen Beetle was equipped with redesigned frontal air bags for the driver and front right passenger positions. The air bags deployed as a result of the crash. The driver air bag was housed in the center of the steering wheel with a horizontally oriented flap tear seam (H-configuration). The flaps were asymmetrical in shape as the upper flap measured 16.5 cm (6.5 in) in width and 7.0 cm (2.8 in) in height

(**Figure 5**) while the two lower flaps measured 8.0 cm (3.1 in) in width and 6.0 cm (2.4 in) in height (**Figure 6**). Although no contact evidence was found on the exterior surface of the module cover flaps, blood spattering was identified at the (right) upper and lower quadrants of the air bag. The NASS researcher measured the diameter of the driver air bag at 73.0 cm (28.7 in) in its deflated state (**Figure 7**). The bag was tethered by three internal straps and vented by one port located at the 12 o'clock sector on the rear aspect of the air bag.



Figure 5. Air bag upper module cover flap.



Figure 6. Air bag lower module cover flaps.



Figure 7. 1998 Volkswagen Beetle redesigned driver air bag.

The front right passenger air bag deployed from a top mount module in the right instrument panel with a single cover flap design hinged at the forward aspect. No contacts were noted to the flap which opened in an upward direction toward the windshield. Damage was noted to the lower windshield from the passenger air bag module cover flap. The cover flap was rectangular in shape and measured 34.0 cm (13.4 in) in width and 17.0 cm (6.7 in) in height. There was no contact evidence documented on the redesigned passenger air bag. The NASS researcher measured the passenger air bag at 43.0 cm (17.0 in) in width and 101.0 cm (39.8 in) in height in its deflated state (**Figure 8**). The air bag was tethered by one internal strap and vented by two ports located at the 3 o'clock and 9 o'clock sectors on the side aspect of the air bag.



Figure 8. 1998 Volkswagen Beetle redesigned passenger air bag.

The vehicle was also equipped with a side impact air bag system. The right side air bag deployed from a module mounted in the outboard side of the front right seat back (**Figure 9**) and measured 31.0 cm (12.2 in) in diameter in its deflated state (**Figure 10**). The air bag module cover flap was rectangular in shape and measured 10.0 cm (3.9 in) in width and 22.0 cm (8.7 in) in height. The air bag was vented by one port located at the 3 o'clock sector on the side aspect of the bag (no tether straps present). No contacts were documented to the side impact air bag or exterior surface of the module cover flap.



Figure 9. Front right seat side impact air bag module.

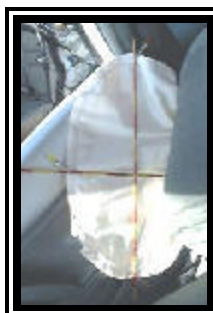


Figure 10. Front right seat side impact air bag.

DRIVER DEMOGRAPHICS

Age/Sex: 27 year old male
 Height: 175 cm (69 in)
 Weight: 84 kg (185 lb)
 Seat Track Position: Mid-to-rear position
 Manual Restraint Use: None
 Usage Source: NASS vehicle inspection, surrogate interview, medical reports
 Eyeware: None
 Type of Medical Treatment: Transported to a local hospital and released

Driver Injuries

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
Contusion kidney (NFS)	Moderate (541610.2,9)	Seat back (taper)
Contusion right abdomen	Minor (590402.1, 1)	Steering wheel rim (lower portion)
Cervical strain	Minor (640278.1,6)	Indirect contact injury (front left air bag)
Abrasion right forehead (multiple)	Minor (290202.1,7)	Front left air bag
Abrasion anterior forearms (multiple/bilateral-hand to deltoid)	Minor (790202.1,3)	Front left air bag

Driver Injuries (continued)

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
Abrasion knees (multiple - bilateral)	Minor (890202.1,3)	Knee bolster
Abrasion left face (below eye to temple)	Minor (290202.1,2)	Front left air bag
Abrasion left head	Minor (190202.1,2)	Front left air bag
Abrasion right anterior lower extremity (distal to knee)	Minor (890202.1,1)	Transmission lever
Contusion right anterior lower extremity (distal to knee)	Minor (890402.1,1)	Transmission lever
Abrasion left anterior lower extremity (proximal to knee)	Minor (890202.1,2)	Steering wheel rim (lower portion)
Contusion right lower back	Minor (690402.1,8)	Seat back (taper)

Driver Kinematics

The 27 year old male driver of the Volkswagen Beetle was seated in an upright posture with the seat track adjusted to the mid-to-rear position. His hands were positioned at the 2 o'clock and 10 o'clock sectors on the steering wheel rim. The police report noted that the driver was unrestrained, further evidenced by the lack of loading marks to the belt webbing and extent of deformation to the driver seating area.

At impact, he initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed redesigned air bag which resulted in multiple abrasions to the head and face, evidenced by his posture in relation to the rearward extent of the deployed air bag. The driver air bag provided restraint to his face/head which prevented further contact to the steering wheel hub/rim and windshield. In addition, he received abrasions to the anterior aspect of both forearms (hand to the deltoid area) from contact by the expanding air bag as evidenced by the pre-crash hand placement on the steering wheel rim in conjunction with the type of injury sustained. Both knees loaded the bolster as the left anterior thigh and right abdomen contacted the lower portion of the steering wheel rim resulting in bilateral abrasions to the knees, an abrasion to the left lower extremity (proximal to the knee) and a contusion to the right abdomen. This trajectory was evidenced by the scuff marks noted to the bolster and the placement of the tilt column in relation to the location of the abdominal/thigh trauma. The driver continued the kinematic response into the center instrument panel area and (floor mounted) transmission lever which resulted in a contusion and

abrasion to the right lower extremity (distal to the knee), evidenced by the scuff marks and displacement of these components. The driver subsequently rebounded into the seat back resulting in a contusion to the right lower back and kidney as evidenced by the location of the trauma in conjunction with the forward extent of the seat back taper. The cervical strain was probably a result of the sudden forward head movement as the body loaded the deployed driver air bag. The driver was transported to a local hospital for treatment and released.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex: 19 year old female
 Height: Unknown
 Weight: Unknown
 Seat Track Position: Mid-to-forward position
 Manual Restraint Use: None
 Usage Source: NASS vehicle inspection, medical reports
 Eyewear: Unknown
 Type of Medical Treatment: Transported to a local hospital and released

Front Right Passenger Injuries

<i>Injury</i>	<i>Severity (AIS 90)</i>	<i>Injury Mechanism</i>
Cervical strain	Minor (640278.1,6)	Indirect contact injury (front right air bag)
Abrasion right face	Minor (290202.1,8)	Front right air bag

Front Right Passenger Kinematics

The 19 year old female passenger of the Volkswagen Beetle was seated in an upright posture with the seat track adjusted to the mid-to-forward position. The police report noted that she was unrestrained, further evidenced by the lack of loading marks to the belt webbing. At impact, she initiated a forward trajectory in response to the 1 o'clock impact force and loaded the deployed redesigned passenger air bag resulting in an abrasion to the right face. This trajectory was evidenced by the type of injury in relation to the kinematic response pattern. The passenger air bag provided restraint from further contact to the instrument panel and windshield. The cervical strain was probably a result of the sudden forward head movement as the body loaded the deployed air bag. The front right passenger was transported to a local hospital for treatment and released.

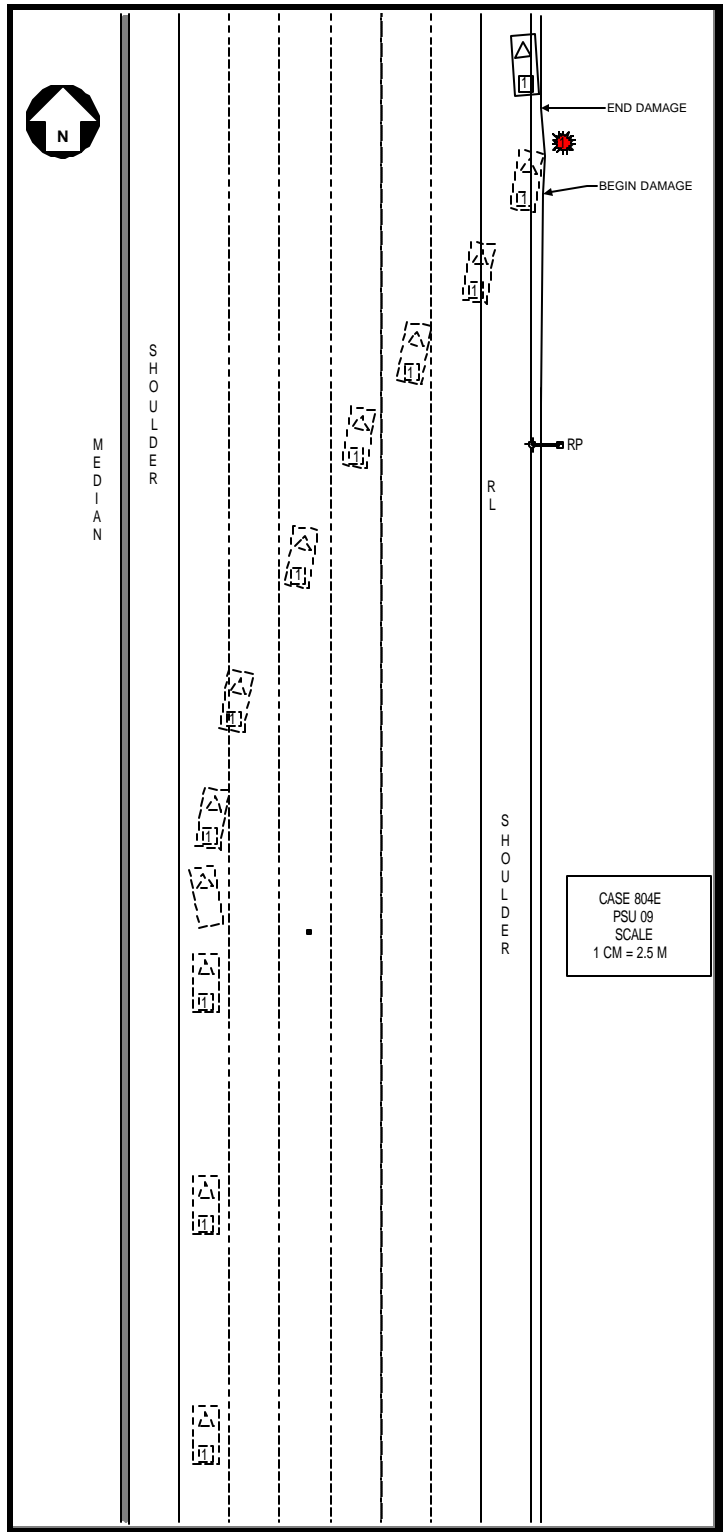


Figure 11. NASS Scene Diagram