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VERIDIAN ON-SITE SIDE IMPACT OCCUPANT PROTECTION INVESTIGATION

VERIDIAN CASE NO. CA01-041

VEHICLE - 2001 VOLKSWAGEN JETTA

LOCATION - STATE OF NEW YORK

CRASH DATE - FEBRUARY, 2001

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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 on-site investigation focused on the performance of the side impact occupant protection system of a 2001 Volkswagen Jetta 4-door sedan. The 2001 Volkswagen Jetta was equipped with redesigned frontal air bags, (seat mounted) side impact air bags, side impact curtains, and retractor pretensioners for the driver and front right passenger positions. The redesigned frontal air bags deployed as a result of an offset frontal collision with a 1987 Toyota Celica 2-door coupe. The driver side impact air bag and curtain deployed as a result of a subsequent left side collision with a roadside concrete post. The 16 year old male driver of the 1987 Toyota Celica was operating the vehicle eastbound on a two lane rural roadway and negotiating a right curve when he allowed the vehicle to cross the centerline into the path of the westbound 2001 Volkswagen Jetta. As the Toyota entered the westbound lane, the front left area impacted the front left area of the Volkswagen resulting in moderate damage to both vehicles. At this point, the Volkswagen rotated counterclockwise and departed the north pavement edge where the left rear side surface struck a concrete post resulting in minor damage. The 43 year old male driver of the 2001 Volkswagen Jetta initiated a forward and slightly lateral trajectory in response to the initial 11 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. Loading of the manual restraint resulted in a cervical strain which was a result of the sudden forward head movement as the body loaded the belt system (flexion). At impact with the concrete post, he initiated a lateral trajectory in response to the 9 o'clock impact force and loaded the deployed side impact air bag and curtain. Contact to the deployed left side impact curtain resulted in an abrasion to the posterior aspect of the left wrist. The driver of the 2001 Volkswagen Jetta was subsequently transported to a local hospital for treatment and released.			
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BACKGROUND

This on-site investigation focused on the performance of the side impact occupant protection system of a 2001 Volkswagen Jetta 4-door sedan. The 2001 Volkswagen Jetta was equipped with redesigned frontal air bags, (seat mounted) side impact air bags, side impact curtains, and retractor pretensioners for the driver and front right passenger positions. The redesigned frontal air bags deployed as a result of an offset frontal collision with a 1987 Toyota Celica 2-door coupe. The driver side impact air bag and curtain deployed as a result of a subsequent left side collision with a roadside concrete post. The 16 year old male driver of the 1987 Toyota Celica was operating the vehicle eastbound on a two lane rural roadway and negotiating a right curve when he allowed the vehicle to cross the centerline into the path of the westbound 2001 Volkswagen Jetta. As the Toyota entered the westbound lane, the front left area impacted the front left area of the Volkswagen resulting in moderate damage to both vehicles. At this point, the Volkswagen rotated counterclockwise and departed the north pavement edge where the left rear side surface struck a concrete post resulting in minor damage. The 43 year old male driver of the 2001 Volkswagen Jetta initiated a forward and slightly lateral trajectory in response to the initial 11 o'clock impact force and loaded the manual restraint and deployed redesigned driver air bag. Loading of the manual restraint resulted in a cervical strain which was a result of the sudden forward head movement as the body loaded the belt system (flexion). At impact with the concrete post, he initiated a lateral trajectory in response to the 9 o'clock impact force and loaded the deployed side impact air bag and curtain. Contact to the deployed left side impact curtain resulted in an abrasion to the posterior aspect of the left wrist. The driver of the 2001 Volkswagen Jetta was subsequently transported to a local hospital for treatment and released.

This investigation was identified by the Veridian Engineering SCI team on Thursday, July 12, 2001. Due to the involvement of a 2001 Volkswagen Jetta equipped with redesigned frontal air bags, side impact air bags, and side impact curtains, the case was immediately assigned as an on-site investigative effort. The vehicle was located in an insurance salvage yard and tracked through the insurance company to identify the location, driver injury, and date of the crash. The police accident report was subsequently obtained to initiate the local investigation. The on-site investigator completed field activities on Monday, July 16, 2001.

SUMMARY

Crash Site

This two vehicle crash occurred during the evening hours of February, 2001. At the time of the crash, it was dark (street not lighted) with no adverse conditions as the roads were dry. The crash occurred in the westbound lane of a (level) two lane east/west rural roadway which curved left for westbound traffic **(see Figure 11 - page 8)**. The asphalt surfaced roadway was bordered to the north by narrow paved shoulders, large rocks, and a cluster of concrete posts spaced 1.3 meters (4.3 feet) apart. No traffic control was present at the scene which had a posted speed limit of 72 km/h (45 mph).

Pre-Crash

The 16 year old male driver of the 1987 Toyota Celica 2-door coupe was operating the vehicle eastbound **(Figure 1)** and negotiating a right curve at a (police reported) unknown speed when he allowed the vehicle to cross the centerline into the path of the westbound 2001 Volkswagen Jetta. The police reported no tire marks at the scene indicative of driver avoidance maneuvers.

The 43 year old male driver of the 2001 Volkswagen Jetta was operating the vehicle westbound **(Figure 2)** on approach to a left curve at a (driver reported) speed of 72 km/h (45 mph) when he observed the 1987 Toyota Celica cross his path of travel. Upon recognition of the impending harmful event, the Volkswagen driver steered right and slowed (braked) the vehicle to a speed of 8 km/h (5 mph) as he partially departed the north (right) pavement edge prior to the collision.

Figure 1. Eastbound approach for the 1987 Toyota Celica 2-door coupe.

Figure 2. Westbound approach for the 2001 Volkswagen Jetta 4-door sedan.

Crash

As the Toyota Celica entered the westbound lane of the two lane rural roadway, the front left area impacted the front left area of the Volkswagen resulting in moderate damage to both vehicles. The missing vehicle algorithm of the WinSMASH reconstruction program computed velocity changes of 21.7 km/h (13.5 mph) for the subject vehicle and 24.4 km/h (15.2 mph) for the striking Toyota. Respective longitudinal components were -20.4 km/h (-12.7 mph) and -22.9 km/h (-14.2 mph). The impact induced deceleration was sufficient to deploy the Volkswagen's redesigned frontal air bag system.

At this point, the Volkswagen Jetta rotated 210 degrees counterclockwise and traveled approximately 11.9 meters (39.0 feet) in a northwesterly direction as the left rear side surface struck a concrete post **(Figure 3)** resulting in minor damage. Although the impact was classified as out-of-scope *(yielding object)*, the WinSMASH reconstruction program computed a barrier equivalent velocity change of 5.3 km/h (3.3 mph) with a latitudinal component of 5.2 k/h (3.2 mph). The impact deployed the Volkswagen's

Figure 3. 2001 Volkswagen Jetta northwest post-impact trajectory to secondary impact with a roadside concrete post.

front left side impact air bag and curtain. The 2001 Volkswagen Jetta came to rest off the north shoulder (against the final point of impact) facing southeast. The Toyota Celica rotated 100 degrees counterclockwise and traveled approximately 11.0 meters (36.1 feet) coming to rest in the roadway perpendicular to the centerline facing northeast.

Post-Crash

The driver of the Volkswagen Jetta exited the vehicle under his own power. The exit status (and subsequent extent of treatment) of the Toyota driver was unknown, however, he was reported by police as sustaining only a minor contusion to an unspecified lower extremity. Both drivers were transported by ambulance to the emergency room of a local hospital for treatment and released. Both vehicles were towed from the scene due to disabling damage.

VEHICLE DATA

The 2001 Volkswagen Jetta was manufactured in November, 2000 and identified by the vehicle identification number (VIN): 3VWRK69M11M (production number deleted). The driver was the owner of the vehicle which was leased in January, 2001. The vehicle was a 4-door sedan equipped with power door locks, front-wheel drive, and a 2.0 liter, 4-cylinder engine. The odometer reading at the time of the crash was approximately 3,219 kilometers (2,000 miles). The seating was configured with front bucket and a rear split bench seat (with folding backs). The driver reported no previous crashes or maintenance on the Volkswagen's frontal, side impact air bag or side curtain system. A cellular phone was present (and on), however, it was not in-use at the time of the crash. Cargo consisted of three 6.8 kg (15.0 lb) bowling balls unsecured in the trunk.

VEHICLE DAMAGE

Exterior

The 2001 Volkswagen Jetta sustained moderate frontal damage as a result of the impact with the 1987 Toyota Celica **(Figure 4)**. The direct contact damage began at the front left bumper corner and extended 94.0 cm (37.0 in) inboard. The impact deformed the entire front end width resulting in a combined direct and induced damage length (Field L) of 119.0 cm (46.9 in). Six crush measurements were documented at the level of the reinforcement bar *(bumper fascia separation)*: C1= 27.5 cm (10.8 in), C2= 22.5 cm (8.9 in), C3= 21.5 cm (8.5 in), C4= 18.5 cm (7.3 in), C5= 2.5 cm (1.0 in), C6= 0 cm. The Collision Deformation Classification (CDC) assigned for this initial impact to the Volkswagen was 11-FYEW-2 with a principal direction of force of (-)20 degrees. An indentation was

Figure 4. Front left damage to the 2001 Volkswagen Jetta.

documented along the reinforcement bar and attributed to the front left bumper corner of the opposing Toyota. The hood was deformed slightly up and rearward from the impact force. The left fender was deformed rearward which produced a partial restriction of the left front door opening. Induced contact damage produced minor roof buckling at the left B-pillar area. The windshield was fractured at the left lower A-pillar from exterior impact forces (only). All tempered glazing remained undamaged. Reduction in the left side wheelbase measured 4.0 cm (1.6 in).

Direct contact damage was also identified to the left rear side surface and attributed to the concrete post impact **(Figure 5)**. The direct contact damage began 108.0 cm (42.5 in) forward of the rear left bumper corner and extended forward 35.0 cm (13.8 in). The combined direct and induced damage length (Field L) began 96.0 cm (37.8 in) forward of the rear left bumper corner and extended forward 52.0 cm (20.5 in). Six crush measurements were documented at the level of the mid door: C1= 0, C2= 2.0 cm (0.8 in), C3= 4.0 cm (1.6 in), C4= 7.0 cm (2.8 in), C5= 3.0 cm (1.2 in), C6= 0 cm. The CDC assigned for this secondary impact was 09-LPEN-2 with a principal direction of force of (-)100 degrees. The hubcap was fractured as the left rear wheel was bent inward from the impact force. Unknown superficial contact damage *(red paint transfers - no crush)* was also identified on the rear left bumper corner and attributed to tow yard/salvage damage post-crash.

Figure 5. Left rear side surface damage to the 2001 Volkswagen Jetta.

Interior

Interior damage to the Volkswagen Jetta was minimal and was attributed to occupant contact. Scuff marks were documented on the left knee bolster (no rim deformation or column compression noted). No component intrusions were found in the vehicle.

MANUAL RESTRAINT SYSTEMS

The interior of the Volkswagen Jetta consisted of a five passenger seating configuration with front bucket and a rear split bench seat (with folding backs). The driver 3-point manual lap and shoulder belt system consisted of a continuous loop belt webbing with a sliding latchplate and a dual mode retractor (inertial lock/belt sensitive). Dimpling was noted to the shoulder portion of the driver restraint and attributed to latchplate loading **(Figure 6)**. The front right (and rear) seating position was equipped with a 3-point manual lap and shoulder belt system which consisted of a continuous loop belt webbing with a sliding latchplate and a retractor equipped with an inertial and switchable lock mechanism. The front restraint systems also included retractor pretensioners mounted in the lower B-pillars. The activated driver retractor pretensioner reduced the amount of slack in both the lap and shoulder belt webbing.

Figure 6. Loading evidence to the 2001 Volkswagen Jetta driver restraint.

SUPPLEMENTAL RESTRAINT SYSTEMS

The 2001 Volkswagen Jetta was equipped with redesigned frontal air bags for the driver and front right passenger positions which deployed as a result of the crash **(Figure 7)**. 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 symmetrical in shape and measured 16.7 cm (6.6 in) in width and 6.1 cm (2.4 in) in height. No contact evidence was identified on the air bag or exterior surface of the module cover flaps. The diameter of the driver air bag measured 61.0 cm (24.0 in) in its deflated state. The bag was tethered by one internal strap and vented by one 5.0 cm (2.0 in) diameter port located at the 12 o'clock sector on the rear aspect of the air bag. Air bag excursion measured 29.0 cm (11.4 in) from the steering wheel hub.

Figure 7. 2001 Volkswagen Jetta deployed redesigned frontal air bags.

The front right passenger air bag deployed from the right mid-instrument panel area with a single cover module cover flap design hinged at the top aspect. The flap was rectangular in shape and measured 31.9 cm (12.6 in) in width and 17.6 cm (6.9 in) in height. No contact evidence was identified on the exterior surface of the cover flap, however, multiple black vinyl transfers were noted across the top portion of the bag face from expansion within the module. The passenger air bag measured 77.5 cm (30.5 in) in width and 70.0 cm (27.6 in) in height in its deflated state. The bag was tethered by one internal strap and vented by two 6.5 cm (2.6 in) diameter ports located at the 10 o'clock and 2 o'clock sectors on the side aspect of the air bag. Air bag excursion measured 54.0 cm (21.3 in) from the aft portion of the right instrument panel.

The Volkswagen was equipped with seat-mounted side impact air bags for the front seated positions. The driver side impact air bag deployed as a result of the impact with the concrete post **(Figure 8)**. The air bag modules were housed in the outboard side aspect of the front seat backs [16.5 cm (6.5 in) above the level of the seat cushion] with a single cover flap design. No contact evidence was identified on the air bag or exterior surface of the module cover flap. The air bag was oval shaped and measured 29.5 cm (11.6 in) in width and 58.0 cm (22.8 in) in height in its deflated state. No internal tether straps or vent ports were present.

Figure 8. 2001 Volkswagen Jetta deployed driver side impact air bag.

The Volkswagen was also equipped with side impact curtains for the outboard seating positions. The left side impact curtain deployed as a result of the impact with the concrete post **(Figure 9)**. No contact evidence was identified to the side impact curtain. The side curtain air bag was housed between the interior roof headliner and structural roof side rail with a horizontal seam measuring 195.0 cm (76.8 in) in length (separation of the headliner versus an actual flap). Inflation was achieved by the use of a cold gas (stored) inflator located in the C-pillar. The air bag measured 180.0 cm (70.9 in) in width and 33.0 cm (13.0 in) in height in its deflated state. The air bag utilized a stitched tether design as no vent ports were present.

Figure 9. 2001 Volkswagen Jetta deployed left side impact curtain.

DRIVER DEMOGRAPHICS

Age/Sex:	43 year old male
Height:	178 cm (70 in)
Weight:	91 kg (200 lb)
Seat Track Position:	Full rearward position
Manual Restraint Use:	3-point lap and shoulder belt
Usage Source:	Vehicle inspection, driver interview, police report
Eyeware:	Prescription glasses
Type of Medical Treatment:	Transported to a local hospital for treatment and released

Driver Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
*Cervical strain	Minor (640278.1,6)	Non-contact injury (flexion)
*Abrasion posterior left wrist - small	Minor (790202.1,2)	Deployed left side impact curtain

*Source: driver**

Driver Kinematics

The 43 year old male driver of the 2001 Volkswagen Jetta was restrained by the available 3-point manual lap and shoulder belt system, and seated in an upright posture with the seat track adjusted to the full rearward position. His hands were placed at the 10 o'clock and 2 o'clock positions on the steering wheel rim. Belt usage was evidenced by the loading marks documented on the shoulder webbing of the driver restraint.

At impact with the 1987 Toyota Celica, the driver initiated a forward and slightly lateral trajectory in response to the 11 o'clock impact force and loaded the knee bolster, manual restraint, and deployed redesigned driver air bag. Loading of the knee bolster was evidenced by the scuff marks documented on each side of the steering column **(Figure 10)**, however, no injury was reported as a result. Loading of the manual restraint resulted in a cervical strain which was a result of the sudden forward head movement as the body loaded the belt system (flexion). At this point, the driver initiated a lateral trajectory in response to the secondary 9 o'clock impact force and loaded the deployed side impact air bag and curtain. Contact to the deployed side impact curtain resulted in an abrasion to the posterior aspect of the left wrist, as evidenced by the aspect of the injury relative to the driver's stated placement of the left hand at the 10 o'clock position on the steering wheel rim during pre-crash avoidance maneuvers. Following the crash, he exited the vehicle under his own power through the left front door and was transported by ambulance to the emergency room of a local hospital for treatment and released within three hours. The deployed redesigned frontal, side impact air bag and curtain provided additional protection against further contact to frontal and left side components, and this, potential serious injury.

Figure 10. Interior view of the 2001 Volkswagen Jetta driver space.

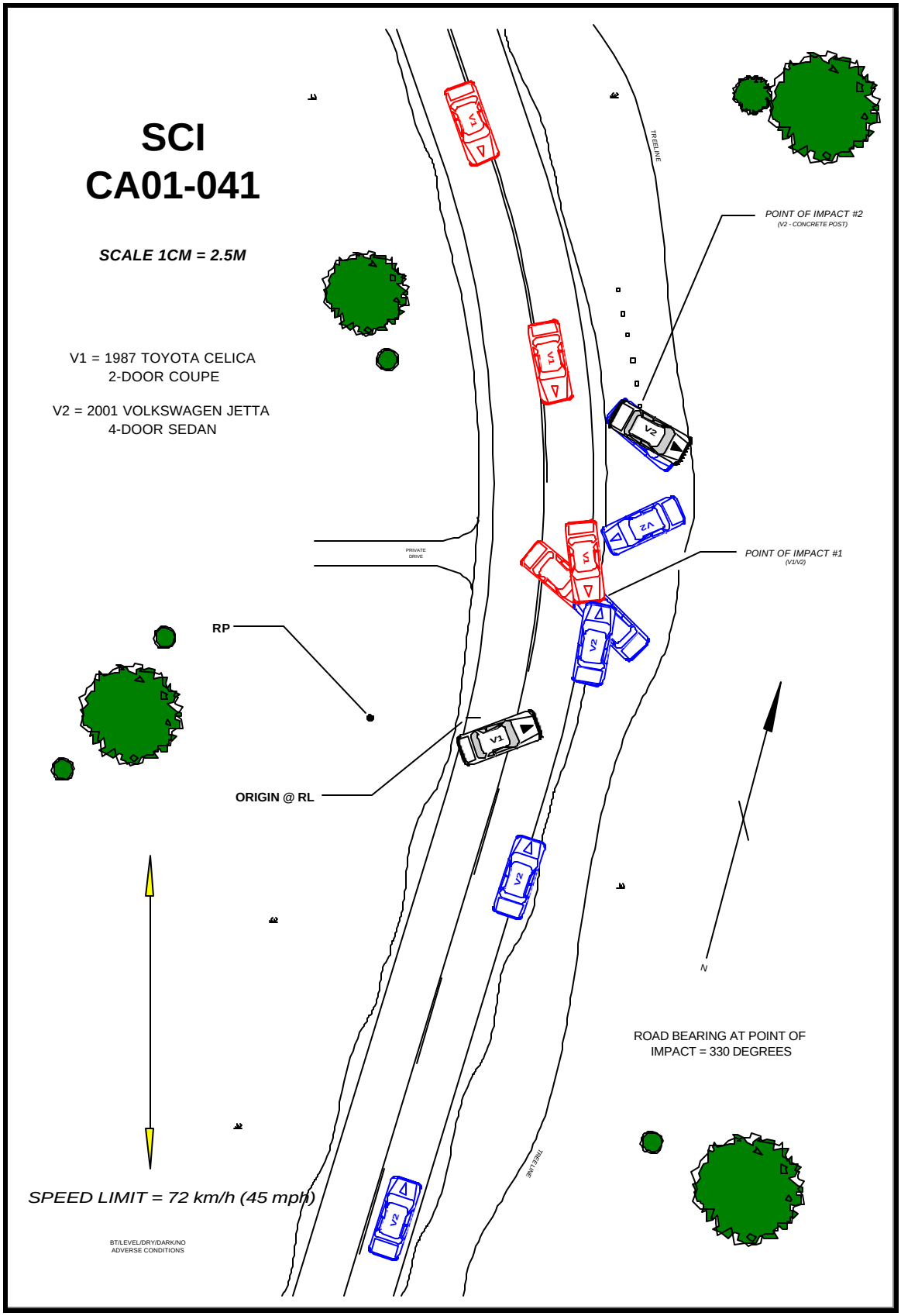

Figure 11. Scene Diagram.