CRASH DATA RESEARCH CENTER
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ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION

CALSPAN CASE NO: CA05-042

VEHICLE: 2005 VOLKSWAGEN NEW BEETLE CONVERTIBLE
LOCATION: VIRGINIA
CRASH DATE: JUNE 2005

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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 investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in a 2005 Volkswagen New Beetle Convertible. The vehicle was certified by the manufacturer that the CAC system met the requirements of the advanced FMVSS 208 ruling. This advanced occupant protection system was comprised of dual-stage frontal air bags, driver seat track position sensor, front safety belt buckle switch sensors, front seat belt pretensioners, and a front right occupant detection sensor. The vehicle was also equipped with head/thorax side impact air bags, active front seat head restraints and automatic rollover protection. The automatic rollover protection was integrated into the rear seat head restraints and deploys vertically in the event of a rollover.

The Volkswagen was involved in a roadside departure rollover crash event on a three-lane divided roadway. Reportedly at the time of the crash, the Volkswagen experienced a right rear tire puncture resulting in a loss of pressure. Subsequently, the tire overheated and the tire's tread separated. The lost of the tire tread induced a left steer to the Volkswagen resulting in a sideswiping impact with a 2002 Audi A6. The Volkswagen driver steered right, lost control of the vehicle and departed the highway to the right. The vehicle drove up the roadside embankment and overturned. The vehicle's automatic rollover protection deployed. The driver was restrained by the vehicle's 3-point lap and shoulder belt and was not injured in the crash.

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BACKGROUND

This investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in a 2005 Volkswagen New Beetle Convertible, **Figure 1**. The vehicle was certified by the manufacturer that the CAC system met the requirements of the advanced FMVSS 208 ruling. This advanced occupant protection system was comprised of dual-stage frontal air bags, driver seat track position sensor, front safety belt buckle switch sensors, front seat belt pretensioners, and a front right occupant detection sensor. The vehicle was also equipped with head/thorax side impact air bags, active front seat head restraints and automatic rollover protection. The automatic rollover protection was integrated into the rear seat head restraints and deploys vertically in the event of a rollover.

Figure 1: 2005 VW Beetle.

The Volkswagen was involved in a roadside departure rollover crash event on a three-lane divided roadway. Reportedly at the time of the crash, the Volkswagen experienced a right rear tire puncture resulting in a loss of pressure. Subsequently, the tire overheated and the tire's tread separated. The lost of the tire tread induced a left steer to the Volkswagen resulting in a sideswiping impact with a 2002 Audi A6. The Volkswagen driver steered right, lost control of the vehicle and departed the highway to the right. The vehicle drove up the roadside embankment and overturned. The vehicle's automatic rollover protection deployed. The driver was restrained by the vehicle's 3-point lap and shoulder belt and was not injured in the crash.

The Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) was notified of the crash by a local police investigator. In turn, the NHTSA assigned an on-site investigation of the crash to the Calspan Special Crash Investigations (SCI) team due to its interest in the performance of the advanced safety systems installed on current model year vehicles. The Calspan SCI team initiated follow-up investigation and the subject Volkswagen was being held by the police investigator. It was available for inspection. The on-site portion of the investigation took place on July 6, 2005. The 2002 Audi A6 was driven from the crash site and was not inspected.

SUMMARY

Crash Site

This crash occurred during the daylight hours in June 2005. At the time of the crash it was daylight and the weather was not a factor. The crash occurred on the eastbound lanes of a three-lane divided interstate highway. The south side of the traffic lanes was bordered by a 3.7 m (12.0 ft) wide breakdown lane and a 10 cm (4 in) concrete curb. Beyond the curb, there was an earth embankment. The embankment had a 35 degree positive slope, measured 4.6 m (15.0 ft) south of the curb line. The highway speed limit in the area of the crash was 89 km/h (55 mph). **Figure 2** is an eastbound view of the roadway configuration in the area of the crash. **Figure 3** is a trajectory view of the Volkswagen at the point of road side departure.

Figure 2: Eastbound view of the roadway.

Figure 3: View at the point of roadside departure.

CRASH SEQUENCE

Pre-Crash

The 2005 Volkswagen New Beetle Convertible was eastbound in the right (outboard) lane of the highway driven by a 42 year old female. The convertible top was up. She was restrained at the time of the crash by the vehicle's manual three-point lap and shoulder belt. The driver was in the process of commuting to her place of employment. She had traveled approximately 24 km (15 miles) from her residence to the crash site.

At an unknown point in time and unbeknownst to the driver, the right rear tire was punctured by a nail resulting in a slow decrease in its inflation pressure. Over time, the tire deflated and the under-inflated tire overheated during the vehicle's operation. This overheating resulted in a circumferential separation of the tread from the tire's sidewall at the shoulders, **Figure 4**. The sudden change in the vehicle's dynamic behavior induced a left steer in the Volkswagen that resulted in a reported partial lane change to the left.

Figure 4: View of the separated right rear tire.

Crash

Reportedly, the Volkswagen crossed the lane line and the forward left side of the vehicle contacted the right rear of a 2002 Audi A6 traveling in the center lane of the interstate, Event 1. The Audi was not inspected as part of this investigation. Corresponding contact damage to the forward left side of the Volkswagen as a result of this event was not identified during its inspection. That damage may have been masked by overlapping damage from the vehicle's rollover. The Collision Deformation Classification (CDC) for this event was 12-LFES1.

The driver overreacted to the induced left steer by steering to the right and lost control of the Volkswagen. The vehicle initiated a southeast trajectory, traversed the right (outboard) lane, the breakdown lane, and left the paved roadway. The vehicle's departure angle measured approximately 15 degrees relative to its initial travel direction. The driver then steered back to the left in an effort to regain the road.

The Volkswagen overrode the curb bordering the breakdown lane and began climbing the roadside embankment. The SCI inspection of the scene identified tire marks attributed to the right side tires of the Volkswagen. These marks indicated a parabolic arcing trajectory along the embankment. The trajectory indicated the vehicle was rotating counterclockwise (resultant to the late left steer input). At the peak of its trajectory, the right front tire of the vehicle was located 4.6 m (15.2 ft) south of the curb line and the slope of the embankment at that location measured 35 degrees. As the vehicle's trajectory transitioned to the northeast and it began to descend the slope, the vehicle tripped over the right front wheel into a right side leading roll. During the roll sequence, the right side impact air bag and the automatic rollover protection deployed. The vehicle rolled onto its top causing the backlight to fracture and disintegrate. A pool of tempered glazing was identified. The disintegrated glazing was located 27.9 m (91.5 ft) east and 0.6 m (2.0 ft) south of the point of roadway departure. The Volkswagen rolled a total of four quarter turns coming to rest on its wheels in the breakdown lane of the roadway. **Figure 12** at the end of this report is a schematic of the crash.

Post-Crash

The police and ambulance personnel responded to the crash site. The driver remained within the vehicle until the arrival of the ambulance. She was transported to a local hospital examined and released. She was not injured. The Volkswagen sustained disabling damage and was towed. The Audi A6 was driven from the scene.

Figure 5: Right side view of the Volkswagen.

VEHICLE DATA

2005 Volkswagen New Beetle Convertible

The 2005 Volkswagen New Beetle Convertible, **Figure 5**, was identified by the Vehicle Identification Number (VIN): 3VWCM31Y45M (production sequence deleted). The two door, four passenger front wheel drive convertible was equipped with a 2.0 liter/I4 engine linked to a six-speed automatic transmission. The service brakes were a power-assisted front/rear disc system with

ABS. The odometer read 7,535 km (4,682 miles). The date of manufacture was not known. The manual restraint system consisted of three-point lap and shoulder belts in all four seat positions. The front restraints utilized retractor pretensioners. The vehicle was equipped with advanced 208 compliant frontal air bags, front seat back mounted side impact air bags and automatic rollover protection. The Volkswagen was equipped with Goodyear Eagle RS-A 91H P225/45R17 tires on alloy wheels. The recommended tire pressure was 227 kPa (33 psi) front and 269 kPa (39 psi) rear. The vehicle was not equipped with a Tire Pressure Monitoring System (TPMS). The specific measured tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	221 kPa (32.0 psi)	7.1 mm (9/32)	No	None
LR	234 kPa (34.0 psi)	7.1 mm (9/32)	No	None
RF	10 kPa (1.5 psi)	7.1 mm (9/32)	No	Debris in bead
RR	Tire flat	7.1 mm (9/32)	No	Punctured/Separated (see below)

As noted earlier in this report, the right rear tire tread was punctured at an unknown point in time by a nail. The deformed nail was still embedded in the tread post-crash. The tire slowly deflated. During the vehicle's operation, the under-inflated tire overheated and over stressed the plies of tire's sidewalls. The tread of the right rear tire separated from its sidewalls circumferentially. The subject tire's DOT number was M67R ENOR 3004. The sidewall was constructed of two polyester cord plies. The tread was constructed of five plies (two polyester, two steel, one nylon). The tread wear, traction and temperature ratings were 260, A, A, respectively. **Figure 6** is a view of the alloy rim and sidewalls. **Figure 7** is a close-up view of the heat stressed sidewall cords. The police investigator indicated the right rear wheel rim was damaged during the towing of the vehicle and was not crash related.

Figure 6: Right rear wheel.

Figure 7: Close-up view of the sidewall.

Exterior Damage

An inspection of the Volkswagen revealed direct damage indicators of a four-quarter turn rollover. The direct damage consisted of abrasions and minor deformation to the body panels and minor residual vertical deformation of the reinforced windshield frame consistent with the rollover dynamics. The rake angle of the left side windshield frame was deflected down 7 degrees due to ground contact. The deflection reduced the height of the upper left corner of the windshield frame 8 cm (3.3 in) The rake angle of the right side windshield frame was unchanged. There was no change in the overall vehicle length. The left wheelbase dimension was unchanged. The right wheelbase dimension increased 6 cm (2.3 in). The increased dimension was attributed to damage to the right rear suspension at a result of the crash and reported damage that occurred during towing. The left door was jammed shut and exhibited indications of attempted extrication. The right door was operational. The windshield was completely fractured. All the side window glazings were disintegrated except for the partially open front right. The CDC of the rollover event was 00-TDDO1.

Interior Damage

The interior damage to the Volkswagen consisted of the deployment of the front right seat back mounted side impact air bag and the automatic rollover protection. There were no identified occupant contacts consistent with the lack of injury sustained by the belted driver. There was no intrusion.

The driver seat was adjusted to a rear track position that measured 4 cm (1.5 in) forward of full rear. The total seat track travel measured 18 cm (7.0 in). The seat back angle measured 30 degrees and had been reclined by EMS. The three-spoke steering wheel was mounted to a tilt steering column. The column was adjusted to the full up position. There was no deformation of the steering wheel rim. There was no shear capsule displacement.

Manual Restraint System

Figure 8 is a view of the driver's manual three-point restraint in the buckled position. The restraint consisted of a sliding latch plate, continuous loop webbing and a B-pillar mounted Emergency Locking Retractor (ELR) with pretensioner. There was no D-ring due to the vehicle's convertible features. Upon initial inspection, the driver's webbing was extended from the retractor and the retractor was jammed. However, after manipulation, the webbing freely extended and retracted from the spool. The pretensioner did not actuate in the rollover crash. It was noted in the vehicle owner's manual that the pretensioner would not actuate in a side impact or rollover crash. Inspection of the webbing revealed indicators of use during the crash. A 4 cm (1.5 in) webbing abrasion began 78 cm (30.5 in) above the outboard anchor. This abrasion was located at the latch plate in the buckled condition. The plastic turning loop of the latch plate exhibited a corresponding abrasion. An 9 cm (3.5 in) abrasion was located at the exit of the B-pillar trim, 109 cm (43.0 in) above the anchor. This abrasion was related to frictional contact with the trim surface after the ELR retractor had locked at the time of the crash.

Figure 8: Driver's manual restraint.

Supplemental Restraint System

The Supplemental Restraint System in the Volkswagen New Beetle consisted of Certified Advanced - 208 Compliant (CAC) frontal air bags and head/thorax side impact air bags mounted in the outboard aspects of the front seat backs. The driver and front right passenger air bags did not deploy in the crash.

During the first quarter turn of the right side leading rollover sequence, the right side impact air bag deployed, **Figure 9**. The deflated head/thorax bag measured 71 cm x 25 cm (28 in x 10 in), height by width. The bag's excursion longitudinally forward of the seat bolster measured 18 cm (7 in). The bag was not tethered and there were no external vent ports. There was no evidence of occupant contact to the air bag.

Figure 9: Right side impact air bag.

Automatic Rollover Protection System

The convertible models of the Volkswagen New Beetle were equipped with an Automatic Rollover Protection System (ARPS) designed into the head restraints of the rear seats. The rear head restraints were spring loaded and fired vertically to help the reinforced windshield frame support the vehicle in the event of a rollover. The system was controlled by a module that measured roll angle and roll rate and released the device when those values exceeded a programmed threshold.

Figure 10 is a view of the ARPS in its deployed condition. **Figure 11** is a close-up of the construction and released mechanism on its rear aspect. The ARPS was constructed of 16 cm x 5 cm (6.3 in x 1.9 in) telescoping aluminum sections that deployed 22 cm (8.5 in) vertically upon release. A locking lever engaged a rack gear (attached to the rear aspect of the ARPS) and locked the ARPS in the deployed position. By releasing the lever, the head restraint could be pushed down against spring pressure. The ARPS could be mechanically re-set.

Figure 10: View of the deployed ARPS.

Figure 11: Rear aspect of the ARPS.

DRIVER DEMOGRAPHICS

Age/Sex:	42 year old/Female
Height:	Not reported
Weight:	Not reported
Seat Position:	Mid to rear track
Restraint Use:	Three-point lap and shoulder
Usage Source:	SCI inspection
Medical Treatment:	Not injured

DRIVER INJURY

The 42 year old driver of the Volkswagen was not injured in the crash.

DRIVER KINEMATICS

The 42 year old female driver of the Volkswagen was seated in a normal posture in a mid to rear track position. She was restrained at the time of the crash by the vehicle's manual restraint. As the vehicle tripped and began to roll, the retractor of the manual restraint locked. The automatic rollover protection and right side impact air bag deployed. The driver exhibited a leftward trajectory and she likely contacted the door panel. As the vehicle rolled over, she loaded the manual restraint evidenced by the webbing abrasions and rode through the crash. The combination of the use of the manual safety belt and the protection provided by the reinforced windshield frame and rollover protection prevented the driver from sustaining serious injury. As the vehicle came to rest on its tires and driver rebounded back into her seat.

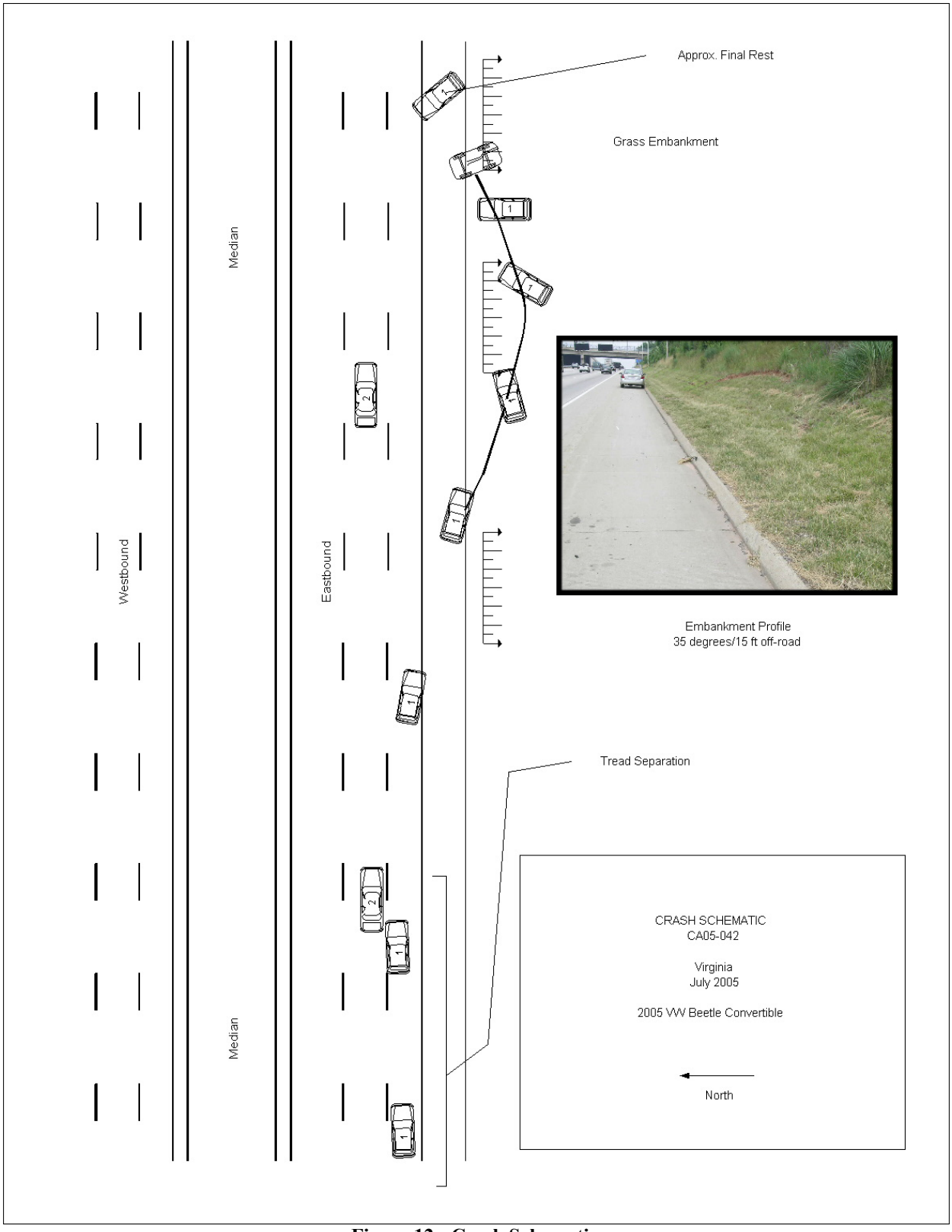

Figure 12: Crash Schematic.