Insurance Institute for Highway Safety
Crashworthiness Evaluation

Crash Test Report
1997 Volkswagen Jetta (CF97018)

Vehicle identification number: 3VWRA81HXVM046024
Body style: Four-door sedan
Engine/transmission: Transverse 2.0-liter 4-cylinder, 4-speed automatic, front-wheel drive

Standard crashworthiness features:

Driver and right front passenger front airbags
Dual-locking shoulder belts (front and rear outboard seating positions)
Shoulder belt upper anchorage height adjusters (front seating positions only)
Seat belt crash pretensioners (pyrotechnic, front seating positions only)
Right front and both rear shoulder belt retractors are convertible from emergency to automatic locking for ease of child restraint use
Rear seat head restraints (outboard seating positions only)

Other standard safety features:

Daytime running lights

Optional safety features:

Four-wheel antilock brakes

Vehicle specifications (provided by manufacturer):

Wheelbase:	247 cm
Overall length:	440 cm
Overall width:	170 cm
Curb weight:	1,175 kg

Vehicle specifications (measured):

Front bumper to firewall:	106 cm
Curb weight:	1,236 kg
Test weight:	1,365 kg
Overall width:	169 cm

Nominal test parameters:

40.0 mi/h (64.4 km/h), 40 percent overlap, deformable barrier face with slotted bumper

Crash test date:

August 21, 1997

Precrash — 1997 Volkswagen Jetta

Postcrash — 1997 Volkswagen Jetta

Summary

A 1997 Volkswagen Jetta was crash tested on August 21, 1997 into a fixed deformable barrier at 40.0 mi/h (64.4 km/h) and a 42 percent overlap on the driver side. A Hybrid III 50th percentile male dummy was positioned in the driver seat with the lap/shoulder belt fastened.

Measures of intrusion taken after the crash indicated the lower instrument panel in front of the dummy moved rearward 7-9 cm. Resultant intrusion in the driver footwell measured 26 cm at the footrest and 20-34 cm at other places on the toepan. The upper end of the steering column moved upward 5 cm and rearward 7 cm. All doors remained closed during the crash. The driver and left rear doors required additional effort to open, but the right front and right rear doors opened with ease after the crash.

The driver dummy was restrained by a three-point lap/shoulder belt and an airbag. During the crash, the belt pretensioner activated and 1 cm of webbing spooled off the retractor. As the dummy moved forward into the airbag, its head, neck, and shoulders moved left toward the driver door, which had bowed outward. During rebound, the head contacted the window frame and B-pillar. The dummy returned to an upright position, its head contacted the head restraint, and the dummy then settled into the seat.

The maximum resultant head acceleration (82 g) was recorded when the dummy's head contacted the window frame. The dummy's head contact against the B-pillar produced a peak resultant head acceleration of 26 g. The left lower tibia had a maximum index of 1.42. The right leg had a maximum lower tibia axial force of 4.6 kN and maximum upper and lower tibia indices of 0.86 and 0.98, respectively.

Test Conditions

This vehicle had been tested previously in the Institute's Low-Speed Crash Test Program and subjected to an impact on the front corner of the passenger side at 5 mi/h (8 km/h) into a 30 degree angle barrier and a rear impact at 5 mi/h (8 km/h) into a flat barrier. All structural damage on the front was repaired prior to this test (see Appendix, Low-Speed Crash Test Damage Repair Estimate).

This test was conducted according to the procedures specified in the IIHS Offset Barrier Crash Test Protocol (Version IV). The Hybrid III dummy positioned in the driver seat was equipped with instrumented lower legs that included feet modified to include two accelerometers and to have a 45 degree dorsiflexion range with soft stops at all extremes of foot-ankle motion. All dummy seating parameters were set according to the procedures specified for Federal Motor Vehicle Safety Standard 208 compliance testing (49 *CFR* Part 571.208 § 11). The dummy's left foot was placed on the footrest.

Seat back, shoulder belt upper anchorage, and steering column adjustments were set according to the manufacturer's specifications for government crash testing. Other adjustments were set according to the procedure specified for Federal Motor Vehicle Safety Standard 208 compliance testing (49 *CFR* Part 571.208 § 7 and 8). After final positioning of the dummy, measurements from various parts of the dummy to a number of vehicle interior points were made. These measurements and the seat back, shoulder belt upper anchorage, and steering column adjustments are described in the Appendix, Dummy Clearance Measurements.

Vehicle acceleration measurements were made by a triaxial arrangement of accelerometers mounted on the vehicle's longitudinal centerline and 56 cm behind its center of gravity (162.5 cm behind the front axle). The vehicle speed recorded just prior to impact was 40.0 mi/h (64.4 km/h), and the actual overlap was 42 percent.

Structural Performance

All doors remained closed during the crash. The driver door aperture shortened 10 cm as measured at the lower edge of the window. The driver door required additional effort to open, and the left rear door required considerable effort to open after the crash. The right front and right rear doors opened with ease after the crash.

No fuel system leaks were observed after the crash. In addition, no fuel system leaks were observed when the vehicle was rotated onto its right side to allow postcrash photography.

Figure 1 shows the overhead view of the crash deformation. Figure 2A illustrates the precrash and postcrash contour measures of the front bumper cover profile and the resulting permanent crush. Figure 2B illustrates the corresponding measures of both the front bumper reinforcement bar and the upper crossmember of the radiator support. Figure 3 shows the precrash and postcrash views from below. Figure 4 illustrates the deformation of the side rails, floor rails, and engine support members, which are visible in Figure 3.

Figure 1
Overhead View of Crash Deformation — 1997 Volkswagen Jetta

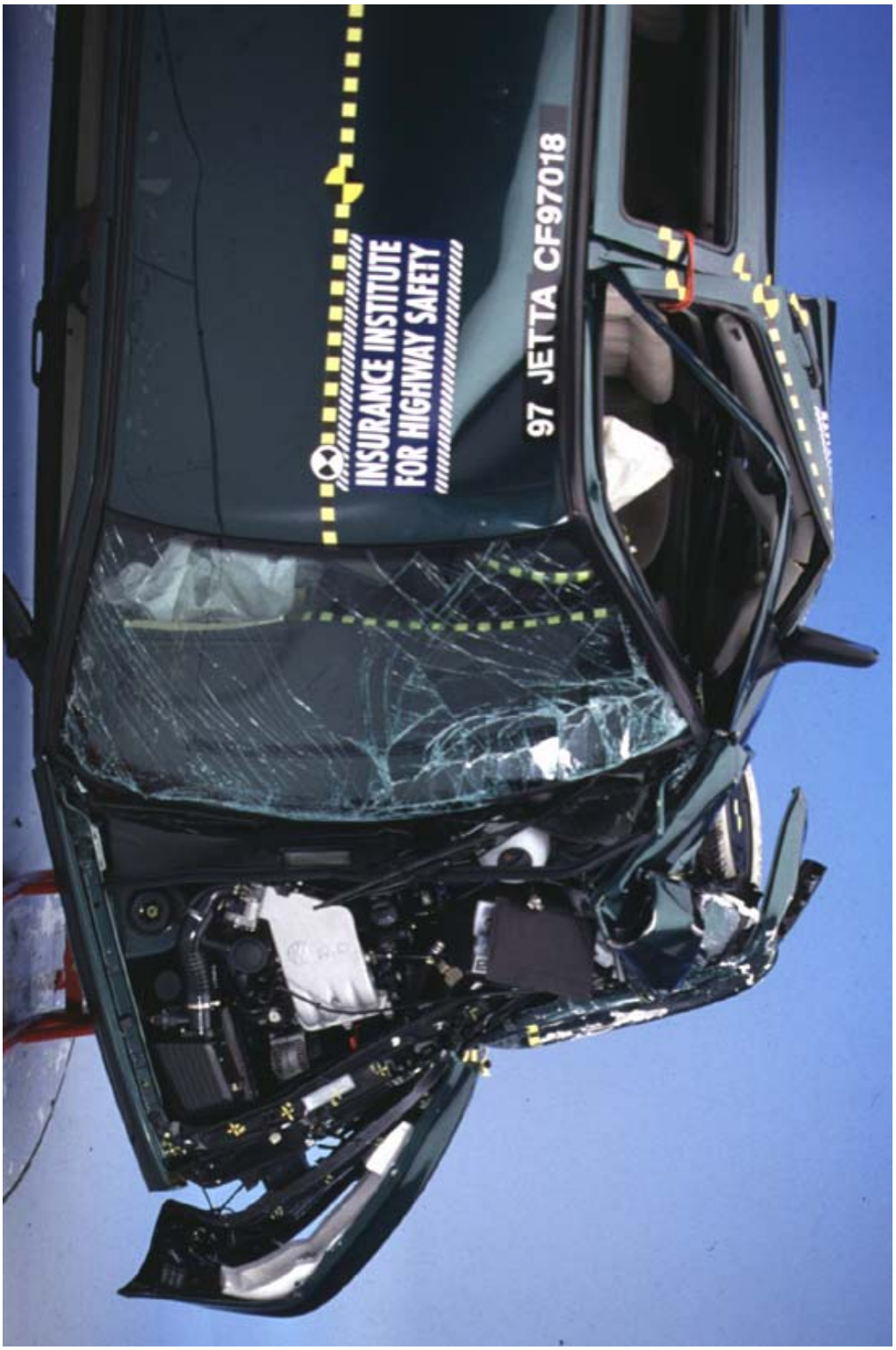
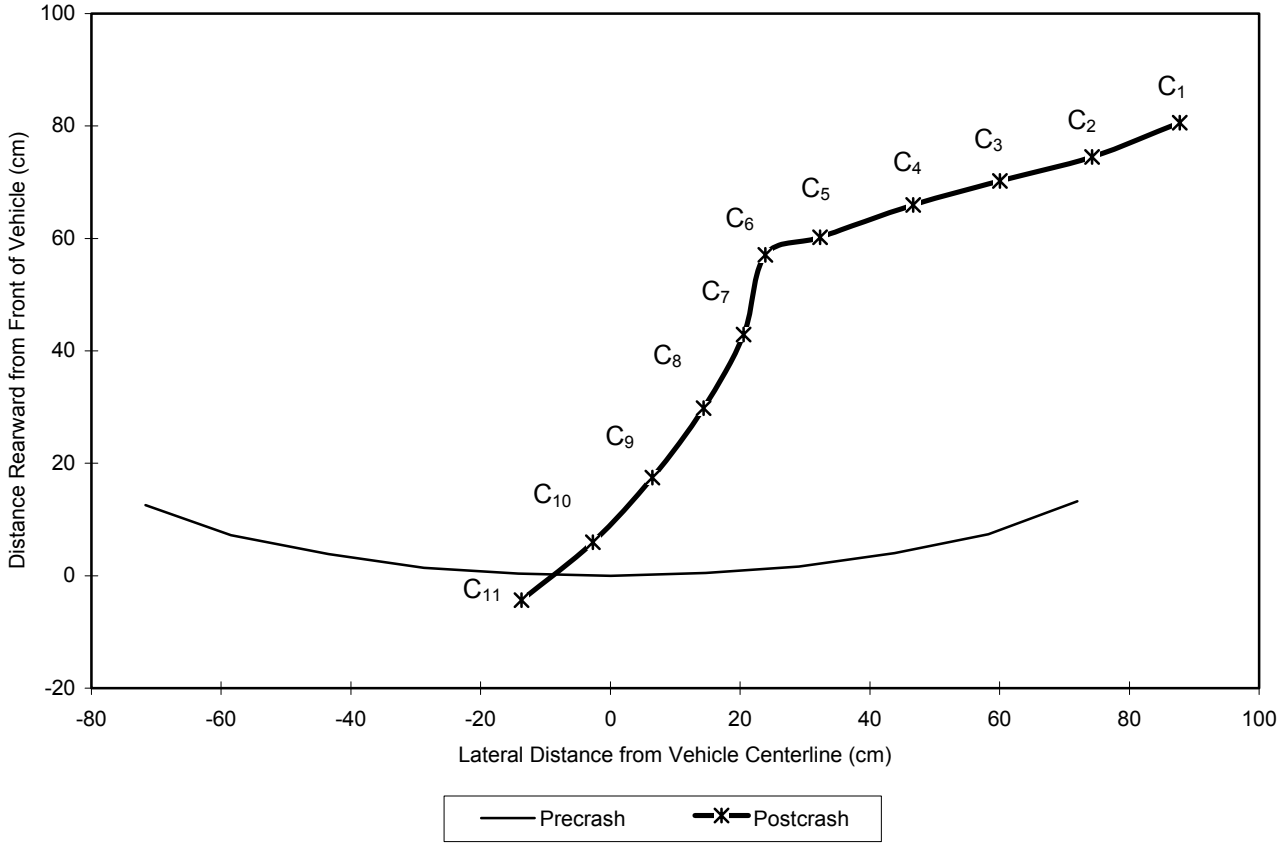


Figure 2
Crush Contour Measurements — 1997 Volkswagen Jetta

a) Exterior Crush Contour at Bumper Height



	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
Postcrash Contour (cm)	81	74	70	66	60	57	43	30	17	6	-4
Precrash Contour (cm)	13	7	4	2	0	0	0	1	4	7	13
Resulting Crush (cm)	68	67	66	64	60	57	43	29	13	-1	-17

The length of the reference line was 144 cm precrash and 102 cm postcrash.

b) Front Bumper Bar and Upper Radiator Support Crossmember Crush Contour

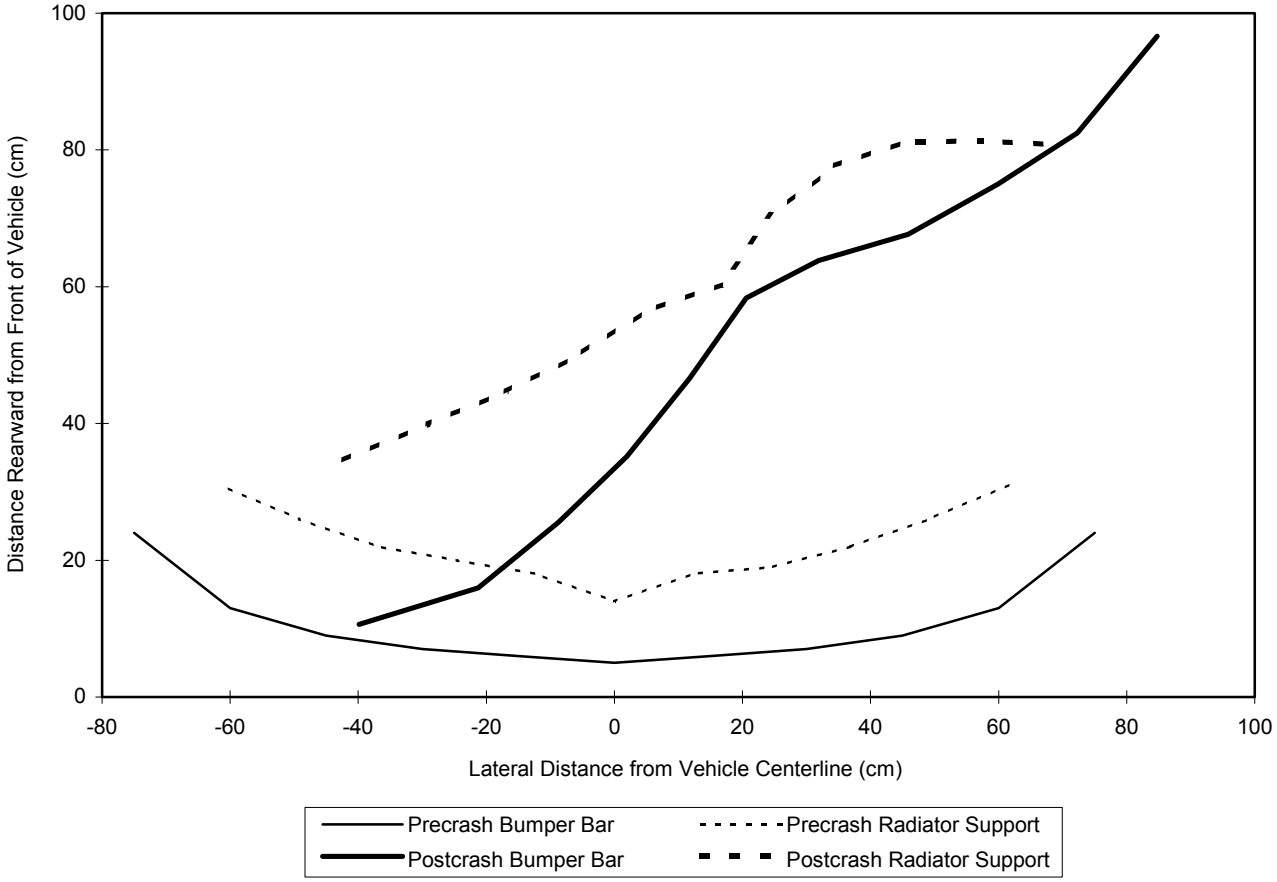
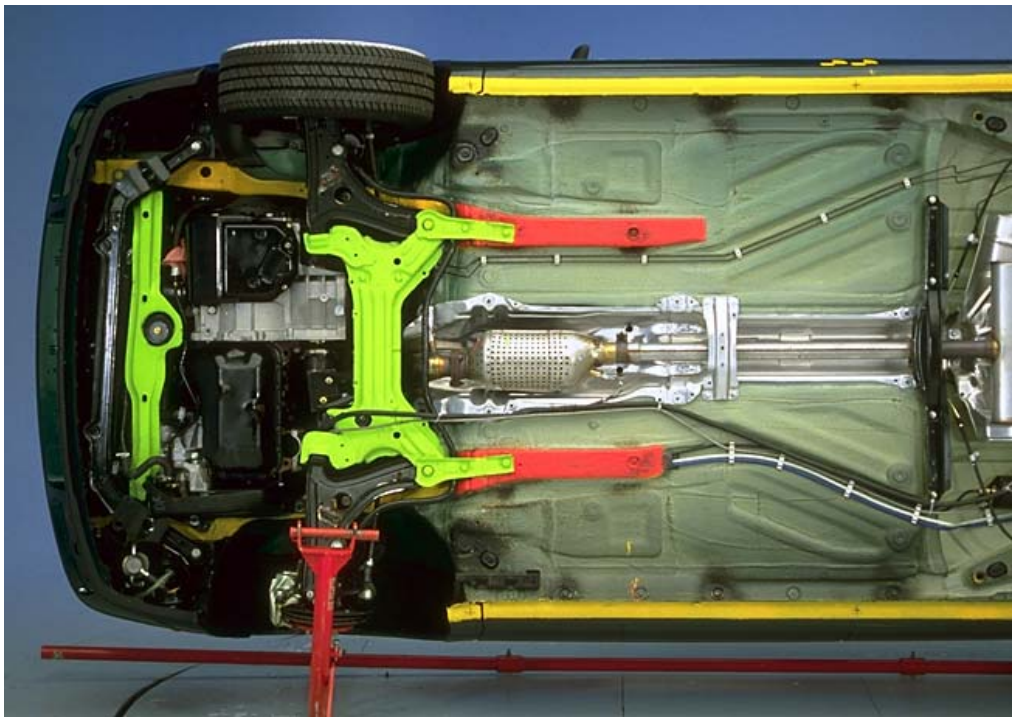


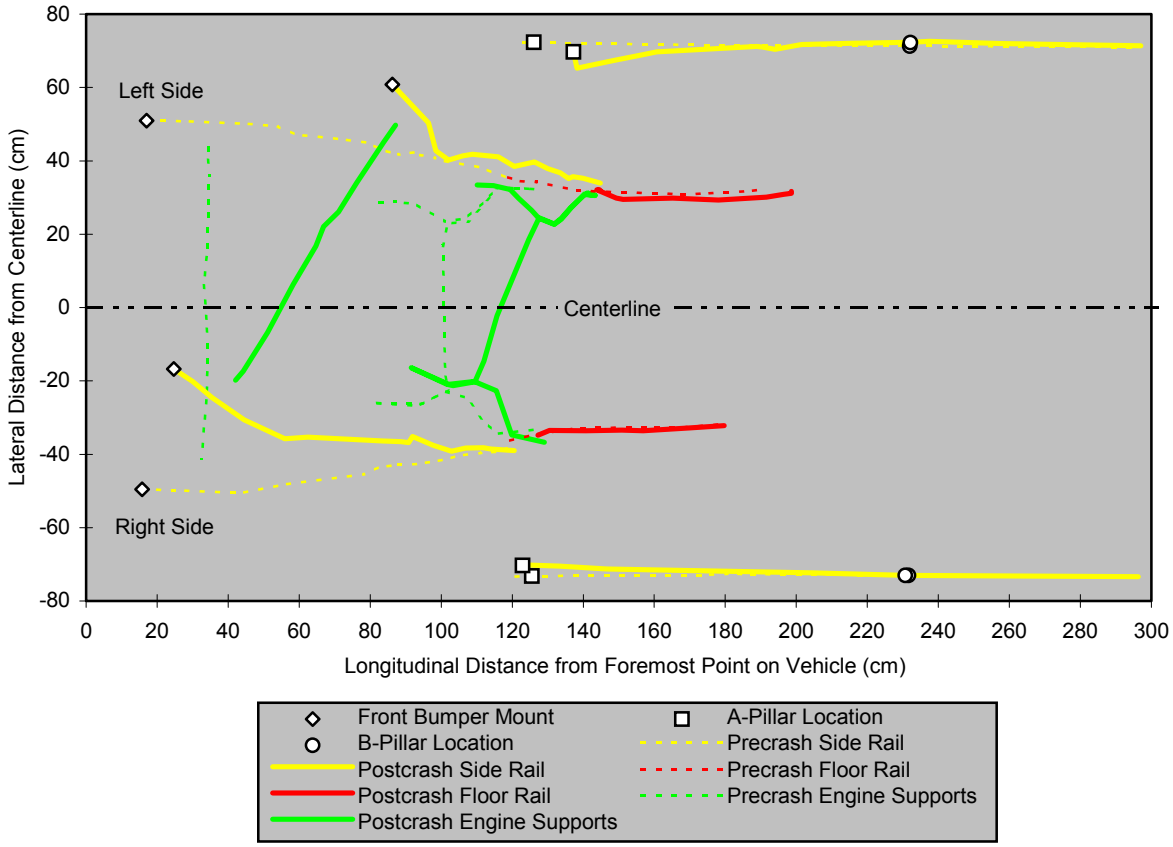
Figure 3
Precrash View from Below — 1997 Volkswagen Jetta



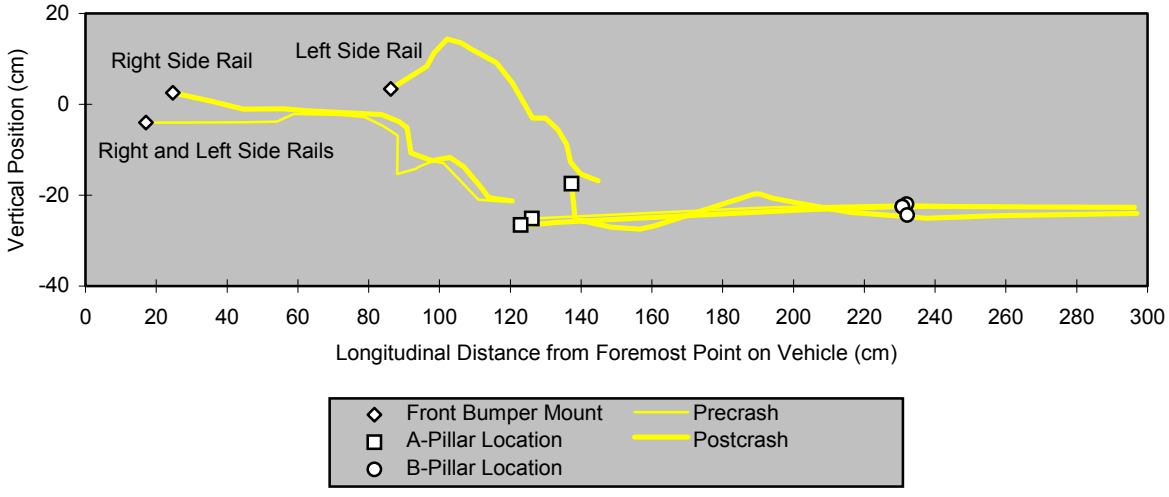
Postcrash View from Below — 1997 Volkswagen Jetta

Figure 4
Frame Rail Deformation — 1997 Volkswagen Jetta

a) View from Below



b) Side View



Various measures of intrusion were made after the crash. These residual measures of intrusion typically are less than the maximum deformation that occurs during the crash. The primary coordinate reference system for these measures is described in the IIHS Offset Barrier Crash Test Protocol (Version IV). The measures of deformation shown in Table 1 have been adjusted to better reflect the displacement of the various target locations relative to the driver. This was done by subtracting the average component displacements of the four seat-attachment bolts, which also were measured relative to the primary coordinate system, from the respective components of displacement for each of the target locations. The average displacement of the four seat-attachment bolts relative to the primary reference system also is shown in Table 1.

Table 1
Residual Measurements of Intrusion Relative to Driver Seat — 1997 Volkswagen Jetta

Selected Locations*	Longitudinal	Lateral	Vertical	Resultant
Steering column (cm)	-7	4	5	10
Left lower instrument panel (cm)	-9	-2	2	9
Right lower instrument panel (cm)	-7	-1	2	7
Brake pedal (cm)	-22	-2	10	24
Left toepan (cm)	-33	-4	8	34
Center toepan (cm)	-29	-3	8	31
Right toepan (cm)	-19	0	6	20
Footrest (cm)	-26	-2	6	26
Average displacement of the four seat attachment bolts from primary reference system (cm)	-1	2	1	—

* All measurements taken on driver side. From the driver's position, positive is forward, left, and up.

Restraint System Performance

Airbags

Driver: The uninflated driver airbag was 71 cm in diameter, and the excursion of its center when inflated was limited by four 27 cm-long tethers. The airbag was vented by two 30 mm-diameter holes at positions corresponding to 10 and 2 o'clock on the forward-facing surface of the airbag. Analysis of the high-speed film taken from camera position D indicated the airbag deployed at
26 ms into the crash and appeared to be fully inflated at 52 ms.

Passenger: The mid-mounted passenger airbag deployed rearward and was untethered. The square-shaped airbag was vented by two 50 mm-diameter holes located at the upper corners. The airbag did not appear to contribute to windshield damage during deployment.

Seat Belts

This vehicle is equipped with dual-locking lap/shoulder belts with sliding latch plates at the outboard seating positions and adjustable upper anchorage points at both front seating positions. The front inboard lower anchorage points are attached to and move with the seats. The front outboard lower anchorage points are bolted to the floor. The front seating positions are equipped with pyrotechnic crash pretensioners that, when activated, remove slack from the shoulder belt webbing by pulling webbing back into the retractor. During the crash, the belt pretensioner activated and 1 cm of webbing was pulled from the retractor through the D-ring as measured by a pull-string mounted between the retractor housing and the webbing just beyond the retractor.

Seat

Postcrash examination of the driver seat rails indicated no discernible movement of the seat in its tracks during the crash. Analysis of the high-speed film taken from camera position D indicated minimal movement of the driver seat. Deformation of the floor under the driver seat caused the seat to tip outboard slightly.

Steering Column

The upper end of the steering column moved upward 5 cm and rearward 7 cm relative to the driver seat. The telescoping steering column compressed 14 cm. The column does not have shear modules; instead, bolts mounted in elongated holes are used. Movement was less than 0.5 cm rearward on the left side and 1 cm rearward on the right side of the column.

Dummy Kinematics

Head, Neck, and Torso

Analysis of the high-speed film taken from camera position D indicated the dummy's face began to load the airbag at 68 ms into the crash (16 ms after the airbag was fully inflated). Paint transferred from the dummy's face onto the airbag indicated the dummy's nose loaded the airbag 4 cm above and 3 cm to the left of its center. The right side of the airbag wrapped around the entire right side of the dummy's face. As the dummy's head continued forward, it rolled left toward the driver door, which had bowed outward. The dummy's head, neck, and shoulders then leaned leftward and moved rearward, and the back of the head contacted the window frame at 221 ms (contact confirmed by paint transfer). The dummy's head deflected off the window frame and continued rearward. Analysis of the high-speed film taken from camera position B indicated the dummy's head then contacted the B-pillar at 233 ms. As the car settled, the back of the dummy's head contacted the head restraint at 538 ms. The dummy then settled into the seat. Table 2 provides the timing and duration of these events.

Table 2 Analysis of Restraint System Performance and Dummy Kinematics — 1997 Volkswagen Jetta	
Event	**Time (ms)**
Deployment of airbag	26
Airbag fully inflated	52
Head begins to load airbag	68
Head contacts window frame	221
Head contacts B-pillar	233
Head contacts head restraint	538

Legs and Feet

Left leg and foot: Paint transferred from the dummy's left knee indicated the knee contacted the lower corner of the steering column trim and the instrument panel padding just above the knee bolster. Paint transferred from the dummy's left shin indicated the shin contacted the knee bolster 2 cm below and 3 cm to the left of the left instrument panel intrusion measurement point. The left foot was found fully dorsiflexed and slightly inverted, with the back of its heel against the downward buckle of the floorpan. The ball of the foot was pressed against the right side of the intruded toepan just to the right of the footrest.

Right leg and foot: Paint transferred from the dummy's right knee indicated the knee contacted the bottom right steering column plastic trim, which extends to the right of the column and includes the ignition switch; however, the knee did not contact the knee bolster. Paint transferred from the dummy's right shin indicated the shin contacted and dented the knee bolster 5 cm below and 7 cm to the left of the right instrument panel intrusion measurement point. The right foot was found fully dorsiflexed and slightly inverted with its sole on the accelerator pedal, which was pressed against the intruded toepan. The back of the heel was suspended above the floorpan. The right side of the foot was pressed against the carpeting on the console housing.

Dummy Injury Measures

Head

The maximum vector resultant head acceleration (3 ms clip) was recorded and the HICs were calculated during an interval that corresponds with the dummy's head excursion into the airbag. The maximum resultant head acceleration was recorded when the dummy's head contacted the window frame. The dummy's head contact against the B-pillar produced a peak resultant head acceleration of 26 g at 238 ms. Table 3 provides a summary of the maximum head injury measurements recorded during the crash.

Table 3
Head Injury Measurements — 1997 Volkswagen Jetta

Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant acceleration (g)	80	82	226
Vector resultant acceleration — 3 ms clip (g)	80	62	91-94
Head Injury Criterion (HIC)	1000	536	79-115
Head Injury Criterion — 15 ms interval (HIC-15)*	700	383	87-102

* A proposed amendment to the Canadian Motor Vehicle Safety Regulations suggests calculating HIC during a 15 ms interval rather than the 36 ms interval specified by the U.S. standard. The Canadian proposal includes an injury threshold of 700 for front-seat occupants protected by airbags.

Neck

Table 4 provides a summary of the maximum neck injury measurements recorded during the crash.

Table 4
Neck Injury Measurements — 1997 Volkswagen Jetta

Measure	Published Tolerance Threshold	Result	Time (ms)
A-P shear force (kN)	±3.1*	0.6	179
Axial compression force (kN)	4.0*	0.1	238
Axial tension force (kN)	3.3*	1.4	107
Flexion bending moment (Nm)	190**	28	189
Extension bending moment (Nm)	57**	18	117

* These values are for instantaneous loading. Neck loads are compared with magnitude-duration injury criteria in Figures A-12 to A-15.

** These published thresholds are recommended injury assessment reference values from Backaitis and Mertz (1994), but significant neck injury may occur at lower bending moments. Mertz and Patrick (1971) report that bending moments of 47 Nm in extension and 88 Nm in flexion would be non-injurious for occupants represented by the Hybrid III 50th percentile adult male dummy.

Chest

Table 5 provides a summary of the maximum chest injury measurements recorded during the crash.

Table 5
Chest Injury Measurements — 1997 Volkswagen Jetta

Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant spine acceleration — 3 ms clip (g)	60	45	106-109
Rib compression (mm)	50	36	98
Viscous criterion (m/s)	1.0	0.2	63

Legs and Feet

Left leg and foot: The left lower tibia had a maximum resultant bending moment of 308 Nm, which contributed to a maximum left lower tibia index of 1.42.

Right let and foot: The right tibia had a maximum axial force of 4.6 kN and maximum upper and lower tibia indices of 0.86 and 0.98, respectively.

Table 6 provides a summary of the maximum leg and foot injury measurements recorded during the crash.

Table 6
Leg and Foot Measurements — 1997 Volkswagen Jetta

Measure	Published Tolerance Threshold	Left Leg		Right Leg	
		Result	Time (ms)	Result	Time (ms)
Axial femur force (kN)	9.1*	2.1	104	3.4	90
Tibia-femur displacement (mm)	15	—	—	8	105
Upper Tibia					
L-M moment (Nm)	±225	-100	102	105	65
A-P moment (Nm)	±225	66	57	138	64
Vector resultant moment (Nm)	225	100	102	165	65
Index	1.00	0.45	102	0.86	65
Lower Tibia					
L-M moment (Nm)	±225**	-13	78	193	65
A-P moment (Nm)	±225**	308	75	38	83
Vector resultant moment (Nm)	225**	308	75	193	65
Axial force (kN)	8.0**	1.9	73	4.6	65
Index	1.00	1.42	75	0.98	65
Foot					
A-P foot acceleration (g)	±150	-35	35	-87	66
I-S foot acceleration (g)	±150	77	74	103	63
Vector resultant foot acceleration (g)	150	81	73	113	64

* This critical value is for instantaneous loading. Femur loads are compared with magnitude-duration injury criteria in Figures A-23 and A-34.

** These published thresholds are for fractures of the tibia. Ankle and foot injuries have been associated with bending moments as low as 50-100 Nm, and heel fractures have been associated with axial forces as low as 6.0 kN.

References

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Appendix

Low-Speed Crash Test Damage Repair Estimate

Dummy Clearance Measurements

Graph Index — index to graphs of time plots of dummy and vehicle data

Manufacturer's window sticker

Low-Speed Crash Test Damage Repair Estimate

1997 Volkswagen Jetta Four-Door Sedan: 5 mi/h Front into Angle Barrier

Test number: LA97011
VIN: 3VWRA81HXVM046024
Mileage: 180
Features: Driver and passenger airbags, air conditioning, automatic transmission, power steering, power door locks, heated back glass, tilt steering wheel, two-stage paint.

	Part		Labor	
Description	**Mfg. No**	**Price**	**Operation**	**Hours**
Bumper cover, front			Repair/align	2.0
Bumper cover, front			Refinish	3.0
Reflector, right front	1HM 941 780 C	$11.75	Replace	
Grille assembly			Repair/align	0.5
Headlamps			Aim	0.5
Lamp assembly, parking and turn signal, right front	1HM 953 156	32.30	Replace	0.2
Socket, parking lamp	701 953 123 A	6.05	Replace	
Crossmember, radiator support, lower	1HM 805 551 B	118.45	Replace*	2.1
Fender panel, right front inner			Repair/align*	1.0
Fender, right front			Repair/align*	1.0
Fender, right front			Refinish	2.8
Sidemember assembly, right front			Repair/align*	0.5
Air cleaner assembly			Remove/reinstall	0.7
Bulb, parking and turn signal, right front	N 017 738 2	2.00	Replace	
Socket, side marker lamp, right front	1H0 949 111	6.75	Replace	
Paint and materials		92.80		
Total Parts		$270.10		
Total Labor		443.30		14.3
Grand Total		$713.40		

* This item was repaired or replaced as indicated before the 40 mi/h frontal offset barrier test.

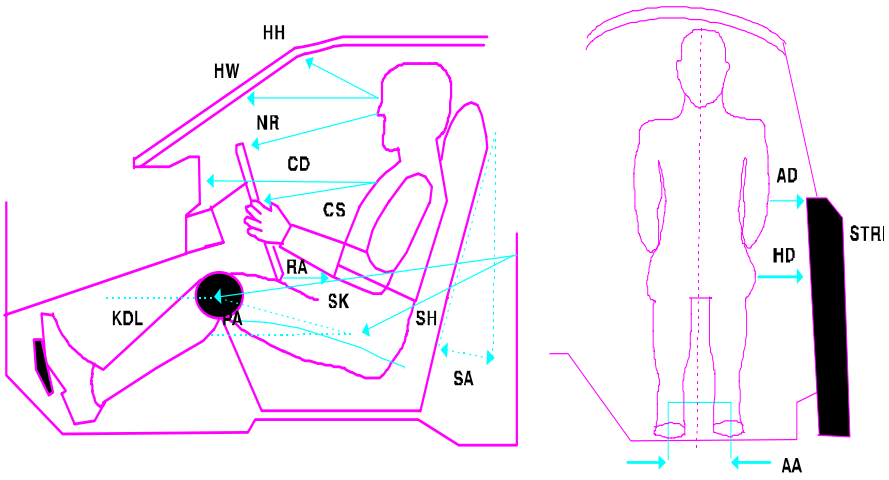
Dummy Clearance Measurements

Test Number: CF97018
Vehicle Make: Volkswagen Jetta
Vehicle Model Year: 1997
Seat Type: Manual adjustment

Manufacturer's Specifications
Seat Back Information: Reclined to 21 degrees torso angle with H-point machine
Upper Belt Anchorage: Adjusted to second position from top
Steering Column Adjustment: Midpoint

Location	Code	Measurement	Location	Code	Measurement
Head to header	HH	415	Torso angle	TA	16.8°
Head to windshield	HW	640	Striker to knee*	SK	600
Nose to rim	NR	470	Striker to knee angle*	SKA	-12.4°
Chest to dash	CD	650	Striker to H-point horizontal	SHH	180
Chest to steering wheel	CS	430	Striker to H-point vertical	SHV	-240
Chest to airbag module	ABM	325	Arm to door	AD	140
Rim to abdomen	RA	250	H-point to door	HD	235
Pelvic angle	PA	25.3°	Seat back angle	SA	11.8°
Knee to dash left	KDL	220	Ankle to ankle	AA	310
Knee to dash right	KDR	185	Knee to knee	KK	290

All distance measurements are in mm.
* These measurements are made in a vertical plane containing the striker and parallel to the driver door sill.



Graph Index