TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION

Calspan Corporation
Buffalo, New York 14225

CALSPAN ON-SITE AIR BAG CHILD FATALITY INVESTIGATION

CALSPAN CASE NO. CA98-027

VEHICLE - 1995 VOLKSWAGEN JETTA

LOCATION - MISSISSIPPI

CRASH DATE - APRIL, 1998

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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 be 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 of the involved vehicle(s) or their safety systems.

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This on-site investigation focused on a front-to-rear crash that resulted in the death of a 10 year old female, seated unrestrained in the right front of a 1995 Volkswagen Jetta. The Jetta was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags that deployed as a result of the crash. The Field Operations Branch of the National Highway Traffic Safety Administration was informed of the crash on April 22, 1998 and assigned an on-site investigation to the Special Crash Investigations Team at Calspan on the same day. Cooperation was immediately established with the investigating officer and the on-site investigation was initiated on April 23. The Volkswagen Jetta was impounded pending SCI inspection.

The unrestrained 10 year old female passenger of the Jetta had a reported height/weight of 142 cm (56 in) and 34 kg (75 lb). Upon application of the Jetta's brakes, the child passenger initiated a forward trajectory with respect to the vehicle. At impact and subsequent underride, the child passenger responded to the 12 o'clock direction of the impact forces and pitching of the vehicle by moving further forward and became positioned in close proximity to the front passenger mid-mount air bag module. The deployment of the SRS occurred late in the collision sequence, subsequent to the underride, during maximum vehicular engagement between the Jetta's upper radiator support and the Ford's rear bumper. The front passenger air bag deployed contacting and abrading the anterior aspect of the child's neck. The air bag membrane then expanded around the neck and under the chin causing multiple abrasions and contusions through the region. The continued expansion of the air bag hyper-extended the head resulting in a fracture of the cervical spine at C1/C2 with spinal cord transection, (AIS 6).

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BACKGROUND

This on-site investigation focused on a front-to-rear crash that resulted in the death of a 10 year old female, seated unrestrained in the right front of a 1995 Volkswagen Jetta. The Jetta was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags that deployed as a result of the crash. As a result of her involvement with the deploying front passenger air bag, the child passenger sustained a fracture of the cervical spine at C1/C2 with complete transection of the spinal cord. The Field Operations Branch of the National Highway Traffic Safety Administration was informed of the crash on April 22, 1998 and assigned an on-site investigation to the Special Crash Investigations Team at Calspan on the same day. Cooperation was immediately established with the investigating officer and the on-site investigation was initiated on April 23. The Volkswagen Jetta was impounded pending SCI inspection.

SUMMARY

This three vehicle, front-to-rear crash occurred in the afternoon hours of April, 1998. At the time of the crash, it was daylight and the weather was not a factor. The traffic was reported as heavy. The crash occurred on a three lane north/south roadway in an urban area. The traffic lanes were configured as a single lane in each travel direction, with a center turn lane. There was a post office and a medical clinic located on the east side of the road. The speed limit in the area of the crash was 72 km/h (45 mph). **Figures 1 and 2** are photographs of the final rest positions of the vehicles taken during the on-scene police investigation and SCI investigation respectively.

Figure 1: On-scene photograph.

Figure 2: View of the final rest positions.

The 1995 Volkswagen Jetta GLS was northbound in a line of heavy stop-and-go traffic, driven by a 16

year old female. The right front passenger was the driver's 10 year old sister. Both occupants in the Jetta were unrestrained. The Jetta was traveling behind an unmarked police car and a Dodge Caravan. The unmarked police car was a 1995 Ford Crown Victoria. Immediately prior to the crash, the Caravan braked and came to a stop behind stopped traffic ahead. The off-duty police officer noted the brake lights illuminate on the Caravan and braked to a controlled stop in the travel lane. The 16 year old driver of the Jetta braked suddenly but failed to react in sufficient time to avoid the crash. The front of the vehicle pitched down in reaction to the sudden brake application and the front bumper of the Jetta impacted and then underrode the rear bumper of the Ford in a 12/6 o'clock impact configuration. The force of the impact deployed the SRS of the Jetta. The police investigation did not identify any skid marks associated with this crash.

Figure 3 is the left front view of the Volkswagen Jetta. The frontal area of the Jetta sustained no measurable deformation at the bumper elevation, indicative of the underride. The direct contact damage to the bumper fascia consisted of a series of scrapes and scratches distributed over a 124 cm (49 in) width of the fascia's frontal and top surfaces. The scrapes began 46 cm (18 in) left of center and extended to the left bumper corner. The front surface of the fascia was penetrated by the tail pipe of the Ford's exhaust system 23 cm (9 in) right of center. There was no damage to the bumper's mounting structures. The deformation at the elevation of the Jetta's upper radiator support was 112 cm (44 in) in width. The upper support direct contact began 33 cm (13 in) right of center and extended to the left front corner. The crush profile of the upper radiator support was as follows (less assumed free space): C1=12.7 cm (5.0 in), C2=5.1 cm (2.0 in), C3=5.1 cm (2.0 in), C4=5.1 cm (2.0 in), C5=5.1 cm (2.0 in), C6=0. The hood deformed rearward in the typical V pattern and the left front fender was buckled. The left front fender also shifted rearward (slightly) restricting the opening of the left front door. There was no measurable change in the wheelbase dimensions. There was no damage to the windshield nor to any windows glazings. The Collision Deformation Classification (CDC) of the Jetta was 12-FDEW-1. The delta V of the Jetta calculated by the Roldmiss model of the SMASH program was 18.7 km/h (11.6 mph).

Figure 3: Left front view of the Volkswagen Jetta.

The CDC of the 1995 Ford Crown Victoria was 06-BDEW-1. The direct contact damage to the vehicle consisted of abrasions on the vertical surface of the rear bumper fascia (**Figure 4**). The direct contact measured 124 cm (49 in) in width, that began 38 cm (15 in) left of center and extended to the right rear bumper corner. There was no residual bumper deformation. The rear bumper of the Ford was mounted to the vehicle's frame by energy absorbing devices (EAD's). Both EAD's showed signs of having compressed during the impact but had returned to their original length through full restitution. The maximum allowable stroke was 3.6 cm (1.4 in). The left and right struts had compressed 1.1 cm (0.4 in) and

Figure 4: Rear view of the Ford Crown Victoria.

3.6 cm (1.4 in) respectively. The tail pipe and rear exhaust pipe were deformed forward due to the contact with the Jetta's front bumper fascia.
The 10 year old female passenger of the Jetta had a reported height/weight of 142 cm (56 in) and 34 kg (75 lb). She was seated unrestrained with a normal posture. The right front seat was adjusted in a mid to forward track position. Upon application of the Jetta's brakes, the child passenger initiated a forward trajectory with respect to the vehicle. She probably attempted to brace herself with her right hand. This action was identified by a skin oil smear located on the right center aspect of the windshield. At impact and subsequent underride, the child passenger responded to the 12 o'clock direction of the impact forces and pitching of the vehicle by moving further forward and became positioned in close proximity to the front passenger mid-mount air bag module. The deployment of the SRS occurred late in the collision sequence, subsequent to the underride, during maximum vehicular engagement between the Jetta's upper radiator support and the Ford's rear bumper. The front passenger air bag deployed contacting and abrading the anterior aspect of the child's neck. The air bag membrane then expanded around the neck and under the chin causing multiple abrasions and contusions through the region. The continued expansion of the air bag hyper-extended the head resulting in a fracture of the cervical spine at C1/C2 with spinal cord transection, (AIS 6). The child then rebounded rearward into the right front seat and slumped to the left, into the driver's lap.

The crash occurred in front of a medical clinic and post office. The child was removed from the left side of the vehicle by witnesses responding to the crash from the post office. Medical personnel responded immediately from the clinic and applied a cervical collar to the child. The child was noted to be in immediate respiratory arrest and resuscitation was initiated. She was transported to the emergency room of a level 1 trauma center where she was pronounced deceased. The severity of the injury indicated that death was immediate. An autopsy was performed the day following the crash at 1700 hours.

The 16 year old driver of the Jetta reportedly had a height/weight of 168 cm (66 in) and 57 kg (125 lb). She was seated unrestrained in a normal posture with the seat adjusted to a mid-track position. Reportedly, she sustained AIS 1 level injuries that included: abrasions to the anterior aspects of her wrists, an unspecified hairline fracture above the left wrist and abrasions about the face, all as a result of contact with the deploying driver air bag.

The Volkswagen Jetta came to rest approximately at the point of impact. The force of the impact displaced the Ford Crown Victoria forward approximately 1 m (3 ft) where it impacted the rear of the stopped Dodge Caravan. This secondary impact was very minor and resulted in no damage. The Dodge Caravan and Ford Crown Victoria were removed from the scene by their respective drivers. The Volkswagen Jetta was towed from the scene and impounded pending the investigation.

AIR BAG VEHICLE

The 1995 Volkswagen Jetta GLS 4-door sedan was identified by a Vehicle Identification Number (VIN) of 3VWSC81H4SM (production sequence deleted). The vehicle was equipped with a Supplemental Restraint System (SRS) that consisted of driver and front passenger air bags that deployed as a result of the crash. The power train consisted of a 2.0 liter, I-4 engine linked to a 4-speed automatic transmission. The odometer read 55,526 km (34,503 miles) at the time of inspection.

AIR BAG VEHICLE (CONT'D)

The vehicle's front seating positions were cloth covered bucket seats with reclining back rests. The investigating officer verified that the seat track positions had not been disturbed from the at-crash positions. The track position of the left front seat measured 10.9 cm (4.3 in) rear of the most forward position. The total seat track travel measured 23.6 cm (9.3 in). The seat back was reclined 35 degrees and the anti-submarine angle of the seat cushion was 20 degrees. The track position of the right front seat measured 8.9 cm (3.5 in) rear of the most forward position, with a total travel of 23.6 cm (9.3 in). The seat back was reclined 30 degrees and the anti-submarine angle of the seat cushion was 20 degrees. The horizontal measurement from the center of the right front seat back to the inflator of the front passenger air bag module was 89 cm (35 in).

INTERIOR DAMAGE

Interior damage to the Volkswagen Jetta consisted of localized areas of scuff marks as a result of occupant interaction. There was no interior damage caused by the external forces of the crash. The windshield was not fractured and the window glazings were undamaged.

A single scuff was noted on the padded driver's knee bolster as a result of contact from the driver's left knee. The contact was located on the bolster panel 54.1 cm (21.3 in) left of center and 33 cm (13 in) above the floor. A contact scuff was noted on the center aspect of the instrument panel, forward and right of the steering column. The scuff mark was located 19.1 cm (7.5 in) left of center and 19.1 cm (7.5 in) below the top of the instrument panel. The scuff was attributed to contact from the driver's right hand. These contacts did not result in injury.

A 19.1 cm x 25.0 cm (7.5 in x 10.0 in) area of smeared skin oil was noted on the right center aspect of the windshield (**Figure 5**). The area was located 27.9 cm to 47.0 cm (11.0 in to 18.5 in) right of center and extended 17.3 cm to 42.7 cm (6.8 in to 16.8 in) below the windshield header. This contact was attributed to at-impact bracing by the right hand of the child occupant. **Figure 6** is a view of the right front interior contacts. The lower flap of the front passenger air bag module exhibited a (1.0 in x 0.5 in) scuff attributed to contact with the right upper extremity of the child occupant. This scuff was located 26.2 cm (10.3 in) right of the inboard edge of the flap and 54.6 cm (21.5 in) above the floor. The padded right side knee bolster exhibited two scuffs attributed to contact from the child passenger's lower extremities. The two scuffs were located 17.8 cm (7.0 in) right of center and 36.8 cm (14.5 in) above the floor and 38.9cm (15.3 in) right of center and 45.7 cm (18 in) above the floor respectively.

Figure 5: Location of the windshield contact.

Figure 6: Right front interior contacts.

MANUAL RESTRAINT SYSTEM

The Volkswagen Jetta was equipped with 3-point lap and shoulder belt systems in the 4 outboard seated positions. The center rear position was equipped with a lap belt. The front seat belt systems consisted of a continuous loop lap and shoulder belt webbing with a sliding latch plate. An inertia activated locking retractor was located in the base of each B-pillar. The restraint's upper anchorages (D-rings) were adjustable. The left front D-ring was adjusted to the full down position. The right front D-ring was adjusted 2 cm (0.8 in) below the full up position. Both front restraints were found in the stowed position at inspection. The respective retractors were not locked. The SCI investigation and the police investigation determined the occupants in the Jetta were unrestrained. The driver admitted the Jetta's occupants were unrestrained as well.

SUPPLEMENTAL RESTRAINT SYSTEM

The Volkswagen was equipped with a Supplemental Restraint System (SRS) that consisted of air bags for the driver and right front passenger. The SRS was manufactured by TRW Inc. The driver air bag module was located in the typical manner in the center hub of the tilt steering column. The steering column was adjusted to the full down position. There was no steering wheel rim deformation or movement of the steering column's shear capsules. The H-configuration air bag module flaps opened as designed at the designated tear points during the deployment sequence. The height of the upper flap measured 8.4 cm (3.3 in). The width of the upper flap measured 16.5 cm (6.5 in) at the center seam and tapered to 12.7 cm (5 in) at the hinge. The date 12/8/94 was written on the interior surface of the upper flap. The width of the lower flap measured 16.5 cm (6.5 in) and tapered to 16.0 cm (6.3 in) over its height of 6.4 cm (2.5 in).

Figure 7: Driver air bag.

The driver air bag measured 71 cm (28 in) in its deflated state, **Figure 7**. The air bag was tethered by four 6.4 cm (2.5 in) wide internal straps sewn to the face of the bag. The air bag was vented by two 3.8 cm (1.5 in) diameter vent ports located in the 10/2 o'clock sectors on the back side of the bag. The following manufacturer's label were fixed to the inflator in the 6 o'clock sector:

TRW Repa 0004 2067R
83454HR103

TRW Repa 0004 3081C
8947HT224

The only contact evidence on the driver air bag consisted of a flesh tone make-up transfer on the face of the bag. The transfer measured 3.3 cm x 1.3 cm (1.3 in x 0.5 in) and was located 3.3 cm (1.3 in) right of the center of the air bag.

SUPPLEMENTAL RESTRAINT SYSTEM (CONT'D)

The passenger air bag was configured as a mid-mount design located in the right instrument panel. The H-configuration air bag module cover flaps were constructed of vinyl backed by a high density foam that measured approximately 2 cm (0.8 in) in thickness. A vulcanized liner for each flap separated the interior surface of the respective cover flap from the air bag membrane. The rectangular cover flaps measured 36.8 cm (14.5 in) at the center seam. The height of the upper and lower flaps measured 7.6 cm (3.0 in) and 10.2 cm (4.0 in) respectively. There was no contact evidence on the upper flap. (Refer to the Interior Damage section above for the location of the upper extremity contact on the lower cover flap.) Two manufacturer's label were fixed to the front passenger module. The nomenclature follows below:

ALWTPA
ALWTPA02JAF1
35/94

AIRBAG - TYP 9002
TRW Repa 00041710/0004 9543
BAM - PT_1 - 0439

The front passenger air bag was untethered and unvented (no external vent port). The face of the air bag membrane measured 46 cm x 46 cm (18 in x 18 in) in its deflated state and extended 46 cm (18 in) from the inflator. The maximum rearward projection of the center aspect of the air bag face was 61 cm (24 in). A large tissue transfer was identified on the face of the bag. The transfer measured approximate 6.4 cm x 36.8 cm (2.5 in x 14.5 in), **Figures 8 and 9**. The transfer began 35.6 cm (14.0 in) rearward of the inflator (10 cm (4 in) forward of the bag face) and 23 cm (9 in) right of the inboard side panel, on the top surface of the air bag membrane. The transfer extended 26.7 cm (10.5 in) onto the face of the bag. The end of the transfer was located 11.4 cm (4.5 in) right of the inboard side panel. The tissue transfer was associated with the air bag membrane contact with the child occupant's neck and chin during the deployment sequence. On the bottom surface of the air bag membrane scattered faint black transfers were noted. These transfer were most likely caused by the friction heating between the membrane and the vulcanized liner during the altered air bag deployment.

Figure 8: View of the tissue transfer on the front passenger air bag.

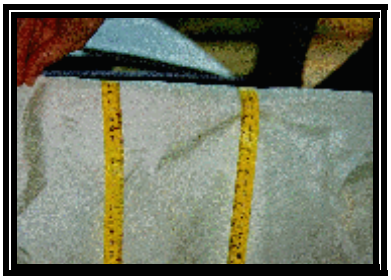

Figure 9: Close-up view of the tissue transfer.

DRIVER INJURIES

Injury	Injury Severity	Injury Mechanism
Abrasions - anterior aspects of right and left wrists	Minor (790202.1,1) Minor (790202.1,2)	Deploying driver air bag
Facial abrasions	Minor (290202.1,0)	Deploying driver air bag
Unspecified hairline fracture - left forearm	Minor (751800.2,2)	Deploying driver air bag

NOTE: this injury information was verbally supplied by the investigating officer.

DRIVER KINEMATICS

The 16 year old female driver of the Volkswagen Jetta had a reported height /weight of 168 cm (66 in) and 57 kg (125 lb). She was seated with a normal posture and was not restrained by the vehicle's manual lap and shoulder belt system. Her seat track was adjusted in a mid track position 10.9 cm (4.3 in) rear of full forward. Immediately preceding the crash, the driver suddenly applied the brakes in response to stopped traffic ahead. At impact, the vehicle's SRS deployed and the driver initiated a forward trajectory in response to the 12 o'clock direction of the impact forces. The deploying driver air bag contacted the anterior aspect of the driver's wrists and displaced them from the steering wheel rim. This contact caused the wrist abrasions and the hairline fracture of the left forearm. The driver's face and upper chest contacted the deployed driver air bag resulting in minor facial abrasions. The driver then rebounded back into the left front seat where she came to rest.

CHILD OCCUPANT INJURIES

Injury	Injury Severity	Injury Mechanism
Cervical fracture C1 and C2 with proximal spinal cord transection	Maximum (640276.6,6)	Deploying front passenger air bag
30 cc sub-dural hemorrhage	Critical (140446.5,6)	Deploying front passenger air bag
Bilateral lung contusions perihilar areas (up to 1.5 cm individually)	Severe (441410.4,3)	Deploying front passenger air bag
Diffuse sub-arachnoid hemorrhage in cerebellar hemisphere	Serious (140466.3,6)	Deploying front passenger air bag
Diffuse sub-arachnoid hemorrhage in right & left cerebral hemispheres	Serious (140684.3,1) Serious (140684.3,2)	Deploying front passenger air bag

CHILD OCCUPANT INJURIES (CONT'D)

Injury	Injury Severity	Injury Mechanism
Contusions of the true & false vocal cords (up to 0.8 cm)	Moderate (341899.2,5)	Deploying front passenger air bag
Fractures of right 1st rib and left 1st rib	Moderate (450220.2,3)	Deploying front passenger air bag
Lacerations of the right and left jugular veins	Minor (320602.1,1) Minor (320602.1,2)	Deploying front passenger air bag
Multiple contusions to the upper and lower lips	Minor (290402.1,8)	Deploying front passenger air bag
Contusions - base of the tongue	Minor (243099.1,8)	Deploying front passenger air bag
7 cm superficial linear abrasion right lateral chin to right anterior cheek	Minor (290202.1,1)	Deploying front passenger air bag
Abrasions inferior chin	Minor (290202.1,8)	Deploying front passenger air bag
20 cm anterior neck abrasion; 15 cm linear pattern anterior neck abrasion	Minor (390202.1,5)	Deploying front passenger air bag
3 cm contusion right anterior temple of scalp	Minor (190402.1,1)	Rebound contact/seat back
5 cm contusion right anterior thigh; 2 cm contusion right distal shin; 4 cm contusion right superior shin; 4 cm contusion left mid anterior thigh; 3 cm contusion left mid shin	Minor (890402.1,3)	Right side knee bolster contact

NOTE: injury information is obtained from the autopsy report.

CHILD OCCUPANT KINEMATICS

The 10 year old child passenger had a reported height/weight of 142 cm (56 in) and 34 kg (75 lb). She was seated unrestrained in the right front seat of the vehicle with a reported normal posture. The ***CHILD***

OCCUPANT KINEMATICS (CONT'D)

seat was adjusted in a mid to forward track position, measured as 8.9 cm (3.5 in) rear of the full forward. Upon the sudden application of the brakes, the child initiated a forward trajectory in response to the sudden deceleration and the downward pitching of the vehicle.. The child probably attempted to brace herself by out-stretching her right arm/hand evidenced by the windshield/skin oil transfer. The front bumper of the Jetta impacted and then underrode the rear bumper of the Ford.

The deployment of the Jetta's SRS occurred due to the impact between the Ford's rear bumper and the Jetta's upper radiator support. Relative to the occupant, this delayed the air bag deployment to a point late in the collision sequence allowing the child to become positioned in the path of the air bag deployment, directly in front of the mid-mount module. The air bag deployed and contacted and abraded the anterior aspect of the child neck. The air bag expanded around the child's neck and up onto the chin causing the large abraded region, that extended from ear to ear. The continued expansion of the air bag hyper-extended the head causing a cervical fracture at C1/C2 with spinal cord transection. A broken chain and pendant was found in right rear seat. The jewelry was displaced from the child by the air bag deployment. An imprint of the chain was evident on the left aspect of the neck. The position of the imprint is significant in that it is an indicator of the upward direction of the air bag's expansion. The child then rebounded back into the seat due to the air bag contact and slumped to the left, onto the driver's lap.