TRANSPORTATION SCIENCES
Crash Data Research Center

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VERIDIAN ON-SITE AIR BAG RELATED CHILD PASSENGER FATALITY INVESTIGATION
VERIDIAN CASE NO. CA99-046
VEHICLE: 1996 VOLKSWAGEN GOLF GL
LOCATION: VIRGINIA
CRASH DATE: SEPTEMBER 1999

Contract No.
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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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15. *Supplementary Notes* On-site investigation of an air bag deployment crash that resulted in the death of a 7 year old female front right passenger.			
16. *Abstract* This on-site investigation focused on the injury mechanisms and the cause of death of a 7 year old female front right passenger of a 1996 Volkswagen Golf. The Volkswagen was equipped with frontal air bags for the driver and passenger positions which deployed as a result of an intersection type crash with a 1996 Buick Roadmaster. The child passenger was not wearing the manual 3-point lap and shoulder belt system. She initiated a forward trajectory in response to the pre-crash braking and was within a close proximity to the front right passenger air bag as it deployed from the mid instrument panel. The air bag module cover flap and the expanding air bag membrane contacted the child under the chin which resulted in extensive abrasions and contusions of the anterior neck, chin, and upper chest which extended ear-to-ear and to the level of the sternum. A large tissue transfer was noted to the top panel and face of the front right air bag. The continued expansion of the air bag hyper-extended the neck that resulted in an atlanto-occipital dislocation and complete transection of the spinal cord. The child was transported to a local trauma center where she expired 1 hour and 13 minutes following the crash. The 32 year old female driver of the Volkswagen sustained an arm abrasion from driver air bag expansion. A 2 year old center rear female passenger of the Golf was restrained in a forward facing booster seat and was not injured.			
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VERIDIAN CASE NO. CA99-046
VEHICLE: 1996 VOLKSWAGEN GOLF GL
LOCATION: VIRGINIA
CRASH DATE: SEPTEMBER 1999

BACKGROUND

This on-site investigation focused on the injury mechanisms and the cause of death of a 7 year old female front right passenger of a 1996 Volkswagen Golf. The Volkswagen was equipped with frontal air bags for the driver and passenger positions which deployed as a result of an intersection type crash with a 1996 Buick Roadmaster **(Figure 1)**. The child passenger was not wearing the manual 3-point lap and shoulder belt system. She initiated a forward trajectory in response to the pre-crash braking and was within a close proximity to the front right passenger air bag as it deployed from the mid instrument panel. The air bag module cover flap and the expanding air bag membrane contacted the child under the chin which resulted in extensive abrasions and contusions of the anterior neck, chin, and upper chest which extended ear-to-ear and to the level of the sternum. A large tissue transfer was noted to the top panel and face of the front right air bag. The continued expansion of the air bag hyper-extended the neck that resulted in an atlanto-occipital dislocation and complete transection of the spinal cord. The child was transported to a local trauma center where she expired on-arrival. The 32 year old female driver of the Volkswagen sustained an arm abrasion from driver air bag expansion. A 2 year old center rear female passenger of the Golf was restrained in a forward facing booster seat and was not injured.

Figure 1. Overall on-site view of the crash scene.

SUMMARY

Crash Site

The crash occurred at a three-leg intersection of a minor arterial roadway and an on/off- ramp system for an interstate roadway. Located opposite of the on/off-ramp system was a wide driveway that provided access to a county facility. The minor arterial roadway consisted of four travel lanes in each direction with designated left turn lanes. The eastbound lanes were divided by a painted flush median while the westbound travel lanes were divided by a curbed median. The roadway curved to the left and have a positive grade of 2 percent for westbound traffic flow. Paved shoulders bordered both road edges. There were no traffic controls for east/westbound traffic flow through the intersection. The posted speed limit was 64 km/h (35 mph). The Crash Schematic is attached as **Figure 13**, Page 15.

Vehicle Data - 1996 Volkswagen Golf

The subject vehicle was a 1996 Volkswagen Golf GL, 4-door hatchback. The vehicle was identified by vehicle identification number 3VWFA81H4TM (production number deleted) with a manufacture date of 10/95. The front-wheel drive Golf was equipped with a 2.0 liter gasoline engine linked to a five-speed

manual transmission with a floor mounted shifter. The interior was a five passenger configuration with front bucket seats and a rear bench with split folding backs. The front bucket seats had manual track adjusters with reclining seat back supports and adjustable head restraints. The four outboard seated positions were equipped with 3-point lap and shoulder belt systems. A center rear lap belt was also available. Supplemental restraint was provided to the front seated positions with frontal air bags and seat belt pretensioners. The frontal air bags and the right pretensioner deployed as a result of the crash.

1996 Buick Roadmaster

The 1996 Buick Roadmaster was a full-size, four-door, rear wheel drive platform that was equipped with a 5.7 liter V-8 engine linked to a four-speed automatic overdrive transmission. The interior was configured with a split bench front seat and a fixed rear bench seat forming a six-passenger seating platform. The Buick was equipped with frontal air bags for the driver and front right passenger positions. The frontal air bags did not deploy during the right side impact crash sequence.

Crash Sequence

Pre-Crash

The crash occurred at a signalized intersection of a major arterial and an on-ramp for an interstate roadway during morning rush hour traffic. The 32 year old female driver of the Volkswagen Golf was transporting her daughter to a local elementary school. The child was positioned in the front right of the vehicle. A two year old female was secured in a forward facing Century Breverra booster seat in the center rear of the Golf. It should be noted that both front seat occupants of the Volkswagen Golf were not wearing the manual belt systems. Although en route to school, the child passenger was not wearing a backpack while seated in the vehicle.

The driver of the Volkswagen Golf was traveling in an westerly direction on the inboard travel lane at an estimated speed of 72 km/h (45 mph). As she approached the intersection, the driver maintained speed to continue westbound.

The driver of the 1996 Buick Roadmaster was traveling in an easterly direction on the arterial roadway on an approach to the intersection with the interstate ramps. The driver decelerated to prepare for a left turn onto the southbound on-ramp. The 63 year old male driver of the Buick either attempted to beat the Volkswagen across the intersection or failed to detect the vehicle as he initiated the left turn across the Golf's path of travel.

The Volkswagen driver detected the Buick as it turned across its path of travel. She braked with sufficient force to lock the front wheels of the Golf as it skidded on the worn asphalt surface to impact **(Figure 2)**. The investigating officer documented front wheel skid marks of 14 m (46') for the left tire and 19.2 m (63.0') for the right front tire. This

Figure 2. Trajectory and final rest of Volkswagen.

pre-crash braking resulted in an equivalent velocity loss due to braking of 60.5 km/h (37.6 mph). There were no avoidance actions initiated by the Buick driver.

Crash

The front center and right area of the Golf impacted the right passenger compartment area of the Buick. Impact speeds were computed by the damage and trajectory algorithm of the WinSMASH at 39.7 km/h (24.6 mph) for the Volkswagen and 37.7 km/h (23.4 mph) for the struck Buick. The resultant directions of force were 11 o'clock for the Golf and within the 2 o'clock sector for the struck Buick with corresponding Collision Deformation Classifications (CDCs) of 11-FZEW-2 and 02-RPEW-3. Velocity changes were computed by the WinSMASH program at 23.9 km/h (14.8 mph) for the Golf and 14.7 km/h (9.1 mph) for the struck Buick. The specific longitudinal and lateral components were -23.1 km/h (-14.4 mph) and 6.1 km/h (3.8 mph) for the Volkswagen and -6.9 km/h (-4.3 mph) and -12.5 (-7.7 mph) for the Buick Roadmaster. The longitudinal component was sufficient to trigger the deployment of the Golf's frontal air bag systems and the front right emergency tensioning retractor (pretensioner).

The Volkswagen Golf continued approximately 3 m (10') forward from its at impact position and rotated approximately 40 degrees in a clockwise direction before coming to rest diagonally across the inboard westbound travel lane. The Buick was deflected in a clockwise direction across the westbound travel lanes toward the curbed median for the interstate ramp system. The left rear quarter panel area of the Buick impacted and fractured a 10x10 cm (4x4") sign post. The vehicle probably came to rest in the vicinity of the sign post impact, however, it this position, the vehicle would have been blocking the on-ramp. The driver drove the vehicle forward to a shoulder area where he waited for emergency assistance.

Post-Crash

Both driver's exited their respective vehicles unassisted. A passing motorist stopped at the crash site and assisted the driver of the Volkswagen in removing the injured front right child passenger from the vehicle. This person administered CPR activities until the local professional fire department personnel arrived on-scene. The child was transported by ambulance to a local trauma center where she expired approximately 1 hour and 13 minutes following the crash. The involved vehicles sustained disabling damage and were towed to the police impound lot where they were held for the SCI inspection.

Vehicle Damage

Volkswagen Golf - Exterior

The 1996 Volkswagen Golf sustained moderate frontal damage as a result of its intersection crash with the 1996 Buick Roadmaster. The direct contact damage on the bumper fascia began 18.4 cm (7.25") left of center and extended 93.3 cm (36.75") to the right bumper corner **(Figure 3)**. The off-set frontal damage pattern displaced the full width of the frontal structure resulting in a combined induced and direct contact damage length (Field L) of 143.8 cm (56.6"). Maximum crush was 30.5 cm (12.0") located at the right corner of the front bumper. A crush profile was documented at bumper level **(Figure 4)** and was as follows: C1 = 2.2 cm (0.875"), C2 = 3.2 cm (1.25"), C3 = 11.1 cm (4.375"), C4 = 11.7 cm (4.6'), C5 = 16.5 cm (6.5"), C6 = 30.5 cm (12.0").

The damage pattern resulted from an 11 o'clock impact force with a Collision Deformation Classification (CDC) of 11-FZEW-2. The undeformed end width of the frontal plane was 146.1 cm (57.5"). The baseline dimension (base of windshield to front bumper) was 106.7 cm (42.0"). The left wheelbase was not deformed, however, the right wheelbase was reduced in length by 1.7 cm (0.7").

Figure 3. Frontal damage pattern to the Volkswagen Golf.

Figure 4. Profile view documenting the extent of crush.

Interior - Volkswagen Golf

The interior damage to the Volkswagen Golf was rated as minor and was associated with deployment of the frontal air bag system and occupant contact. There was no intrusion or damage related to exterior deformation.

The unrestrained front right child passenger was displaced forward by the pre-crash braking and was in close proximity to the mid mount front right air bag at deployment. The upper cover flap and the air bag membrane exhibited tissue transfers that are discussed in detail in the Supplemental Restraint System heading of this report.

The child passenger impacted the right door panel, separating the adjustment knob for the outside rear view mirror and displacing the stem for the knob. The interior mounted rear view mirror was separated from the windshield mount from probable expansion of the front right passenger air bag. There was no damage to the mirror glass.

Exterior - Buick Roadmaster

The right passenger compartment area of the 1996 Buick Roadmaster was impacted by the frontal area of the Volkswagen. The direct contact damage began 10.2 cm (4.0") forward of the right rear axle position and extended 168.9 cm (66.5") forward to the mid point of the right front door. The induced damage (Field L) began on the right rear quarter panel 22.9 cm (9.0") rearward of the referenced axle position and extended 267.0 cm (105.1") forward to the leading edge of the right front door. Maximum crush was 22.2 cm (8.75") located 21.6 cm (8.5") rearward of the right B-pillar. The crush profile

Figure 5. Right side damage to the Buick Roadmaster.

documented at mid door level **(Figure 5)** at six equidistant points along the Field L was as follows: C1 = 0 cm , C2 = 7.9 cm (3.1"), C3 = 21.6 cm (8.5"), C4 = 20.0 cm (7.875"), C5 = 9.5 cm (3.75"), C6 = 0 cm . The CDC for this impact was 02-RPEW-3.

The Buick rotated in a clockwise direction as a result of the initial right side impact. The left rear quarter panel area impacted an apparent sign post which resulted in approximately 12.7 cm (5.0") of crush to the rear aspect of the quarter panel. The lateral impact resulted in a CDC of 09-LBEN-2.

Manual Restraint Systems - Volkswagen Golf

The Volkswagen Golf was equipped with 3-point lap and shoulder belt systems for the four outboard seated positions and a center rear lap belt. The front manual belt systems consisted of a continuous loop webbing with a sliding latchplate and adjustable upper anchorages (D-rings). The webbings retracted onto a dual mode locking retractor that was located in the lower aspect of the B-pillars. The outboard lower anchorage was affixed to the sill of the vehicle. Both front belt systems yielded evidence of occasional usage (i.e., wear marks on the latchplate and webbings), however, these systems were not worn at the time of the crash. In addition, the front belt systems were equipped with pyrotechnic emergency tensioning retractors (ETRs). The ETRs are discussed in detail in the Automatic Restraint System section of this report.

The rear seat was equipped with 3-point lap and shoulder belts systems in the outboard positions and a 2-point lap belt for the center position. The outboard belts consisted of a continuous loop webbing with a sliding latchplate and a fixed D-ring. The webbings retracted onto an emergency locking retractor that was switchable to a locking retractor for use with child safety seats. The left rear latchplate yielded superficial routine usage wear marks and was neatly stowed against the left C-pillar. There was no occupant in this position at the time of the crash.

The center lap belt was a fixed length adjustable system that secured a forward facing child booster seat. Although the webbing was properly routed through the restraint's belt path, the adjustment of the belt was loose resulting in 11.4 cm (4.5") of forward excursion (in the static mode) of the booster seat. There was no loading evidence on the lap belt system, however, the plastic shell of the booster seat was abraded from belt loading at the belt path points.

The right rear belt webbing was fully extended from the retractor and folded over in the D-ring which prevented the belt from retracting. The spooled out webbing was tucked behind the rear folding seat back support. Again, this position was not occupied at the time of the crash.

Supplemental Restraint System (Volkswagen Golf)

The 1996 Volkswagen Golf was equipped with a Supplemental Restraint System that consisted of frontal air bags for the driver and front right passenger positions and front seat belt pretensioners. The frontal air bags and the front right belt system pretensioner deployed as a result of the crash with the Buick Roadmaster.

The driver air bag deployed from a typical mount within a four spoke steering wheel rim with the spokes located at the 3/9 and 5/7 o'clock positions. The air bag unit was concealed within an H-configuration module cover with symmetrical cover flaps. The upper flap was 7.0 cm (2.75") in height while the lower flap was 6.4 cm (2.5"). The width of both flaps at the horizontal tear seam was 16.8 cm (6.6"). The flaps were hinged with rigid sheet metal hinges that resulted in the flaps remaining fully opened against the wheel rim post-crash. **Figure 6** is a profile view of the deployed front left air bag.

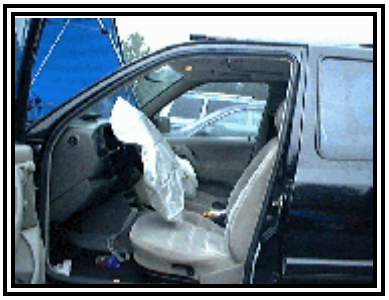

Figure 6. Overall view of the driver's seated position and the deployed front left air bag.

The driver air bag was vented by two 3.2 cm (1.25") diameter ports located at the 10 and 2 o'clock positions, centered 7.0 cm (2.75") forward of the internally sewn peripheral seam. The bag measured 67.3 cm (26.5") in diameter in its deflated state and was tethered internally by four straps sewn to the face of the bag with a 8.9 cm (3.5") diameter reinforcement. In addition to the internal tethers, the two panels of the bag were sewn together at the 6 o'clock sector. This stitching separated during deployment which probably controlled the deployment path and expansion of the bag. The two rows of stitching were 19.1 cm (7.5") in length and at the mid point, located 14.0 cm (5.5") above the peripheral seam. This stitch pattern was similar to an energy management loop on a seat belt webbing. There was no driver contact evidence (i.e., make-up, tissues transfers) on the deployed driver air bag.

The front right passenger air bag deployed from a mid instrument panel mounted module assembly **(Figure 7)**. The module was configured with H-configuration cover flaps that opened horizontally. The flaps were constructed of the vinyl outer skin with a rigid foam backer panel. The maximum thickness of the flaps was 2.5 cm (1.0"). The upper flap measured 7.3 cm (2.9") in height while the lower flap was 9.5 cm (3.75"). Both flaps had a maximum width of 37.1 cm (14.6") at the center tear seam. The upper flap contained several small tissue fragments at the mid point which extended 4.6 cm (1.8") above the tear seam **(Figure 8)**. The tissue fragments resulted from contact against the chin of the child passenger. The upper flap contained a label with the following identification:

ALWTPA
ALWTPA062AHX
5/95

The lower cover flap contained a yellow label which identified the following production data:

BEIFAHER-AIRBAG-MODUL
90002 BAM PT-0439
HERSTELLER TRW REPA ALFDORF
TEL 07172/30 20
HERSTELLUNGS-JAHR 1995

Figure 7. View of the deployed front right passenger air bag.

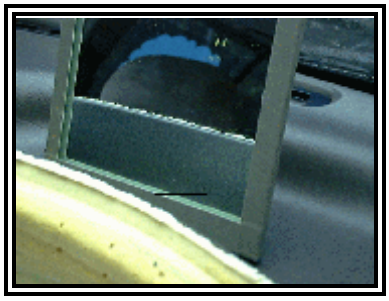

Figure 8. Small tissue fragments on the face of the upper module cover flap.

The front right passenger air bag membrane deployed from the mid mount module assembly. The module mounting bracket was setback 5.1 cm (2.0") inboard of the face of the mid instrument panel while the inflator manifold was recessed 12.7 cm (5.0") forward of the mid panel. The bag membrane was rectangular in shape with a vertical measurement of 71.1 cm (28.0") and a horizontal width of 47.0 cm (18.5"). In its deflated state, the face of the bag protruded 33.0 cm (13.0") rearward of the mid panel. There were no internal tethers or vent ports. Venting of the deployment gases was achieved by porous side panels.

Front right occupant contact evidence to the air bag system consisted of a tissue transfer to the mid point of the upper module cover flap and a large tissue transfer to the bag membrane. The vertically oriented flap transfer was located 17.5-19.1 cm (6.9-7.5") left of the right edge of the cover flap and extended 4.6 cm (1.8") above the horizontal tear seam.

A large vertically oriented tissue transfer originated on the top panel of the passenger air bag membrane and extended onto the face of the bag as the membrane expanded against the child passenger. The transfer began on the top panel, 17.8 cm (7.0") forward of the bag face and 17.8-20.3 cm (7.0-8.0") left of the right side seam. The transfer continued across the upper apex of the bag onto the face of the membrane **(Figure 9)**. At the apex, the transfer was 14.0 cm (5.5") in width and tapered to 5.1 cm (2.0") in width at its termination point which was located 20.3 cm (8.0") below the referenced apex point. It should be noted that larger fragments of tissue were scattered throughout this area with a vertical streaking of the transfers **(Figure 10)**. There was no tearing or other damage to the bag membrane.

Figure 9. Vertically oriented tissue transfer on the front right air bag.

Figure 10. Close-up view of the tissue transfer.

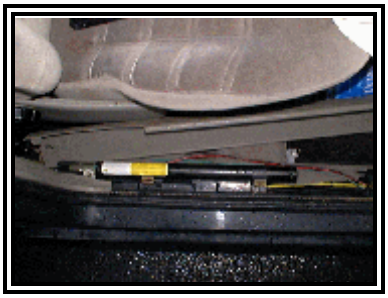

Figure 11. Front right pretensioner.

In addition to the frontal air bags, the Supplemental Restraint System (SRS) utilized pyrotechnic emergency tensioning retractor seat belt systems (retractor pretensioners) to spool-up belt slack in the front seat manual belt systems. The pretensioners were mounted horizontally to the sills of the vehicle and concealed by the plastic sill covers **(Figure 11)**. The units were mechanical systems that operated independently of the frontal air bags and of each other. That is, the unit's sensor mass would detect a frontal impact force of sufficient velocity to deploy the gas generator which drives an internal piston, thus providing a pull force to the tensioning cable that is affixed to the belt retractor mechanism. There was no electrical wiring associated with these pretensioner units.

In this off-set front right crash, the right passenger pretensioner detected a sufficient frontal pulse to deploy the pyrotechnical device while the off–side (from the impact) driver unit did not deploy. Although the front right passenger was not wearing the manual belt system, the pretensioner fired and spooled the belt taut against the right B-pillar and locked the retractor in this position. The front left belt system (also not worn) remained in its pre-crash state which allowed the retractor to spool-out and retract the shoulder belt webbing.

A Volkswagen representative noted that a "tell-tail" sign of pretensioner deployment involved a physical inspection of the forward end cap on the unit's tube. If the plastic end cap is separated/displaced from the tube, then the system deployed. This end cap had separated from the front right unit while the cap remained intact within the tube of the front left unit.

Child Safety Seat

The center rear position of the Volkswagen Golf was occupied by a 2 year old female passenger seated in a forward facing child booster seat. The booster seat was a Century Breverra Classic equipped with a 5-point integral harness. The booster seat was identified by Model No. 4865RCK and was manufactured on July 7, 1998. The forward facing booster seat was restrained in the vehicle by the center fixed length adjustable lap belt. The lap belt was routed through the proper belt path in the shell of the seat, however, the belt was loosely adjusted. At the time of our SCI inspection of the vehicle which occurred

on the day following the crash, there was 11.4 cm (4.5") of forward excursion of the booster seat, measured between the seat back support and the rear shell of the seat.

A terry-cloth towel was folded and placed behind the padding of the booster seat in an attempt to provide a better fit of the child passenger in the restraint. The child was restrained within the booster seat by the integral 5-point harness system. The position and specific fit of the harness on the child was unknown. There was no loading evidence on the integral harness or system components. The molded belt path of the booster seat shell was abraded from loading against the lap belt. Both lateral surfaces of the belt path exhibited this abrasion pattern.

Driver Demographics - Volkswagen Golf

Age/Sex:	32 year old female
Height:	168 cm (66")
Weight:	73 kg (160 lb)
Manual Restraint Usage:	None
Usage Source:	Vehicle inspection
Eyeware:	None
Mode of Transport From Scene:	Ambulance, accompanied daughter to a local hospital
Type of Medical Treatment:	None

Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanism
Right anterior forearm abrasion	Minor (790202.1,1)	Deploying front left air bag membrane

Driver Kinematics

The driver of the Volkswagen Golf was a 32 year old female with a height of 168 cm (66") and weight of 73 kg (160 lb). She was seated in a mid track position and was not restrained by the manual belt system. Although the driver initially told the investigating officer that she and her daughter were restrained, the vehicle evidence did not support restraint usage. The driver's belt system was stowed against the B-pillar with no evidence of loading to the system components. The front left ETR did not fire as a result of the off-set frontal crash, therefore the webbing extended and retracted onto the emergency locking retractor. At impact, the driver initiated a forward trajectory and loaded the deployed front left air bag which protected her from contact against the steering assembly. There was no loading evidence on the bag or displacement of the steering assembly. The expanding air bag did produced a soft tissue abrasion to the driver's anterior right arm.

Front Right Child Passenger Demographics

Age/Sex:	7 year old female
Height:	127 cm (50")
Weight:	41.7 kg (90.5 lb)
Manual Restraint Usage:	None
Usage Source:	Vehicle inspection, injury pattern
Eyeware:	None
Mode of Transport From Scene:	Ambulance
Type of Medical Treatment:	Transported to a local trauma center where she expired within one hour of arrival

Front Right Child Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Complete transection of the spinal cord	Maximum (640276.6,6)	Expanding front right passenger air bag membrane
Traumatic fracture/dislocation of the atlanto-occipital joint with wide separation and associated hemorrhages of the superior aspect of the falciform ligament, focal hemorrhages of the thymus, and hemorrhage in the soft tissue overlying the bodies of the cervical vertebrae	Moderate (650208.2,6)	Expanding front right passenger air bag membrane

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
Large continuous area of abrasion and contusion to the underside of the chin, anterior neck, and upper chest as follows:		
8x2" abrasion of the under side of the chin	Minor (290202.1,0)	Expanding front right passenger air bag membrane
5x2" purple blue contusion of the anterior neck	Minor (390402.1,5)	Front right air bag module cover flap
3.5x1.5" reddish abrasion of the anterior neck	Minor (390202.1,5)	Expanding front right passenger air bag membrane
Upper chest abrasion with contusion	Minor (490202.1,4 490402.1,4)	Expanding front right passenger air bag membrane
1.5x1" purple contusion of the left face over the mandible	Minor (290402.1,2)	Upper air bag module cover flap
1x0.25" abrasion of the left ear (pinna)	Minor (290202.1,2)	Expanding front right passenger air bag membrane
2x2" pulmonary contusion of the left upper lobe with hemothorax	Serious (441406.3,2)	Expanding front right passenger air bag membrane
Hemorrhage (contusion) in the left pertrous portion of the temporal bone	Severe (140629.4,2)	Unknown, probable rebound into the seat back support (no contact evidence to support injury mechanism)
Left mandibular ramus fracture	Minor (250606.1,2)	Front right air bag module cover flap

Injury	Injury Severity (AIS 90/Update 98)	Injury Mechanisms
2x2" subgaleal hemorrhage over the right posterior region of the scalp	Minor (190402.1,1)	Unknown, probable rebound into the seat back support (no contact evidence to support injury mechanism)
Hemorrhage in the superior esophageal wall contiguous with perivertebral hemorrhage	Moderate (440899.2,4)	Expanding front right passenger air bag membrane
Subarachnoid hemorrhage over the cerebellum at the posterior and parietal lobes	Serious (140466.3,6)	Unknown, probable rebound into the seat back support (no contact evidence to support injury mechanism)
Cerebral edema with flattened gyri	Serious (140660.3,9)	Unknown, probable rebound into the seat back support (no contact evidence to support injury mechanism)
0.5x0.75" abrasions of the knuckles of the right 2-4 digits	Minor (790202.1,1)	Probable fling injury into the right door panel or Upper A-pillar
1.5x1.5" contusion of the right dorsal wrist	Minor (790402.1,1)	Probable fling injury into the right door panel or Upper A-pillar
1x1" contusion of the dorsal right mid forearm	Minor (790402.1,1)	Probable fling injury into the right door panel or Upper A-pillar
0.75x0.75" abrasion of the right elbow	Minor (790202.1,1)	Right door mounted mirror control knob
3x2" contusion of the right elbow	Minor (790402.1,1)	Right door mounted mirror control knob
Purple contusion of the right lower leg	Minor (890402.1,1)	Lower right instrument panel

Front Right Child Passenger Kinematics

The front right child passenger was 127 cm (50") in height with a weight of 41.7 kg (90.5 lb). She was wearing a print dress and was seated with the manually adjusted seat positioned to a mid track position. The seat back support was adjusted to a recline angle of 30 degrees, aft of vertical. The unrestrained child passenger was displaced in a forward direction as a result of the pre-crash braking. This action probably resulted in her sliding forward on the fabric seat cushion and pitching forward at the waist, placing her head within a close proximity to the mid mount front right air bag module. The lack of restraint use was determined by her trajectories (both pre- and crash related), contact evidence within the vehicle, and the lack of evidence on the manual belt system. The ETR for this belt system fired as a result of the crash which spooled the belt webbing taut against the right B-pillar, in its stowed and unused posiiton.

At impact with the Buick, the Golf's frontal air bag system deployed. The upper module cover flap contacted the chin of the forward positioned child passenger **(Figure 12)**. The child passenger sustained a fracture of the left mandibular ramus with a contusion over the fracture site from flap contact. This contact sequence was confirmed by faint tissue transfers on the mid point of the cover flap. The flap was not deformed. This contact sequence probably began to rotate the head in an upward and rearward direction which exposed the anterior neck to the deploying air bag membrane. The subsequent expansion of the frontal air bag against the child resulted in a large triangular continuous abrasion and contusion pattern that extended across the anterior neck from ear-to-ear and vertically from the chin to the 1st intercostal space of the sternum. A large tissue transfer was present of the top surface of the air bag. In addition, she sustained an abrasion over the left ear. The expanding air bag hyper-extended the child's head which resulted in a traumatic fracture/dislocation of the atlanto-occipital joint and transection of the spinal cord at the level of the pons.

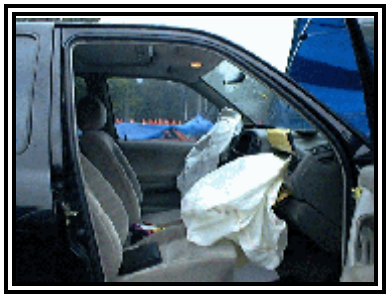

Figure 12. Occupant trajectory and deployment path of the front right air bag.

The expanding air bag displaced the child's right arm against the right door panel. This indicated that she probably attempted to brace against the upper instrument panel at the on-set of the crash sequence. The dorsal aspect of her right hand impacted the door panel or the right upper A-pillar. The contact sequence resulted in abrasions of the right 2-4 digits and contusions of the right wrist and forearm. Her right elbow impacted the door mounted adjustment knob for the rear view mirror, separating the knob and deforming the rigid stalk. This contact abraded and contused the child passenger's right elbow.

The expanding air bag engaged against the child's thoracic region that resulted in a hemorrhage of the esophageal wall and a left pulmonary contusion. The bag expansion probably displaced the child passenger in a rearward direction into the front right seat back support. She sustained a subgaleal contusion of the

right posterior region of the scalp, a hemorrhagic contusion in the left petrous portion of the temporal bone, subarachnoid hemorrhage, and cerebral edema from the probable seat back contact. There were no contact points within the vehicle to support the later injuries. She slumped onto the front right seat cushion where she came to rest.

Medical Treatment

A passing motorist stopped at the crash site to offer aid. This person administered CPR to the injured child until the local professional fire department and para-medic staff arrived on-scene. The child was transported by ambulance to a local hospital where she expired approximately 1 hour and 13 minutes following the crash. An autopsy was performed on the body the following day.

Center Rear Child Passenger Demographics

Age/Sex:	2 year old female
Height :	Unknown
Weight:	11-14 kg (25-30 lb)
Restraint Usage:	Improperly restrained in a forward facing child booster seat
Usage Source:	Vehicle inspection
Type of Medical Treatment:	None, not injured

Center Rear Child Passenger Demographics

The rear seated 2 year old female passenger of the Volkswagen Golf was restrained in a Century Breverra booster seat with the integral 5-point harness. The Century Breverra was loosely secured by the lap belt which was correctly routed through the belt path of the restraint. The child loaded the integral harness straps and remained in the CSS during the crash which prevented her from probable injury.

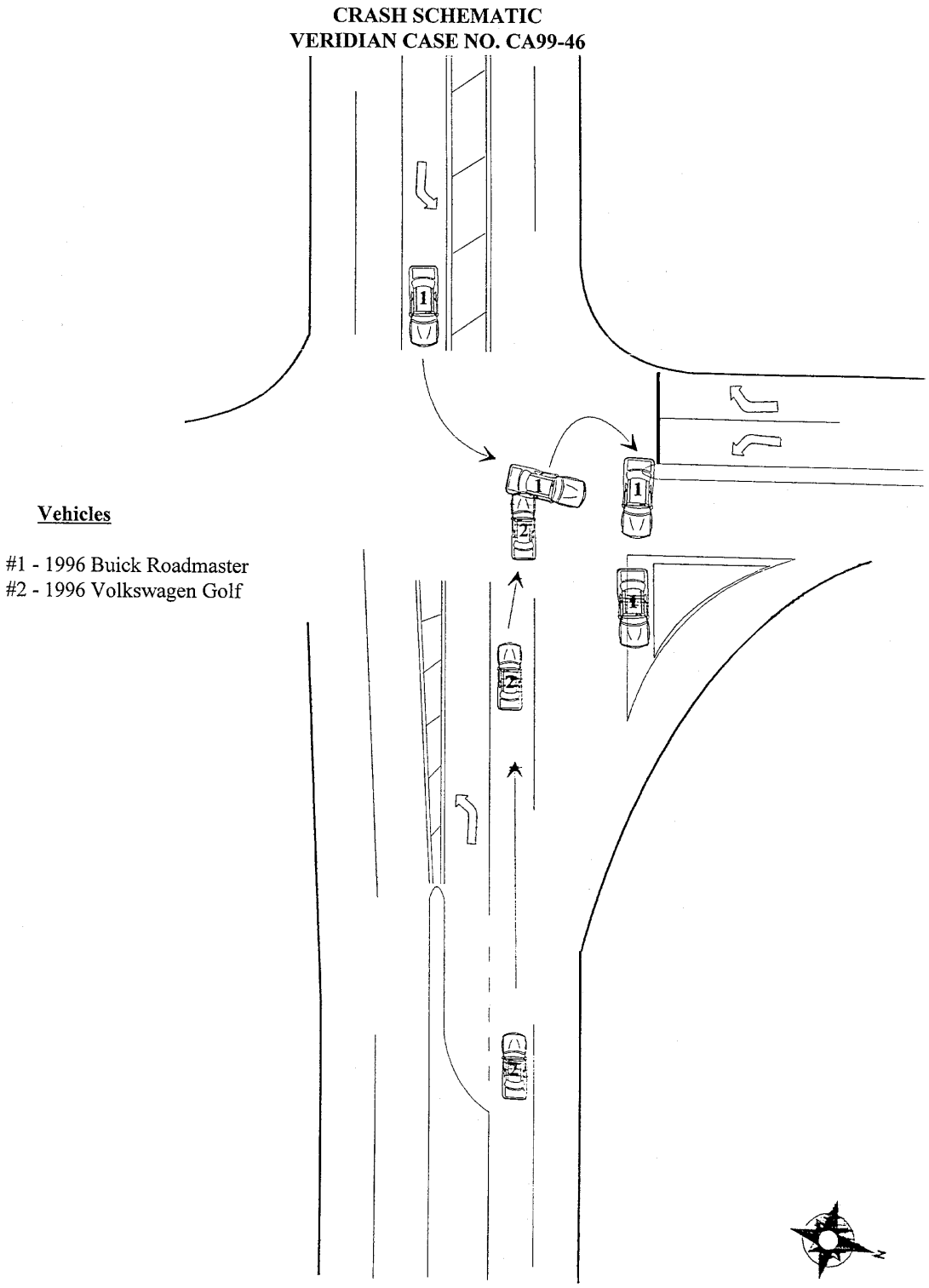

Figure 13. Crash Schematic