CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CHILD AIR BAG RELATED FATALITY CRASH INVESTIGATION

CASE NO: CA06-002

VEHICLE: 1999 CHEVROLET CORVETTE

LOCATION: FLORIDA

CRASH DATE: FEBRUARY 2006

Contract No. DTNH22-01-C-17002

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. Abstract This on-site investigation focused on the severity of the crash and the injury severity and sources that caused the death of a 5-year old male front right passenger of a 1999 Chevrolet Corvette. The Corvette was equipped with redesigned frontal air bags for the driver and front right passenger positions. The Corvette was involved in a moderate severity intersection crash with a 2003 Toyota Sequoia sport utility vehicle that resulted in deployment of the Corvette's frontal air bags. The vehicle was not equipped with a manual cut-off switch for the front right air bag. The child was displaced forward by pre-crash braking and was struck by the deploying mid-mounted front right air bag, which resulted in a large abrasion pattern of the anterior and lateral neck. He sustained a fracture of the odontoid (dens) with atlanto-axial dislocation, a diffuse axonal injury of the brain, subarachniod and subdural hemorrhage. He was removed from the vehicle and transported by helicopter to a regional trauma center where he expired due to his injuries. The 26-year old female driver and a 6-year old male who shared the front right position with his 5-year old brother occupied the Corvette. The children were seated side-by-side with the five year old positioned on the inboard side of the front right seat. Both children were restrained by the manual 3-point lap and shoulder belt system. The driver was unrestrained. The driver and surviving child passenger were not injured. Following the police investigation, the Corvette was towed from the scene and the Toyota was driven to the driver's destination. The Corvette was equipped with an Event Data Recorder (EDR) that was downloaded during this on-site investigation. The output is included as Attachment A of this report.			
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SCI CASE NO.: CA06-002
VEHICLE: 1999 CHEVROLET CORVETTE CONVERTIBLE
LOCATION: FLORIDA
CRASH DATE: FEBRARY 2006

BACKGROUND

This on-site investigation focused on the severity of the crash and the injury severity and sources that caused the death of a 5-year old male front right passenger of a 1999 Chevrolet Corvette. The Corvette was equipped with redesigned frontal air bags for the driver and front right passenger positions. The Corvette was involved in a moderate severity intersection crash with a 2003 Toyota Sequoia sport utility vehicle that resulted in deployment of the Corvette's frontal air bags. **Figure 1** is an on-scene view of the Corvette's final rest position. The vehicle was not equipped with a manual cut-off switch for the front right air bag. The child was displaced forward by pre-crash braking and was struck by the deploying mid-mounted front right air bag, which resulted in a large abrasion pattern of the anterior and lateral neck. He sustained a fracture of the odontoid (dens) with atlanto-axial dislocation, a diffuse axonal injury of the brain, subarachniod and subdural hemorrhage. He was removed from the vehicle and transported by helicopter to a regional trauma center where he expired due to his injuries. The 26-year old female driver and a 6-year old male who shared the front right position with his 5-year old brother occupied the Corvette. The children were seated side-by-side with the five year old positioned on the inboard side of the front right seat. Both children were restrained by the manual 3-point lap and shoulder belt system. The driver was unrestrained. The driver and surviving child passenger were not injured. Following the police investigation, the Corvette was towed from the scene and the Toyota was driven to the driver's destination. The Corvette was equipped with an Event Data Recorder (EDR) that was downloaded during this on-site investigation. The output is included as Attachment A of this report.

Figure 1. On-scene final rest position of the 1999 Chevrolet Corvette.

The crash was identified through an Internet news search for potential cases of interest by the Calspan Special Crash Investigations team on February 7th. The notification was forwarded to NHTSA and assigned on the same day for on-site investigation due to the reported involvement of the air bag with the child's death. Telephone follow-up was initiated with the investigating officer and cooperation was established to conduct the on-site investigation. Due to training conflicts by the investigating officer, the case was scheduled for on-site investigation on February 21. The Corvette was held in police

impound and the Toyota was available for inspection as it was removed from service by the registered business.

SUMMARY

Crash Site

The crash occurred at a four-leg intersection of two local roadways in a commercial area during daylight hours. At the time of the crash, the conditions were clear and dry. The subject vehicle was traveling in a northerly direction on a two lane road on approach to the intersection **(Figure 2)**. The asphalt road surface was 9.1 m (29.9') in width and was bordered by concrete rain gutters and grass roadsides. There were no lane lines or delineations of the road surface. North/southbound traffic was not controlled through the intersection. The struck Toyota approached the intersection in a westerly direction, traveling on a two-lane road that was 8 m (26.2') in width. This roadway was surfaced with asphalt and was bordered by rain gutters and grass roadsides. Westbound traffic flow was controlled by a regulatory stop sign that was posted 5.7 m (18.7') east of the intersection. A painted stop line was present on the westbound lane 6 m (19.7') east of the intersection. The posted speed limit for both roadways was 56 km/h (35 mph).

Figure 2. Northbound approach of the Corvette to the crash site.

Figure 3. Toyota driver's view from the stop line of the Corvette's northbound approach to the intersection.

The roadways were straight and level with minimal crown. The southeast road edge contained a tree line, a hedgerow and a property sign that could have offered a momentary visual obstruction of approaching northbound traffic to the driver of the Toyota as he approached the intersection **(Figure 3)**. These roadside objects would not interfere with a driver's line of sight of approaching northbound traffic for a vehicle stopped in the vicinity of the painted stop line. The crash schematic is included as **Figure 14** of this report.

Vehicle Data

1999 Chevrolet Corvette

The subject vehicle in this crash was a 1999 Chevrolet Corvette convertible. The vehicle belonged to the driver's father's estate and was recently transferred to Florida for her use. The prior history of the Corvette is unknown. The Corvette was manufactured on November 1998 and was identified by Vehicle Identification Number (VIN) 1G1YY32G7X5 (production number deleted). The Corvette was powered by a 5.7 liter

conventionally mounted V-8 gasoline engine linked to a four-speed automatic transmission with a console mounted transmission selector lever. The vehicle was rear-wheel drive with power-assisted four wheel disc brakes with anti-lock (ABS). The two-seat platform had a listed Gross Vehicle Weight Rating of 1,686 kg (3,717 lb). The body was constructed of fiberglass with composite front fenders. At the time of the crash, the black convertible top was in the up/closed position. The OEM tire specifications listed P245/45ZR17 for the front axle and P275/40ZR18 for the rear with recommended inflation pressures of 206 kPa (30 PSI). The Corvette was equipped with aftermarket Falken GR3 FK451 directional tires at the four positions. The tires were mounted on OEM five-spoke alloy wheels. The specific tire data at the time of the SCI inspection is documented in the following table:

Position	Measured Tire Pressure	Measured Tread Depth	Tire/Wheel Damage
Left Front	199 kPa (29 PSI)	6 mm (7/32”)	None
Left Rear	285 kPa (41.5 PSI)	6 mm (7/32”)	None
Right Front	189 kPa (27.5 PSI)	6 mm (7/32”)	Black tire transfers from V-2 on alloy wheel
Right Rear	189 kPa (27.5 PSI)	5 mm (6/32”)	None

The interior of the Corvette was configured with leather-wrapped bucket seats for the two seated positions. Both seats were equipped with integral head restraints and power-track adjusters. Interior equipment included power windows, power door locks, power outside rear view mirrors, and an instrument panel mounted CD player. A storage compartment was located behind the seat backs. This compartment was full of items for car care and personal items and toys for the driver’s children. During the crash, some of these items were displaced forward onto the floor of the vehicle with additional items captured behind the seat backs and rear wall area. The safety systems included manual three-point lap and shoulder belts and redesigned frontal air bags for the two seated positions. These safety systems are addressed in detail under the specific headings later in this narrative report.

2003 Toyota Sequoia

The struck vehicle in this crash was a 2003 Toyota Sequoia sport utility vehicle. The Sequoia was identified by VIN 5TDBT48A635S (production number deleted). The vehicle was a four-wheel drive platform powered by a V-8 gasoline engine linked to an automatic transmission. The Toyota was equipped with dealer installed step bars at both side rails. The tires were Michelin LTX M/S all-season radials, size P265/70R16 mounted on OEM six-spoke alloy wheels. The interior of the vehicle was locked at the time of the SCI inspection; therefore the recommended tire pressure was unknown. The specific tire data at the time of the inspection was as follows:

Position	Measured Tire Pressure	Measured Tread Depth	Tire/Wheel Damage
Left Front	192 kPa (28.0 PSI)	9 mm (11/32”)	None
Left Rear	185 kPa (27.0 PSI)	9 mm (11/32”)	None
Right Front	185 kPa (27.0 PSI)	9 mm (11/32”)	None
Right Rear	182 kPa (26.5 PSI)	9 mm (11/32”)	None

Crash Sequence

Pre-Crash

The 26-year old female driver of the 1999 Chevrolet Corvette was en route to her residence and was traveling in a northerly direction on the two-lane road, on approach to the four-leg intersection. She negotiated a right curve located approximately 225 m (750’) south of the intersection and was traveling at 68-71 km/h (42-44 mph) over the four seconds of EDR recorded pre-crash data. The throttle input was recorded at 20 percent and the brake switch status was off for the -5 to -3 second intervals prior to algorithm enable (AE).

The driver of the 2003 Toyota Sequoia was initially southbound on a divided state route and turned right onto a local street to travel in a westerly direction. He traveled the distance of one block prior to his approach to the four-leg intersection. A regulatory stop sign was positioned at the northeast corner of the intersection. Located to the Toyota driver’s left was a hedgerow that bordered the east sidewalk, a row of trees, and a large sign located off-road at the southeast quadrant of the intersection. These obstructions could have posed a visual threat of northbound traffic to the Toyota driver as he approached the intersection when stopped behind the painted stop line. Based on a reconstruction of the crash events, the driver either failed to detect the stop sign or intentionally passed the stop sign without yielding to the northbound Corvette, therefore the obstructions were not a causal factor in this crash. The Toyota emerged from the Corvette’s right roadside and entered the intersection.

The driver of the Corvette detected the Toyota and lifted her foot from the accelerator pedal and applied brake pedal pressure at –2 seconds prior to AE. The level of braking was unknown as this is not recorded by the EDR, and there was no physical evidence at the crash site from the ABS equipped vehicle.

Crash

The front center and right area of the Corvette impacted the left sill area of the Toyota near the center of the intersection. The EDR output recorded the speed of the Corvette at approximately 56 km/h (35 mph) at -1 second prior to AE. This deceleration of 14 km/h (9 mph) was attributed to the pre-crash braking initiated by the female driver. The initial impact involved the front bumper of the Corvette against the left step bar of the Toyota. The step bar crushed as the Corvette continued forward and engaged the left sill area of the Sequoia. Due to the speed and mass of the Sequoia, the vehicle continued on a near straight line trajectory following the initial engagement. The Corvette penetrated under the side structure of the Sequoia and was rotated in a counterclockwise direction by the crash. The resultant directions of force were within the 2 o’clock sector for the Corvette

and 11 o'clock for the struck Toyota. The EDR recorded a maximum velocity change of -20 km/h (-12.3 mph) for the Corvette. The damage algorithm of the WinSMASH program computed total velocity changes of 11 km/h (6.8 mph) for the Corvette and 7 km/h (4.3 mph) for the struck Toyota. The specific longitudinal and lateral components were -7 km/h (-4.3 mph) and -8 km/h (-5.0 mph) for the Corvette and -6 km/h (-3.7 mph) and 4 km/h (2.5 mph) for the Sequoia. The crash induced deceleration was sufficient to deploy the designed frontal air bag system in the Corvette.

As the Corvette was rotated CCW by the Toyota, the vehicles remained engaged resulting in secondary contact involving the left rear tire and quarter panel of the Sequoia against the right front wheel and composite fender of the Corvette. This engagement occurred as the Toyota continued in a westerly direction through the intersection ahead of the rotating Corvette. The resultant directions of force were 3 o'clock for the Corvette and 9 o'clock for the Toyota. Both vehicles sustained minor severity damage from this secondary contact.

The Corvette was rotated approximately 49 degrees CCW by the crash as it was redirected in a northwesterly direction and continued forward to final rest. The Corvette traveled 12.6 m (41.3') to the northwest quadrant of the intersection coming to rest with its right front wheel on top of the mountable curb and the left front tire engaged against the face of the curbline. At rest, the Corvette was facing in a northwesterly direction.

The Toyota Sequoia continued on a westerly direction following the crash due to its pre-crash momentum. The Sequoia's trajectory was not significantly altered by impact with the Corvette. Reportedly, the Toyota came to rest at the west leg of the intersection.

Post-Crash

The driver of the Sequoia drove the vehicle forward into the parking lot at the west leg of the intersection where he parked the vehicle and exited to check on the status of the Corvette's occupants. He was not injured and subsequently drove the vehicle from the scene.

The driver and 6-year old male passenger of the Corvette exited the vehicle from their respective doors. Police and emergency medical personnel arrived on-scene within minutes of the crash and attended to the injured 5-year old. He was removed from the vehicle and transported by helicopter to a regional trauma center where he expired due to his injuries. The Corvette was subsequently towed from the scene and impounded by the investigating officer and held for this on-site SCI investigation. The driver of the Corvette and her and 6-year old passenger were not injured.

Vehicle Damage

Exterior – 1999 Chevrolet Corvette

Primary - The Corvette sustained moderate severity frontal damage as a result of the initial impact with the left side of the Toyota. Maximum crush was measured at 6 cm (2.25") located at the front right corner of the bumper beam. The direct contact damage began 37 cm (14.4") left of the vehicle's centerline and extended 114 cm (45") to the

right bumper corner **(Figure 4)**. The contact damage consisted of black transfers and abrasions to the bumper fascia and hood. The impact deformed the full width of the bumper system, resulting in a combined induced and direct contact damage length of 152 cm (59.75”). The residual crush **(Figure 5)** measured at the level of the bumper beam was as follows: C1 = 1 cm (0.25”), C2 = 3 cm (1”), C3 = 4 cm (1.5”), C4 = 5 cm (2”), C5 = 6 cm (2.2”), C6 = 6 cm (2.25”).

Due to the pre-crash braking by the driver of the Corvette and the ride height of the Toyota, the front bumper engaged and underrode the left side step bar of the Toyota Sequoia. This underride resulted in direct contact damage that extended 6 cm (2.5”) onto the leading edge of the hood. The Collision Deformation Classification (CDC) for this crash was 02-FDEW-1

Figure 4. Overhead view of the direct contact damage.

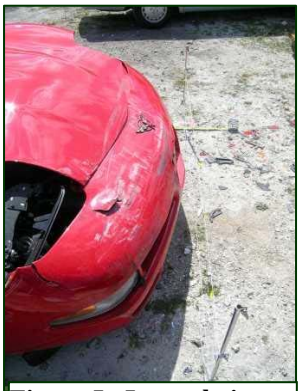


Figure 5. Lateral view of the depth of crush.

Secondary – The secondary engagement of the right front tire and fender of the Corvette by the left rear tire and quarter panel of the Toyota resulted in minor severity damage to the involved components. The composite fender fractured at the area of contact and black tire transfers were noted to the right front alloy wheel of the Corvette **(Figure 6).** There was no structural damage or measurable crush associated with this event. The CDC for this event was 03-RFEW-1.

Figure 6. Secondary damage to the right front fender and alloy wheel.

Interior – 1999 Chevrolet Corvette

The interior of the 1999 Chevrolet Corvette was not damaged, or reduced in size by intrusion. There were no distinct occupant contact points other than tissue transfers on the deployed front right air bag membrane and a possible loading mark of the front right shoulder belt webbing. These are addressed in greater detail in the respective sections addressing the air bags and safety belt systems.

Exterior – 2003 Toyota Sequoia

Primary - The 2003 Toyota Sequoia sustained moderate severity left side damage that was associated with the initial impact with the subject vehicle. This damage was located between the left wheelbase and involved both doors, the sill, and the left step bar **(Figure 7)**. The direct contact damage began at the base of the left A-pillar and extended 207 cm (81.6") rearward to the dogleg at the base of the left C-pillar. Maximum crush was 11 cm (4.4") located on the sill at the mid point of the left front door. The combined direct and induced damage was isolated to this area and was the same length as the direct damage measurement. Two planes of crush measurements were documented for this damage pattern. The left sill was representative of the severity of the crash since this was direct structure to the vehicle. The second profile was documented at the face of the step bar, which yielded the greatest crush. This add-on component was supported by four hangers and was not a structural component to the Sequoia. The crush profile at the level of the sill was as follows: C1 = 0 cm, C2 = 2 cm (0.6"), C3 = 4 cm (1.4"), C4 = 8 cm (3.1), C5 = 6 cm (2.4"), C6 = 0 cm. The crush profile at the level of the step rail was as follows: C1 = 6 cm (2.5"), C2 = 14 cm (4.0"), C3 = 14 cm (5.5"), C4 = 29 cm (11.5"), C5 = 38 cm (15.0"), C6 = 38 cm (15.0"). The CDC for this impact was 11-LPLW-2.

Figure 7. Left side damage to the Toyota Sequoia.

Figure 8. Secondary damage to the left rear bumper fascia.

Secondary – The left rear tire and the side surface of the rear bumper fascia of the Toyota engaged the right front fender and wheel of the Corvette as the Sequoia passed through the intersection. The left rear tire of the Sequoia sustained subtle rub marks from the contact while the lower edge of the fascia was abraded with red paint transfers **(Figure 8)**. The contact on the fascia began 77 cm (30.25") aft of the rear axle position and extended 37 cm (14.5") to the rear corner. Due to the compliant nature of the fascia, there was no crush associated with this event. The CDC for this secondary contact was 09-LBLW-2.

Manual Safety Belt Systems – 1999 Chevrolet Corvette

The Corvette was equipped with manual 3-point lap and shoulder safety belts for the two seating positions. Both belt systems utilized two separate belt webbings that were sewn to a common latch plate. The lap belts extended from switchable Emergency/Automatic locking retractors that were mounted to the sills of the vehicle. The shoulder belts extended from upper-B-pillar mounted Emergency Locking Retractors (ELR). Both latch plates yielded historical usage wear marks. An emergency management loop **(Figure 9)** was incorporated into the shoulder belt webbing of both belt systems. The loops consisted on a double fold that measured 16 cm (6.125") in length and stitched at the upper and lower aspects of the loop. Both looped originated 5 cm (2") above the latch plates. The loops did not separate in the crash.

Figure 9. Driver's side energy management loop.

The driver's belt system was not worn in this crash. Driver statements to the investigating officer, the lack of loading evidence on the system, and EDR output data supported the driver's non-use of safety belt system.

The front right belt system was positioned over both child occupants who were seated in a side-by-side position on the front right seat. Although the crash severity was low, and the belt loading was primarily provided by the outboard occupant, the shoulder belt webbing did yield a subtle loading mark from webbing engagement against the B-pillar mounted D-ring. This loading mark reflected a polishing of the webbing that was diagonally oriented to the webbing and located 74-77 cm (29-30.5") above the latch plate. The lap belt webbing was gathered at the sill trim panel. This gather prevented the lap belt from retracting onto the ELR/ALR retractor. There was no other crash related loading evidence or damage to the safety belt systems.

Redesigned Frontal Air Bag System – 1999 Chevrolet Corvette

The 1999 Chevrolet Corvette was equipped with redesigned frontal air bags for the driver and right passenger positions. Both air bags deployed **(Figure 10)** as a result of the initial crash with the left side of the Toyota.

Figure 10. Deployed redesigned frontal air bags.

The Corvette's air bag system consisted of a conventionally mounted driver air bag module, a mid mount front right air bag located in the right instrument panel, and a single point Sensing and Diagnostic Module (SDM) that was located on the center tunnel at the forward aspect of the console. The SDM also had Event

Data Recording (EDR) capabilities. The EDR was downloaded during this on-site investigation and the output data is discussed in the section that follows.

The driver air bag deployed from an I-configuration air bag module that was housed within the four-spoke steering wheel assembly. The cover flaps opened at the designated tear seam and the air bag membrane deployed. The symmetrical cover flaps measured 13 cm (5.25") in height and 7 cm (2.75") in width. The driver air bag membrane measured 66 cm (26.0") in diameter in its deflated state. The bag was tethered by two straps at the 3 and 9 o'clock positions. The tether reinforcement measured 17 cm (6.5") and was sewn to the face of the bag with two rows of stitching. The bag was vented by two 1 cm (0.375") diameter vent ports located at the 11 and 1 o'clock positions on the bag side of the air bag, 11 cm (4.5") forward of the peripheral seam.

The face of the driver air bag had three horizontally oriented black vinyl transfers from expansion against the inside surface of the module. These were located 21 cm (8.25") and 30 cm (11.75") above the horizontal centerline and 19 cm (7.5") below the reference line. All three transfers were centered on the vertical centerline.

Two subtle orange/rust-like transfers were located on the lower right quadrant of the driver air bag. The first transfer was located 15-18 cm (5.75-7.0") below the horizontal centerline and 5-10 cm (2.0-3.75") right of the vertical centerline. The second transfer was located with respective measurements of 12-15 cm (4.75-6.0") and 6-10 cm (2.25-3.75"). The source of these transfers could not be determined as they could have been related to driver make-up or dirt from the hands of the tow operator.

The front right passenger air bag deployed from the mid mount module that was located in the right instrument panel. The module was concealed by a single cover flap that measured 27 cm (10.5") in width and 18 cm (7.125") in height. The single layer vinyl cover flap was approximately 5 mm (3/16") in thickness and was embossed with AIRBAG in the lower right corner. Located at the top surface of the top hinged flap was a brow/grab handle that restricted the vertical excursion of the flap. There no was occupant contact evidence or damage to the flap.

The front right air bag membrane deployed as designed with no tears or defects noted. The bag was rectangular in shape with the face of the deflated bag measuring 41 cm (16") in width and 33 cm (13") in height. The top panel that extended from the module was 43 cm (17") in depth, measured from the inflator to the face of the membrane. The front right air bag was tethered by a single wide-band tether and was not directly vented into the passenger compartment. The maximum excursion of the front right air bag measured 43 cm (17") from the leading edge of the module/cover flap.

Figure 11. Red fabric and tissue transfers on the front right air bag.

The air bag membrane contained several transfers that were related to expansion against the module cover flap and the child passenger. The top right aspect of the top panel contained a black vinyl fabric transfer with a subtle red fabric transfer within the black near the perimeter of the joining face panel. This combined transfer was located 3-10 cm (1-3.75") right of the centerline and 0-15 cm (0-6") aft of the junction of the top and face panels.

A vertically oriented transfer, that appeared to be tissue, was located on the face of the air bag **(Figure 11)**. This transfer began at the junction of the top panel and extended 18 cm (7.25") downward to the centerline of the bag. Located within this transfer was a red fabric transfer that extended 13-20 cm (5-8") inboard of the left side panel seam extending 10 cm (4") down from the face from the top panel.

Event Data Recorder – 1999 Chevrolet Corvette

The EDR in the 1999 Chevrolet Corvette was downloaded by the SCI investigator during this on-site investigation. The Vetronix Crash Data Retrieval tool was utilized using software version 2.7. The Report was analyzed using version 2.8. The Corvette sustained minor damage to the engine compartment and remained operational (engine and all accessories) post-crash. The vehicle was downloaded through the diagnostic link connector with the ignition turned to the run position. The output data revealed a Deployment file that was associated with this crash and a Non-Deployment file that was recorded 51 ignition cycles prior to this crash. Both files are included with this report as **Attachment A.**

The Deployment file occurred at ignition cycle 5217. The output data recorded the driver's safety belt switch as Unbuckled and the front right air bag as Not Suppressed. It should be noted that this vehicle did not have a manual cut-off switch. The pre-crash data recorded a vehicle speed of 68 km/h (42 mph) at the -5 second interval prior to AE with a slight increase to 71 km/h (44 mph) to the -2 second interval. At this recording cycle, the driver released throttle pressure and applied a braking force, which decelerated the Corvette to 89 km/h (35 mph) at the -1 second recording interval. The maximum velocity change was 20 km/h (-12.3 mph).

Occupant Demographics/Data – 1999 Chevrolet Corvette

Driver Age/Sex:	26-year old/Female
Height:	170 cm (67")
Weight:	73 kg (160 lb)
Eyewear:	Unknown
Seat Track Position:	Unknown, moved post-crash
Manual Safety Belt Usage:	None
Usage Source:	Vehicle inspection, driver statements, EDR output
Type of Medical Treatment:	None, not injured

Driver Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Source
Not injured	N/A	N/A

Source – police and attorney

Driver Kinematics

The 26-year old female driver of the 1999 Corvette was seated in a presumed upright posture in a mid-to-rear track position based on her demographics. The seat track was moved prior to the SCI inspection, therefore the specific track location was unknown. She was not restrained by the manual 3-point lap and shoulder belt system. The lack of belt usage was supported by the vehicle inspection, EDR data, and driver statements to the investigating officer.

Figure 12. Lateral view of the driver's position and the deployed front left air bag.

Immediately prior to the crash, the driver was probably bracing against the steering wheel with both hands and braking in an attempt to avoid the crash. At impact with the Toyota, the redesigned frontal air bag system deployed. The driver's air bag deployed from the steering wheel mounted module. The unrestrained driver initiated a forward and slight lateral trajectory to her right in response to the 1 o'clock impact force. She loaded the deployed driver's air bag **(Figure 12),** which prevented her from potential contact with the steering assembly and frontal components. The driver was not injured in the crash.

Five-Year Old Male Passenger

Seated Position:	Inboard aspect of the front right seat
Height:	114 cm (45")
Weight:	23 kg (50 lb)
Eyewear:	None
Seat Track Position:	Rear, adjusted 17 cm (6.75") aft of full forward, 1 cm (0.5") forward of full rear
Manual Safety Belt Usage:	Improper use of the 3-point lap and shoulder belt
Usage Source:	Vehicle inspection
Mode of Transport From Scene:	Transported by helicopter
Type of Medical Treatment:	Admitted to a regional trauma center where he expired.

Five-Year Old Male Passenger Injuries

Injury	Injury Severity(AIS 90/Update 98)	Injury Source
Diffuse axonal injury	Critical (140628.5,9)	Acceleration of the head by the expanding front right air bag
Fracture of the odontoid (dens) with dislocation of the atlanto-axial joint	Serious (650228.3,6)	Expanding front right air bag, hyperextension of neck
Thin layer of subdural hemorrhage over the left cerebral hemisphere	Severe (140652.4,2)	Acceleration of the head by the expanding front right air bag
Bilateral pulmonary contusions	Severe (441410.4,3)	Expanding front right air bag
Diffuse subarachnoid hemorrhage (NFS)	Serious (140684.3,9)	Possible occupant-to-occupant interaction
Large abrasion of the anterior neck that extended from ear-to-ear	Minor (390202.1,0)	Expanding front right air bag
Small subgaleal hemorrhage of the right parieto-occiptal region of the scalp	Minor (190402.1,1)	Possible occupant-to-occupant interaction
Faint purple contusion over the left lower aspect of the chest wall	Minor (490402.1,2)	Expanding front right air bag
Small faint purple contusion over the right side of the forehead	Minor (290402.1,7)	Possible occupant-to-occupant interaction
Small abrasion over the dorsal left wrist	Minor (790202.1,2)	Probable fling injury into an unknown component
Contusion over the anterior aspect of the thymus	Not coded under AIS	Expanding front right air bag

Source – Autopsy Report

Five-Year Old Male Passenger Kinematics

The 5-year old male passenger of the 1999 Chevrolet Corvette was seated on the inboard aspect on the front right seat, in a side-by-side attitude with his 6-year old brother. Both children were restrained by the manual 3-point lap and shoulder belt system. Due to the inboard position of the 5-year old, the shoulder belt webbing crossed his lower right chest and lower left abdominal regions resulting in minimal restraint of his torso. The power-adjusted seat was adjusted to a rear track

Figure 13. Lateral view of the child's trajectory and the deployment path of the front right air bag.

position. In this position, the horizontal distance between the leading edge of the mid mount front right air bag cover flap and the seat back was 82 cm (32.375”), measured at 33 cm (13”) above the seat bight. The child was dressed in a school uniform that consisted of a red shirt, slacks and athletic shoes.

As the driver of the Corvette detected the Toyota Sequoia entering the intersection, she braked with sufficient force to displace the 5-year old male passenger forward. Due to the low position of the shoulder belt his upper torso and head to jackknife forward over the manual belt system. This forward movement placed his head and torso within the deployment path of the mid mount front right air bag **(Figure 13)**.

At impact, the front right air bag deployed from the mid right instrument panel module. The narrow shape of the air bag membrane during the initial deployment contacted the out-of-position child passenger under the chin. This contact resulted in a full-thickness abrasion pattern that extended from ear-to-ear across the underside of the chin on the anterior neck. As the air bag began to expand vertically, the expanding membrane hyperextended the child’s neck resulting in a fracture of the odontoid with dislocation of the atlanto-axial joint. The expansion accelerated the child’s head vertically and rearward as the bag expanded against his torso. The acceleration of the head resulted in a diffuse axonal injury and a thin layer of subdural hemorrhage over the left cerebral hemisphere.

The continued expansion of the air bag engaged the chest of the child passenger as he was lifted vertically and displaced rearward while restrained by the lap belt. The bag expansion against his chest resulted in a faint contusion of the lower left chest wall, bilateral pulmonary contusions, and a contusion over the anterior aspect of the thymus. He also sustained an abrasion of the left dorsal wrist from a probable fling by the expanding air bag. The source of the abrasion could not be determined.

The top panel of the air bag contained a black vinyl transfer with a red fabric transfer at the edge of the face panel. The face of the bag membrane contained a red fabric transfer and a substance that appeared to be tissue. These transfers were consistent with the child’s shirt and abrasion pattern to his neck.

The 2 o’clock direction of force impact would have displaced the child passenger forward and to his right. Due to the direction of force his subsequent displacement by the expanding air bag, he possibly contacted the 6-year old seated to his right. This possible occupant-to-occupant interaction resulted in a faint forehead contusion, a small subgaleal hemorrhage of the right parieto-occipital region of the scalp and diffuse subarachnoid hemorrhage. The 6-year old passenger was not injured. There were no additional interior contact points to support these injuries to the 5-year old. The lap belt would have prevented contact with the structural members of the convertible roof. He did not sustain injury from loading the lap belt during the crash.

The 5-year old child passenger came to rest on the front right seat in a slumped/unconscious state. He was removed from the vehicle by rescue personnel and

transported by helicopter to a regional trauma center where he expired due to his injuries. His body was transferred to the Regional Medical Examiner's office where an invasive autopsy was performed.

Six-Year Old Child Passenger

Seated Position:	Outboard aspect of the front right seat
Height:	114 cm (45")
Weight:	26 kg (58 lb)
Eyewear:	None
Seat Track Position:	Rear, adjusted 17 cm (6.75") aft of full forward, 1 cm (0.5") forward of full rear
Manual Safety Belt Usage:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection
Mode of Transport From Scene:	Unknown
Type of Medical Treatment:	None, not injured

Six-Year Old Child Passenger Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Source
Not injured	N/A	N/A

Six-Year Old Child Passenger Kinematics

The 6-year old was seated on the right aspect of the front right seat in a side-by-side position adjacent to the 5-year old passenger. He was dressed in a school uniform that consisted on a short-sleeved polo shirt, slacks and athletic shoes. Both children were restrained by the manual 3-point lap and shoulder safety belt system. The outboard positioned child passenger received greater benefit from the belt system as the shoulder belt webbing extended across his right shoulder and upper torso. Belt usage was verified by a subtle D-ring transfer on the shoulder belt webbing. Safety belt loading was not sufficient to deploy the management loop that was incorporated into the lower aspect of the shoulder belt webbing.

As the driver applied a braking force in response to the Toyota Sequoia crossing her path of travel, the 6-year old child passenger moved forward and loaded the safety belt webbing which restricted his forward movement. At impact, the frontal air bag system deployed. Due to the unrestrained status of the torso of the 5-year old child passenger and the lateral component of the impact force, the 6-year old was probably shielded from the deploying by the other child passenger. There was possible occupant-to-occupant interaction between the child passengers; however, the 6-year old was not injured in the crash.

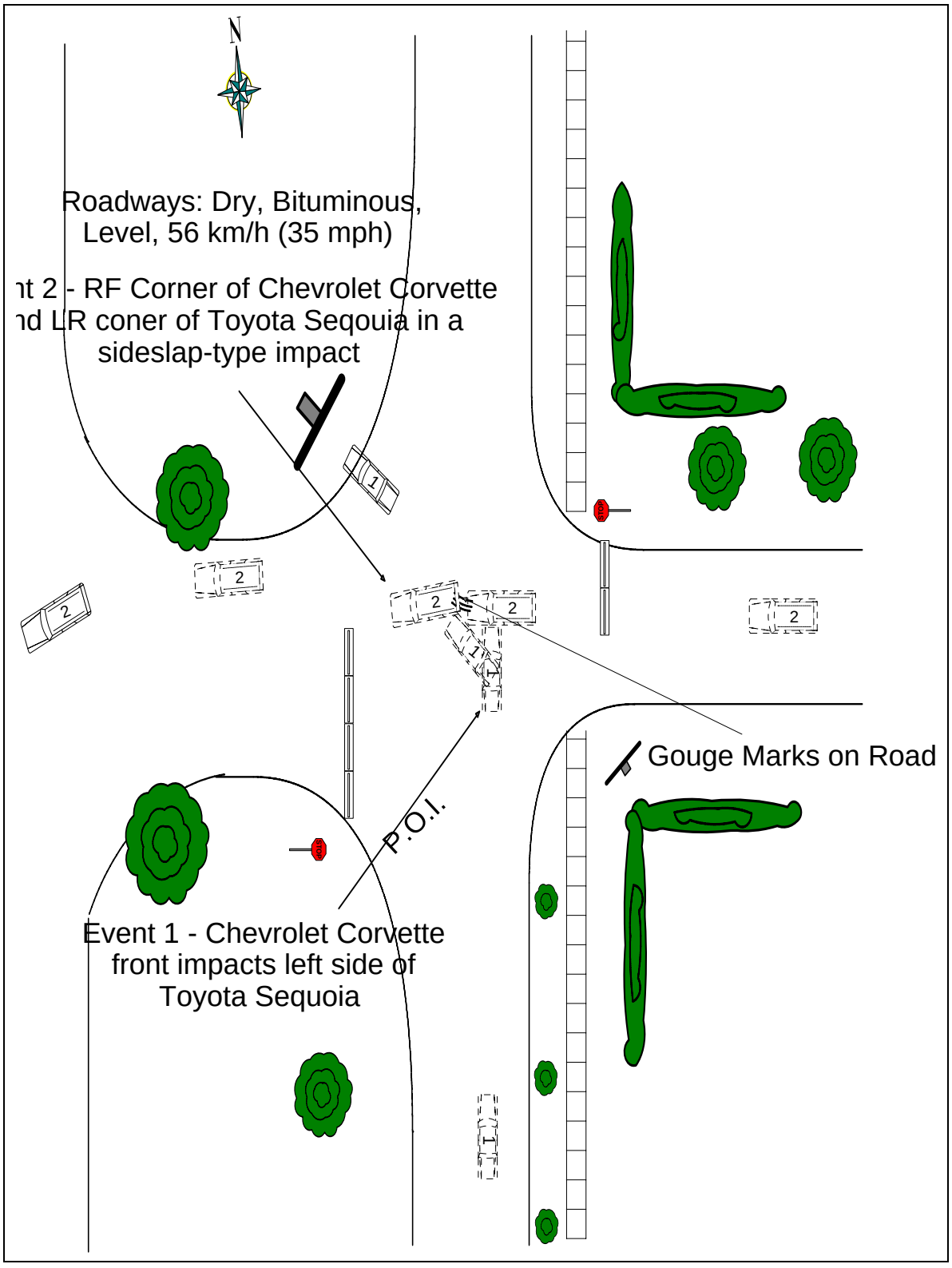


Figure 14. Scene Schematic

Attachment A
EDR Output

CDR File Information

Vehicle Identification Number	1G1YY32G7X5112095
Investigator	TS
Case Number	CA06-003
Investigation Date	Thursday, December 21 2006
Crash Date	Thursday, February 2 2006
Filename	CA06-002.CDR
Saved on	Tuesday, February 21 2006 at 12:44:56 PM
Collected with CDR version	Crash Data Retrieval Tool 2.70
Collecting program verification number	70812808
Reported with CDR version	Crash Data Retrieval Tool 2.800
Reporting program verification number	9238B95E
Interface used to collected data	Block number: 00 Interface version: 41 Date: 11-04-04 Checksum: 9E00
Event(s) recovered	Deployment Non-Deployment

SDM Data Limitations

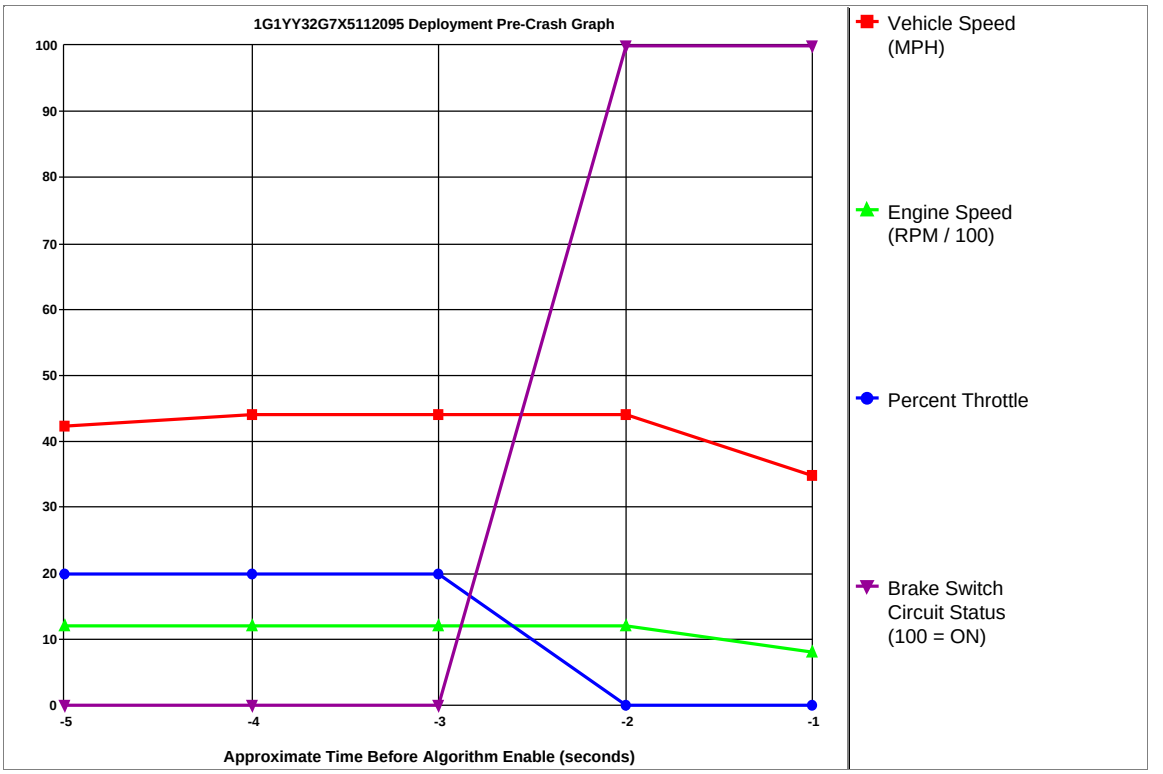
SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to “wake up” the sensing algorithm but not severe enough to deploy the air bag(s). It contains Pre-Crash and Crash data. The SDM can store up to one Non-Deployment Event. This event may be overwritten by another Non-Deployment Event. This event will be cleared by the SDM after the ignition has been cycled 250 times.
The second type of SDM recorded crash event is the Deployment Event. It also contains Pre-Crash and Crash data. The SDM can store up to two different Deployment Events, if they occur within five seconds of one another. Deployment Events cannot be overwritten or cleared from the SDM. Once the SDM has deployed the air bag, the SDM must be replaced.
The data in the Non-Deployment Event file will be locked after a Deployment Event, if the Non-Deployment Event occurred within 5 seconds before the Deployment Event unless a Deployment Level Event occurs within 5 seconds after the Deployment Event, and then the Deployment Level Event will overwrite the Non-Deployment Event file.

SDM Data Limitations:
-SDM Adjusted Algorithm Forward Velocity Change:
Once the crash data is downloaded, the CDR tool mathematically adjusts the recorded algorithm forward velocity data to generate an adjusted algorithm forward velocity change that may more closely approximate the forward velocity change the sensing system experienced during the recorded portion of the event. The adjustment takes place within the downloading tool and does not affect the crash data, which remains stored in the SDM. The SDM Adjusted Algorithm Forward Velocity Change may not closely approximate what the sensing system experienced in all types of events. For example, if a crash is preceded by other common events, such as rough road, struck objects, or off-road travel, the SDM Adjusted Algorithm Forward Velocity Change may be less than and some times significantly less than the actual forward velocity change the sensing system experienced. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. For Deployment Events and Deployment Level Events, the SDM will record 100 milliseconds of data after deployment criteria is met and up to 50 milliseconds before deployment criteria is met. The maximum value that can be recorded for SDM Adjusted Algorithm Forward Velocity Change is about 112 MPH.
-SDM Recorded Vehicle Speed accuracy can be affected if the vehicle has had the tire size or the final drive axle ratio changed from the factory build specifications.
-Brake Switch Circuit Status indicates the status of the brake switch circuit.
-Some of the Pre-Crash data may be recorded after Algorithm Enable (AE). This may happen in situations involving relatively "soft" crash pulses or those that take place over a relatively longer period of time. If this occurs, it may affect the reported pre-crash data values, but does not affect other data such as SDM Adjusted Algorithm Forward Velocity Change.
-Pre-Crash Electronic Data Validity Check Status indicates “Data Invalid” if the SDM receive an invalid message from the module sending the pre-crash data.
-Driver’s Belt Switch Circuit Status indicates the status of the driver’s seat belt switch circuit. If the vehicle’s electrical system is compromised during a crash, the state of the Driver’s Belt Switch Circuit may be reported other than the actual state.
-Passenger Front Air Bag Suppression Switch Circuit Status indicates the status of the suppression switch circuit.
-The Time Between Events is displayed in seconds. If the time between the two events is greater than five seconds, “N/A” is displayed in place of the time.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded.
SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-Vehicle Speed, Engine Speed, and Percent Throttle data are transmitted once a second by the Powertrain Control Module (PCM), via the vehicle’s communication network, to the SDM.
-Brake Switch Circuit Status data is transmitted once a second by either the ABS module or the PCM, via the vehicle’s communication network, to the SDM.

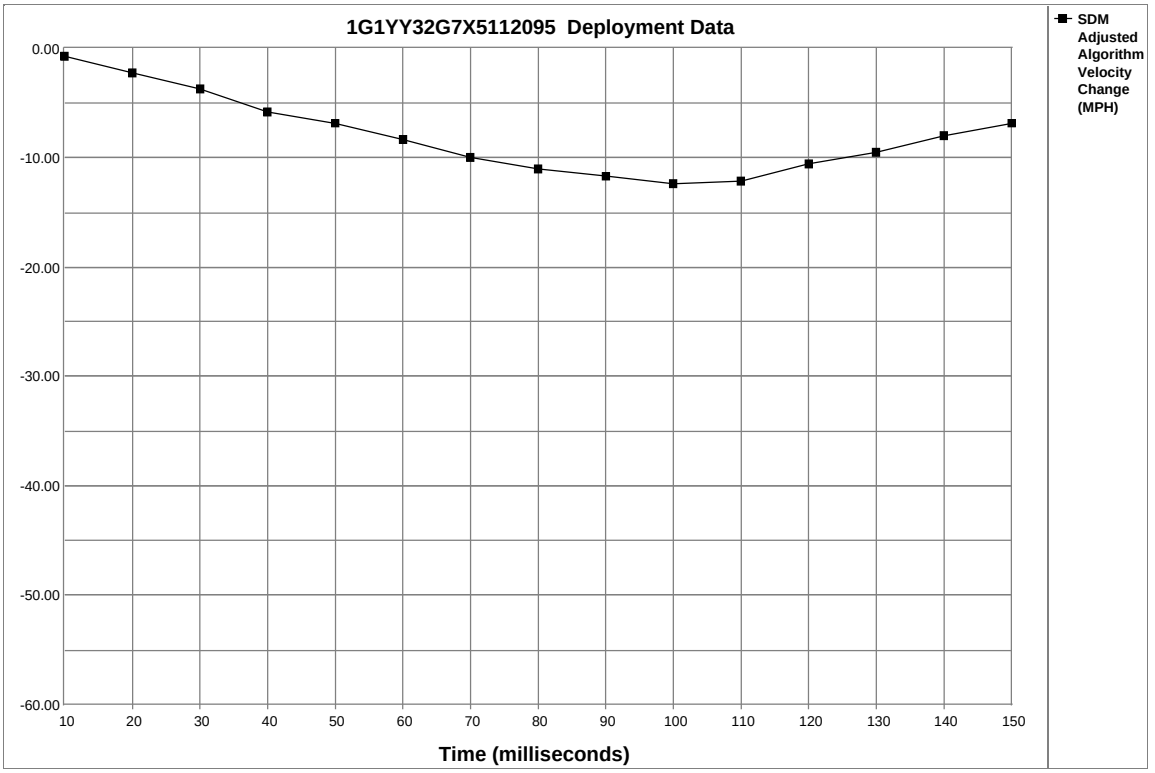
-The SDM may obtain Belt Switch Circuit Status data a number of different ways, depending on the vehicle architecture. Some switches are wired directly to the SDM, while others may obtain the data from various vehicle control modules, via the vehicle's communication network.
-The Passenger Front Air Bag Suppression Switch Circuit is wired directly to the SDM.

System Status At Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Deployment	5217
Time Between Non-Deployment And Deployment Events (sec)	N/A



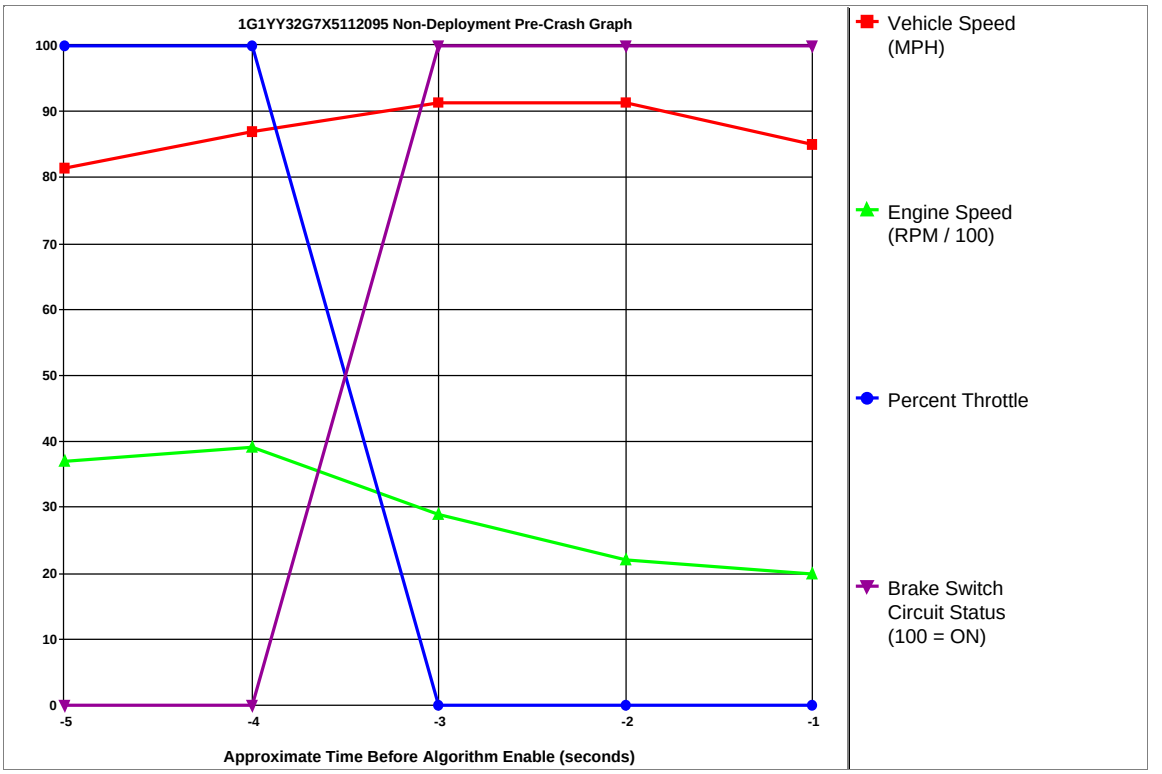
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	42	1216	20	OFF
-4	44	1216	20	OFF
-3	44	1216	20	OFF
-2	44	1216	0	ON
-1	35	832	0	ON



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Adjusted Algorithm Velocity Change	-0.68	-2.22	-3.75	-5.73	-6.83	-8.36	-9.90	-11.00	-11.66	-12.31	-12.10	-10.56	-9.46	-7.93	-6.83

System Status At Non-Deployment

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	UNBUCKLED
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Non-Deployment	5166
Maximum SDM Algorithm Forward Velocity Change (MPH)	-0.10



Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	81	3712	100	OFF
-4	87	3904	100	OFF
-3	91	2944	0	ON
-2	91	2240	0	ON
-1	85	1984	0	ON

Hexadecimal Data

This page displays all the data retrieved from the air bag module.
It contains data that is not converted by this program.

```
$01  7C 05 00 00
$02  8B 2A
$03  41 53 38 32 38 39
$04  4B 30 31 46 57 31
$05  00
$06  16 24 50 01
$11  6F 01 6F FA 75 00
$14  03 04 B5 00
$18  81 81 81 C0 FF 00
$1C  31 32 59 59 59 59
$1D  59 31 32 59 59 59
$1E  59 59
$1F  FF 02 00 00
$20  80 00 00 FF 44 F8
$21  FF FF FF FF FF FF
$22  FF FF 06 00 07 00
$23  00 00 00 00 00 00
$24  FF FF FF FF FF FF
$25  FF FF FF 06 89 93
$26  93 8C 83 00 E0 00
$27  00 00 00 FF FF 00
$28  1F 23 2E 3D 3A 00
$29  FD 7A C0 FE 0A BD
$2A  04 E6 0A BA 00 00
$2B  00 00 00 00 00
$30  80 00 00 FF 80 FE
$31  FF FF FE FF FF FF
$32  FF FF 33 03 00 0F
$33  0B 08 01 04 07 0B
$34  0D 10 13 15 16 17
$35  16 12 03 58 02 F6
$36  38 47 47 47 44 00
$37  C0 00 00 00 32 32
$38  32 00 0D 13 13 13
$39  13 00 FD 73 FE 00
$3A  00 00 80 00
$40  FF FF FF FF FF FF
$41  FF FF FF FF FF FF
$42  FF FF
```