CRASH DATA RESEARCH CENTER

Calspan Corporation
Buffalo, NY 14225

CALSPAN ON-SITE CHILD DRIVER AIR BAG RELATED FATALITY INVESTIGATION

CASE NO: CA05-020

VEHICLE: 1993 TOYOTA TERCEL

LOCATION: NORTH CAROLINA

CRASH DATE: MARCH 2005

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

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

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16. Abstract This on-site investigation focused on the injury mechanisms for a 7-year-old male child driver of a 1993 Toyota Tercel. The Toyota was equipped with a driver's frontal air bag system that deployed as a result of the crash sequence. An 8-year-old male seated in the front right position and restrained by a 2-point lap belt and automatic shoulder belt also occupied the Toyota. The driver was unrestrained and was positioned on the edge of the driver's seat cushion with the seat adjusted full forward so he could reach the foot controls. The 7-year-old male was operating the vehicle westbound on a dirt roadway within the confines of a residential trailer park. The child driver became distracted looking to the left as the vehicle approached an intersecting private roadway on the right side. The driver realized that he was supposed to turn right onto the intersecting roadway and steered right. The child initiated a wide right turn, striking a 1979 Ford Van that was stopped at the intersection, waiting to turn right onto the westbound roadway. The front left corner of the Toyota struck the left rear wheel area of the van. The Toyota sustained minor damage and the impact was sufficient to deploy the driver's air bag. The air bag deployed against the child driver's chin, neck, and chest, which hyper-extended his neck and resulted in facial abrasions, neck contusions and abrasions, a cervical spine fracture, a brain stem transaction, frontal lobe contusions, a subarachnoid hemorrhage and multiple abrasions to the upper extremities. The front right passenger stated that the driver slumped to the left side following the deployment. The Toyota was deflected from the van, free-rolled onto the roadside, and came to rest against the left rear aspect of a parked Chevrolet Cavalier. The front right passenger removed the unresponsive driver from the vehicle through the front left door. The child driver was transported by ambulance to a local hospital were he was pronounced deceased one hour following the crash. The front right passenger was not injured.			
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CALSPAN ON-SITE CHILD DRIVER AIR BAG-RELATED FATALITY INVESTIGATION
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BACKGROUND

Figure 1. Damaged 1993 Toyota Tercel

This on-site investigation focused on the injury mechanisms for a 7-year-old male child driver of a 1993 Toyota Tercel **(Figure 1)**. The Toyota was equipped with a driver's frontal air bag system that deployed as a result of the crash sequence. An 8-year-old male seated in the front right position and restrained by a 2-point lap belt and automatic shoulder belt also occupied the Toyota. The driver was unrestrained and was positioned on the edge of the driver's seat cushion with the seat adjusted full forward so he could reach the foot controls. The 7-year-old male was operating the vehicle westbound on a dirt roadway within the confines of a residential trailer park. The child driver became distracted looking to the left as the vehicle approached an intersecting private roadway on the right side. The driver realized that he was supposed to turn right onto the intersecting roadway and steered right. The child initiated a wide right turn, striking a 1979 Ford Van that was stopped at the intersection, waiting to turn right onto the westbound roadway. The front left corner of the Toyota struck the left rear wheel area of the van. The Toyota sustained minor damage and the impact was sufficient to deploy the driver's air bag. The air bag deployed against the child driver's chin, neck, and chest, which hyper-extended his neck and resulted in facial abrasions, neck contusions and abrasions, a cervical spine fracture, a brain stem transaction, frontal lobe contusions, a subarachnoid hemorrhage and multiple abrasions to the upper extremities. The front right passenger stated that the driver slumped to the left side following the deployment. The Toyota was deflected from the van, free-rolled onto the roadside, and came to rest against the left rear aspect of a parked Chevrolet Cavalier. The front right passenger removed the unresponsive driver from the vehicle through the front left door. The child driver was transported by ambulance to a local hospital were he was pronounced deceased one hour following the crash. The front right passenger was not injured.

This crash was identified by the Calspan Special Crash Investigations (SCI) team during an Internet search of potential cases of interest to the agency on March 17, 2005. The news article was forwarded to NHTSA's Crash Investigations Division and the crash was assigned for on-site investigation on the day of notification. Contact was made with the investigating police agency and a copy of the Police Accident Report (PAR) was obtained. The vehicle had been initially impounded by the police agency; however, it had since been returned to the family, as it was their only means of transportation. Cooperation was established with the investigating police

agency to gain access to the vehicle. A language barrier prevented the SCI team from gaining immediate access through the family by telephone contact. The vehicle was inspected on March 24, 2005. The Ford van was driven from the scene after the crash, and could not be located for inspection. The parked Chevrolet was present at the crash scene and images of the vehicle were taken.

SUMMARY

Vehicle Data - 1993 Toyota Tercel

The 1993 Toyota Tercel was identified by the Vehicle Identification Number (VIN) JT2EL43T4PO (production sequence omitted). The vehicle was a four-door sedan equipped with a 1.5 liter, 4-cylinder engine, front-wheel-drive, an automatic transmission, 33 cm (13") diameter steel wheels, and power front disc/rear drum brakes. The vehicle's history was unknown. At the time of the vehicle inspection, the odometer read 159,873 km (99,343 miles). The manufacturer's recommended tire pressure was unknown. The specific tire information at the time of the SCI vehicle inspection was as follows:

Position	Tire	Measured Pressure	Measured Tread	Damage
LF	Goodyear Weather Handler LS P155/80R13	289.6 kPa (42.0 PSI)	3.2 mm (4/32")	None
LR	Goodyear Weather Handler LS P155/80R13	148.2 kPa (21.5 PSI)	6.4 mm (8/32")	None
RF	Goodyear Weather Handler LS P155/80R13	275.8 kPa (40.0 PSI)	3.2 mm (4/32")	None
RR	Goodyear VIVA 2 P175/70R13	227.5 kPa (33.0 PSI)	6.4 mm (8/32")	None

The 1993 Toyota Tercel was configured with front bucket seats with integral, open head restraints for the driver and front right passenger positions. The driver's seat track was adjusted to the full-forward track position at the time of the crash **(Figure 2)**, based on on-scene photographs and reports from police. The driver's seat track had been moved since the crash, and both seats were initially found in the full-rear track positions at the time of the SCI vehicle inspection. The Tercel was configured with a rear bench seat.

Figure 2. View showing position of driver's seat

Crash Site

This three-vehicle crash occurred during daylight hours in the state of North Carolina in March 2005. At the time of the crash, there were no adverse weather conditions and the dirt roadway was dry. The crash occurred at a T-intersection of a continuous-loop roadway within a mobile home park. The dirt roadway was configured with one travel lane in each direction and was

bordered by mobile home lots. The westbound approach to the intersection exhibited a slight right westbound curve, and the intersecting roadway formed the continuous loop to the Toyota's original point of departure. The north/south intersection leg was also configured with one travel lane in each direction. Concrete parking pads were present, slightly above-grade on the west roadside adjacent to each mobile home. The roadside exhibited a slight positive grade between the road edge and each pad. The scene schematic is included as **Figure 12** at the end of this narrative report.

Crash Sequence

Pre-Crash

The 7-year-old male driver and his 8-year-old brother took the family vehicle for a joyride within the confines of the trailer park. The investigating officer suggested that the children had operated the vehicle in the trailer park on previous occasions. The 7-year-old was operating the vehicle, and departed the residence in a westbound direction on the dirt roadway **(Figure 3)**. According to the statement from the front right passenger, the driver became distracted by something in a yard on the left side of the road as he approached the T-intersection. The driver realized that he needed to turn right in order to return to the residence via the continuous loop roadway. When he realized his proximity to the intersection, he initiated a right turn onto the intersecting roadway **(Figure 4)**. A 1979 Ford van was stopped at the end of the intersecting roadway, facing south, waiting to initiate a right turn. During the turning maneuver, the Toyota drifted wide left toward the stopped van.

Figure 3. Westbound approach for the Tercel

Figure 4. View of intersection showing trajectory of the Tercel

Crash

The front left aspect of the Toyota struck the left rear wheel of the Ford van. The impact was sufficient to deploy the driver's air bag in the Tercel and resulted in minor frontal damage to the Toyota. The Missing Vehicle algorithm of the WinSMASH program computed a total delta-V of 23.0 km/h (14.3 mph) for the Toyota, and 11 km/h (6.8 mph) for the Ford van, based on the Toyota's frontal crush profile. The specific longitudinal and lateral velocity changes were -23 km/h (-14.3 mph) and 4 km/h (2.5 mph) for the Toyota and – 8 km/h (-5 mph) and 7 km/h (4.3 mph) for the Ford. The Toyota was deflected from the stationary van and free-rolled in a tracking mode a total distance of 17 m (56') onto the west roadside. Due to the incapacitating

injuries to the child driver, there were no post-impact driver inputs. The Toyota rolled onto the concrete parking pad located on the west roadside. The front left aspect of the Toyota struck the left rear aspect of a parked 1994 Chevrolet Cavalier. The secondary impact resulted in minor surface damage to both vehicles, and was sufficient to terminate the forward travel of the Toyota. The secondary impact was not sufficient to displace the Cavalier from its parked position.

Post-Crash

The 8-year-old front right passenger exited the Toyota under his own power through the right front door. He told police that he ran around the vehicle, opened the driver's door, and removed the unresponsive 7-year-old driver. He stated that he subsequently ran to the family residence from the scene to alert a family member. Rescue personnel arrived on scene, and transported the 7-year-old child to a local hospital, where he was pronounced dead one hour following the crash. The 8-year-old front right passenger did not sustain injury and did not receive medical treatment. The Toyota was driven by a family member from the scene to the family residence, and was later impounded by police on the day of the crash. The 1979 Ford van was also driven from the scene. The 1994 Chevrolet Cavalier remained parked, and was subsequently moved to another section of the property by the owner. Police released the Toyota back to the owner a number of days following the crash investigation.

Vehicle Damage

Exterior Damage – 1993 Toyota Tercel

The 1993 Toyota Tercel sustained minor damage as a result of the frontal impact with the Ford van. The direct contact damage on the front bumper fascia began 21.0 cm (8.3") left of the centerline and extended 44.0 cm (17.3") to the left on the face of the bumper fascia **(Figure 5)**. The vertical height of the direct damage area measured 12.7 cm (5.0") on the face of the bumper fascia. A tear was present in the direct damage area of the plastic fascia, and significant scuff marks from engagement with the van's wheel also encompassed the direct damage area. The left aspect of the bumper fascia and beam were crushed rearward, and the maximum crush measured 6.6 cm (2.6") at the front left corner. The front left turn signal lens was fractured, and the total width of direct contact measured 44.0 cm (17.3") from the beginning of the scuffmark on the fascia to the fractured turn signal lens on the front left corner. The combined direct and induced damage involved the entire frontal width of the Toyota. The front bumper fascia was displaced and partially separated at the time of the vehicle inspection, and the bumper beam was crushed rearward **(Figure 6)**. There was no deformation present on the hood or front fenders. Six crush

Figure 5. View of frontal damage to bumper fascia

Figure 6. Overhead view of frontal crush profile

measurements were documented across the front bumper beam as follows: C1 = 6.6 cm (2.6”), C2 = 3.8 cm (1.5”), C3 = 1.3 cm (0.5”), C4 = 0.0 cm, C5 = 0.0 cm, C6 = 0.0 cm. The Collision Deformation Classification (CDC) for the impact with the Ford was 12-FLEW-1.

The damage associated with the secondary impact was minor and was masked by the damage associated with the initial impact. The CDC for the secondary impact was 12-FLEE-1.

Interior Damage – 1993 Toyota Tercel

The 1993 Toyota Tercel sustained minor interior damage as a result of the crash. There was no passenger compartment intrusion. A faint scuffmark was present on the bottom right corner of the knee bolster from contact with the driver’s right knee. The scuff mark began 7.6 cm (3.0”) to the left of the right edge and 10.2 cm (4.0”) above the bottom aspect, and extended to the bottom right corner. The left front door interior sustained minor deformation from possible occupant contact. The area above the armrest around the door handle release was slightly deformed, and a minor depression was present above the release handle.

Exterior Damage – 1994 Chevrolet Cavalier

The 1994 Chevrolet Cavalier sustained minor left rear damage **(Figure 7)** as a result of the secondary impact with the Toyota Tercel. The direct damage on the Cavalier was limited to the lower left aspect of the rear bumper. The direct damage began at the left rear bumper corner and extended 7.6 cm (3.0”) forward. The damage consisted of scuff marks and there was no lateral crush. The combined direct and induced damage involved the rear left aspect of the rear bumper. Faint lateral buckling was present on the rear plane of the bumper 67.3 cm (26.5”) left of the centerline. The CDC for the impact with the Toyota was 09-LBEE-1.

Figure 7. View of left side damaged area to the Cavalier

Safety Belt Systems – 1993 Toyota Tercel

The 1993 Toyota Tercel was configured with a manual 3-point lap and shoulder belt for the driver’s position that was configured with a sliding latch plate and an Emergency Locking Retractor (ELR). The driver’s safety belt was not worn by the driver in this crash. At the time of the vehicle inspection, the driver’s safety belt was found in the stowed position and was fully operational.

The front right passenger's safety belt system was configured with an automatic door mounted shoulder belt and a manual lap belt **(Figures 8)**. The automatic shoulder belt was configured with an ELR retractor mounted on the inboard aspect of the front right seat. The two-point shoulder belt was also configured with a sewn-on latch plate and passed through a plastic guide mounted above the retractor. The latch plate engaged with a fixed-position buckle that was mounted to the rear aspect of the interior door frame, located near the vertical mid-point of the window frame. There was no loading evidence on the automatic shoulder belt. The manual lap belt was configured with an ELR and a sewn-on latch plate. The lap belt passed through a plastic guide that was mounted on the outboard aspect of the seat cushion above the retractor. The guide also acted as a stop for the sewn-on latch plate. There was no loading evidence on the manual lap belt.

Figure 8. Automatic shoulder belt

Driver's Frontal Air Bag – 1993 Toyota Tercel

The 1993 Toyota Tercel was equipped with a frontal air bag for the driver. The driver's air bag deployed from the steering wheel hub through symmetrical H-configuration module cover flaps. The cover flaps measured 15.2 cm (6.0") in width and 8.9 cm (3.5") in height. It should be noted that at the time of the crash, the steering wheel was probably rotated 180 degrees. Both module cover flaps displayed contact evidence **(Figures 9 and 10)**. The bottom cover flap exhibited a distinct white fabric transfer on the top left corner from contact to the child driver's T-shirt. The fabric transfer measured 3.8 cm (1.5") in width and 3.5 cm (1.4") in height. The area around the transfer was deformed slightly. The top cover flap also sustained white fabric transfers, although not as pronounced as the transfers on the bottom flap. The transfers on the top flap began at the lower left corner, extended laterally 11.4 cm (4.5") to the right, and extended vertically 2.9 cm (1.1"). Fabric transfers were also located on the tear seam of the top flap.

Figure 9. Top air bag module cover flap

Figure 10. Bottom air bag module cover flap

The driver's air bag measured 66.0 cm (26.0") in diameter in its deflated state **(Figure 11)**. A faint probable tissue transfer was present on the right aspect of the air bag face. The transfer began 4.4 cm (1.8") above the horizontal centerline and 5.7 cm (2.3") to the right of the vertical centerline. The transfer extended 15.2 cm (6.0") downward and 18.4 cm (7.3") to the right.

Figure 11. Deployed driver's air bag

The driver's air bag was vented by two circular ports that measured 3.2 cm (1.3") in diameter. The vent ports were laterally spaced 15.9 cm (6.3") apart, and located 5.7 cm (2.3") inboard of the circumferential seam. The air bag was not tethered.

Occupant Demographics

Child Driver

Age/Sex:	7-year-old/Male
Height:	129.5 cm (51.0")
Weight:	27.2 kg (60.0 lbs)
Seat Track Position:	Full forward
Safety Belt Use:	Unrestrained
Usage Source:	Vehicle inspection, injury data
Eyewear:	None
Type of Medical Treatment:	Transported by ambulance to a local hospital and expired one hour following the crash

Child Driver Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Brain stem ponto-medullary laceration	Maximum (140212.6,8)	Expanding driver's air bag
Atlanto-occipital dislocation	Maximum (650208.2,6)	Expanding driver's air bag
Inferior frontal lobe contusions	Serious (140612.3,1)	Expanding driver's air bag
Subarachnoid hemorrhage	Serious (140684.3,9)	Expanding driver's air bag
Left lower eyelid laceration	Minor (290602.1,2)	Expanding driver's air bag
Anterior neck abrasions 13.0 x 7.6 cm (5.5 x 3.0")	Minor (390202.1,5)	Expanding driver's air bag
Anterior neck contusion	Minor (390402.1,5)	Expanding driver's air bag
Contusions on chin	Minor (290402.1,8)	Expanding driver's air bag

Faint contusion to left lateral arm 8.9 x 3.8 cm (3.5 x 1.5")	Minor (790402.1,2)	Left door panel
Abrasion on right index finger 0.5 x 0.5 cm (0.2 x 0.2")	Minor (790202.1,1)	Expanding driver's air bag
Right knee abrasion 1.3 x 0.6 cm (0.5 x 0.3")	Minor (890202.1,1)	Left knee bolster
Abrasions to whole region of face including, symmetrical right and left lower cheeks 1.5 x 0.5 cm (0.6 x 0.2"), inner lip 1.9 x 0.8 cm (0.8 x 0.4") chin 13.0 x 7.6 cm (5.5 x 3.0"), and forehead 1.9 x 1.0 cm (0.8 x 0.4").	Minor (290202.1,8)	Expanding driver's air bag

Injury source: *Autopsy, investigating officer (witnessed autopsy), medical examiner photographs.*

Driver Kinematics

Child Driver Kinematics

The 7-year old male child driver of the 1993 Toyota Tercel was seated on the leading edge of the seat cushion with the seat track adjusted to a police reported forward track position. His forward position was necessary in order for him to reach the foot pedals. In this position, he was in close proximity to the steering wheel and the driver air bag module. Given his stature and forward position on the seat cushion, his chest was at the approximate level of the air bag module.

At impact with the Ford van, the driver's frontal air bag deployed. The initial expansion of the bag resulted in flap contact to the chest of the child driver. His white T-shirt transferred onto the leading edges of the upper and lower flaps. The expanding air bag contacted the chest of the child driver and began to displace him rearward as the air bag membrane expanded circumferentially, initially abrading and contusing the underside of his chin and anterior neck. Continued air bag expansion hyper-extended the driver's neck, which resulted in a complete separation of the atlanto-occipital joint and a brain stem ponto-medullary laceration.

The air bag expanded across the driver's face resulting in multiple abrasions of the face and a laceration of the left eyelid. The deployment force of the expanding air bag produced multiple subarachnoid hemorrhage and inferior frontal lobe contusions of the brain.

The child driver responded to the frontal impact force as the air bag deployed against his body. His right knee impacted the knee bolster, which resulted in a contusion over the knee. He was subsequently displaced rearward and to his left be the deploying air bag. His upper left arm contacted the left interior door panel resulting in a faint contusion of the arm. He also sustained an abrasion of the right index finger that was related to air bag expansion.

The child driver came to rest slumped in the driver's position of the vehicle. He was removed from the vehicle by the 8-year old front right passenger and placed on the ground adjacent to the

vehicle while the 8-year old ran to his residence to summon assistance. Rescue personnel arrived on scene and transported the child driver to a local hospital where he was pronounced deceased one hour post-crash.

Front Right Passenger

Age/Sex:	8-year-old/Male
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Full-rear
Manual Restraint Use:	Automatic shoulder belt/manual lap belt
Usage Source:	Police report
Eyewear:	None
Type of Medical Treatment:	Did not sustain injury and did not receive medical treatment

Front Right Passenger Kinematics

The 8-year-old child passenger was restrained by the automatic shoulder belt and the manual lap belt. At impact, he initiated a forward trajectory and loaded the restraint system. He did not sustain injury, although police reported he had a complaint of minor abdominal pain from probable loading to the lap belt. He rebounded rearward into the front right seat back and came to rest in the front right seat as the vehicle free-rolled to final rest.

The secondary impact did not result in any additional displacement. The 8-year-old male child exited the vehicle under his own power. He ran around the vehicle and removed the driver from the Toyota. He subsequently ran across the trailer court to notify a family member of the crash. He did not receive medical treatment.

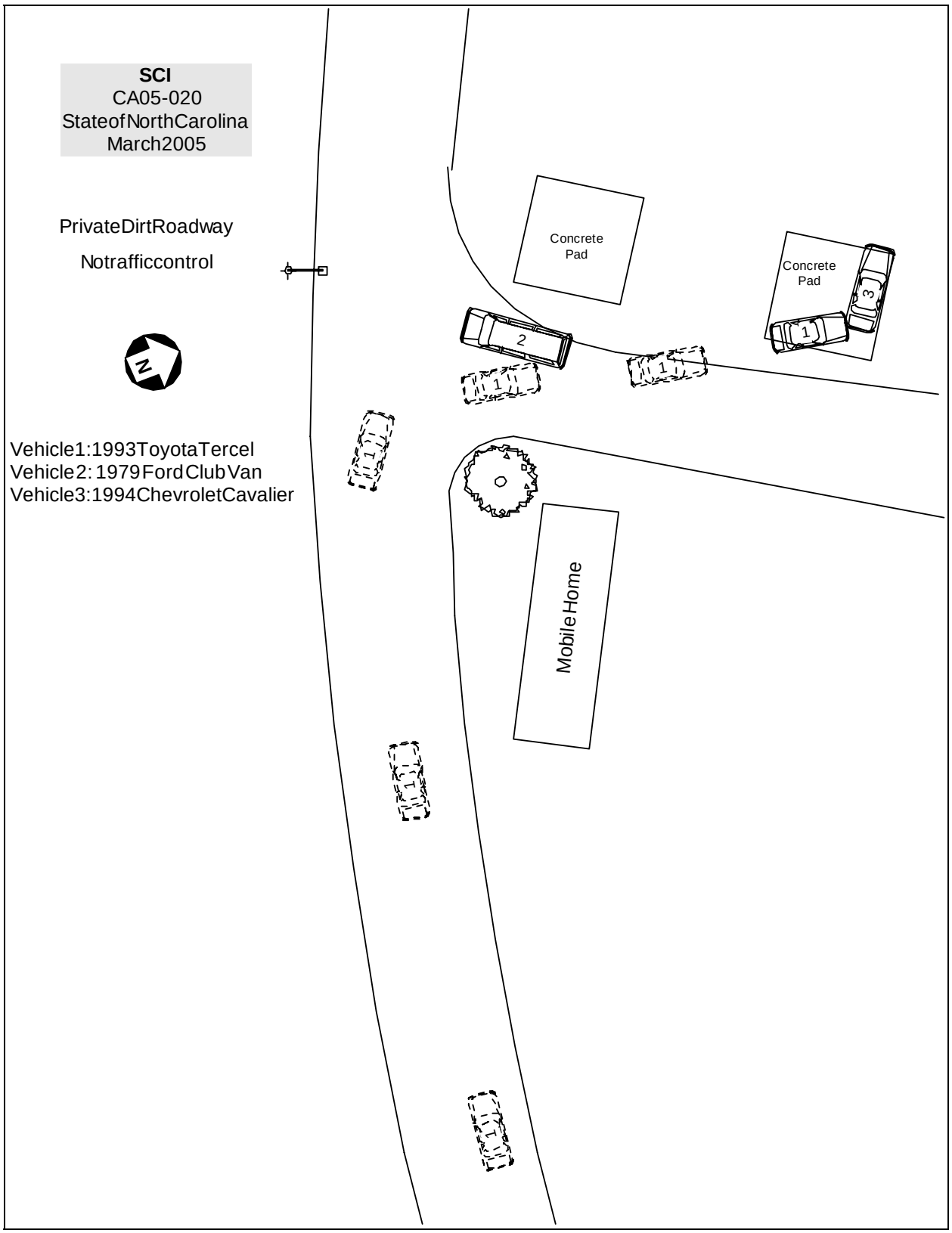

Figure 12. Scene schematic