CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE CRASH INVESTIGATION
SCI CASE NUMBER: CA08045

VEHICLE: 2007 TOYOTA SOLARA

LOCATION: TEXAS

CRASH DATE: JULY 2008

Contract No. DTNH22-07-C-00043

Prepared for:

U.S. Department of Transportation

National Highway Traffic Safety Administration

Washington, D.C. 20590

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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.

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. CA08045	*2. Government Accession No.*	*3. Recipient's Catalog No.*	
4. Title and Subtitle Calspan On-Site Side Impact Inflatable Occupant Protection System Crash Investigation Vehicle: 2008 Honda Civic Location: North Carolina		*5. Report Date*: October 2010 *6. Performing Organization Code*	
7. Author(s) Crash Data Research Center		*8. Performing Organization Report No.*	
9. Performing Organization Name and Address Crash Data Research Center Calspan Corporation P.O. Box 400 Buffalo, New York 14225		*10. Work Unit No.* *11. Contract or Grant No.* DTNH22-07-C-00043	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590		*13. Type of Report and Period Covered* Technical Report Crash Date: July2008 *14. Sponsoring Agency Code*	
15. Supplementary Note An investigation focusing on the Certified Advanced 208-Compliant air bag system in a 2007 Toyota Solara.			
16. Abstract This on-site investigation focused on the deployment of the frontal and side air bag systems of the 2007 Toyota Solara. The Toyota was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual-stage air bags for the driver and front right passenger, seat track positioning sensors, safety belt buckle switches, safety belt retractor pretensioners, and an occupant presence sensor for the front right seating position. The manufacturer of the Toyota has certified that this vehicle is complaint to the advanced air bag portion of Federal Motor Vehicle Safety Standard No. 208. The Toyota was also equipped with a side impact air bag system consisting of front seatback-mounted and Inflatable Curtain (IC) air bags. The Toyota traveled across a four-leg intersection, overrode the curb and impacted the barrier wall that was located parallel to and outboard of the intersecting street. The vehicle was occupied by a 28-year-old female driver and a 48-year-old female front right passenger, both restrained by the manual safety belt systems. The driver sustained AIS-3 level internal injuries and was transported to a trauma center where she was admitted for treatment. The right front passenger sustained non-incapacitating injuries and was transported to a local hospital for treatment. The right front occupant could not be located for interview, and the hospital refused to release the medical records.			
17. Key Words Certified Advanced 208-Compliant frontal air bag system (CAC) Frontal Crash AIS 3 Injuries Inflatable Curtain (IC) air bags		*18. Distribution Statement* General Public	
19. Security Classif. (of this report) Unclassified	*20. Security Classif. (of this page)* Unclassified	*21. No. of Pages* 11	*22. Price*

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BACKGROUND


Figure 1: Left front oblique view.

This on-site investigation focused on the deployment of the frontal and side air bag systems of the 2007 Toyota Solara shown in **Figure 1**. The Toyota was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual-stage air bags for the driver and front right passenger, seat track positioning sensors, safety belt buckle switches, safety belt retractor pretensioners, and an occupant presence sensor for the front right seating position. The manufacturer of the Toyota has certified that this vehicle is complaint to the advanced air bag portion of Federal Motor Vehicle Safety Standard No. 208. The Toyota was also equipped with a side impact air bag system consisting of front seatback-mounted and Inflatable Curtain (IC) air bags. The Toyota traveled across a four-leg intersection, overrode the curb and impacted the barrier wall that was located parallel to and outboard of the intersecting street. The vehicle was occupied by a 28-year-old female driver and a 48-year-old female front right passenger, both restrained by the manual safety belt systems. The driver sustained AIS-3 level internal injuries and was transported to a trauma center where she was admitted for treatment. The right front passenger sustained police reported non-incapacitating injuries and was transported to a local hospital for treatment. The right front occupant could not be located for interview, and the hospital refused to release the medical records.

The Police Crash Report (PAR) for this July, 2008 crash was forwarded to National Highway Traffic Safety Administration (NHTSA) by the National Automotive Sampling System (NASS). The PAR was forwarded to the Calspan Special Crash Investigations (SCI) team on September 12, 2008 for follow-up of a possible on-site investigation. The SCI team located the vehicle and secured cooperation of the insurance company to inspect the Toyota and remove the Event Data Recorder (EDR) for imaging by Toyota. The on-site investigation took place September 17-18, 2008 and involved the inspection and documentation of the vehicle and the crash site.

SUMMARY

Crash Site

This crash occurred during nighttime hours at a controlled four-leg intersection. The route of travel for the Toyota was northbound in a 3.3 m (11 ft) wide left turn lane, as seen in **Figure 2**. To the right of the left turn lane were two straight travel lanes and one right turn lane. The two straight lanes continued through the intersection. A traffic signal support pole was located 3.7 m (12 ft) to the left of the curb, directly across the intersection from the left turn lane. The posted speed limit for this one-way four-lane roadway was 64 km/h (40 mph).

Figure 2: Travel lane of the Toyota.

The left intersecting leg was a four-lane roadway on a bridge. There were two travel lanes in each direction, divided by a 1.8 m (6 ft) wide by 15 cm (6 in) high concrete median. On both sides of the bridge, parallel to the travel lanes and outboard of 15 cm (6 in) high concrete curbs, were 1.8 m (6 ft) wide raised concrete landscaping islands. A sidewalk was outboard of the islands on both sides of the bridge. Encompassing the edge of the bridge was a 30 cm (12 in) thick concrete retaining wall with 66 cm (26 in) tall double row metal bridge rail on top. The overall height of this wall was 165 cm (65 in). At the time of the crash, the nighttime weather was partly cloudy. The dry, straight and level concrete roadway was illuminated by several streetlights. The crash schematic is attached as **Figure 13**.

Vehicle Data

The 2007 Toyota Solara SE **(Figure 3)** was manufactured in January 2007 and was identified by the Vehicle Identification Number (VIN): 4T1CE30P67U (production sequence deleted). The odometer reading at the time of SCI inspection could not be obtained due to vehicle damage. This front-wheel drive vehicle had a 274 cm (108 in) wheelbase. Power came from a 2.4-liter, 4-cylinder gasoline engine linked to a 4-speed automatic transmission. The service brakes consisted of four-wheel, power-assisted discs with anti-lock. The Toyota was also equipped with power steering, power windows, and power locks. A sunroof was integrated into the roof of the vehicle. The Gross Vehicle Weight Rating (GVWR) was 1,465 kg (3,223 lb).

Figure 3: Right front oblique view.

The manufacturer had recommended the tire size of P215/60R16 with cold tire pressure of 200 kPa (29 psi) for all four positions. The tires were Bridgestone Potenza RE 92 of the recommended size, with matching 08X8 PFA 5106 tire identification numbers. All four tires were mounted on OEM 5-spoke alloy wheels. The Toyota was equipped with a direct Tire

Pressure Monitoring System (TPMS). Specific tire data at the time of SCI inspection was as follows:

POSITION	PRESSURE	TREAD DEPTH	DAMAGE
LF	Flat	6 mm (8/32 in)	Tire punctured in tread and sidewall, alloy wheel fractured
LR	214 kPa (31 PSI)	4 mm (5/32 in)	None
RR	221 kPa (32 PSI)	3 mm (4/32 in)	None
RF	Flat	5 mm (6/32 in)	Tire puncture in sidewall, deformation of outer bead of wheel

The interior of the Toyota was configured for the seating of five occupants. The two front seating positions featured leather Liquicell bucket seats with power track adjustment, manual seatback angle adjustment, and manually adjustable head restraints. At the time of the SCI inspection, both head restraints were adjusted full-down. The rear three passenger fixed bench seat had folding seatbacks split 60/40 from right to left. The two outboard positions incorporated manual adjustable head restraints. These were positioned right and left, full-down and 1 cm (0.5 in) from full-down, respectively, at the time of SCI inspection. All five seating positions were equipped with 3-point lap and shoulder safety belts.

Crash Sequence

Pre-Crash

The Toyota was traveling northbound on the concrete road surface in the left turn lane of the one-way, four-lane roadway as it approached the intersection. The west intersecting leg was a four-lane roadway over a bridge immediately to the west of the intersection. The Toyota entered the intersection on a near straight-line trajectory and departed the north edge of the roadway.

Crash

As the Toyota departed the roadway, the front tires and associated undercarriage impacted the curb. Both front wheel rims were damaged by these impacts. The vehicle continued on its travel path, and the left bumper corner impacted the raised concrete landscaping island. As the Toyota contacted the end radius of the concrete island, it was deflected approximately 20 degrees clockwise (CW). This impact engagement caused front left corner and left side damage to the Toyota, and was evidence by gouge marks, abrasions, and rubber transfer on the end radius of the concrete island. The Toyota continued on its forward trajectory and impacted the concrete retaining wall and bridge rail with the full frontal structure. **Figure 4** is an overall view of the crash site.

Figure 4: Location of impacts.

The 12 o'clock direction of the impact force resulted in a total longitudinal delta-V of 69 km/h (43 mph) for this barrier-type impact. The lateral component was 0 km/h. Based on SCI

experience and vehicle damage, the WinSMASH calculations appear to be overestimated. The frontal CAC and left side impact air bag systems deployed as a result of the crash. The top of the concrete wall was displaced forward 5 cm (2 in).

Post-Crash

Emergency response to the incident scene included the local police department, fire and rescue personnel, and Emergency Medical Services (EMS). The driver of the Toyota was unable to exit the vehicle due to the left door having been jammed shut by induced deformation from the impact forces. The door was pried open by emergency response personnel and the driver exited the vehicle with assistance. Both the driver and right front passenger were transported by EMS ground ambulance to a local trauma center for treatment. The Toyota was towed from scene due to damage.

2007 Toyota Solara

Exterior Damage

The Toyota sustained disabling frontal damage as a result of the crash sequence. The initial events fractured the left front wheel and dented the right front wheel. Both tires were punctured and aired out. The Collision Deformation Classification (CDC) associated with these events was 12FLWN3 and 12FRWN3. Damage from the third impact with the raised concrete landscaping island was overlapped by damage from the final impact event. However, crush, scuffing, and abrasion damage was present on the forward lower aspect of the left front door. The CDC associated with this event was estimated at 12FLEE6.

The impact with the concrete wall caused damage resembling a barrier-type crash crush profile. The bumper fascia and grille were separated. The head, marker, and fog lighting assemblies were disintegrated. The hood was buckled, and there were two distinct areas of contact from the bridge rail post during maximum engagement, as seen in **Figure 5**. These contact areas extended diagonally from 24 cm (9 in) to 36 cm (14 in) and 52 cm (20 in) to 62 cm (24 in) left of center. Under hood components including the radiator, fluid reservoirs, battery, and engine were all damaged and crushed rearward. The battery was destroyed by the crush, and acid leakage was found inside the vehicle. The left front suspension was separated and the wheel was rotated with its outboard side facing rearward, crushed into the firewall aft of its pre-crash axle location. The left front fender was crushed and displaced right laterally and rearward. The driver's door had been jammed shut as a result of induced crush, and had been pried open by emergency services personnel. Damage to the vehicle glazing included the disintegration of the driver's door glazing and complete fracturing of the windshield.

Figure 5: Left side damage to the Toyota.

The induced and direct contact damage extended 123 cm (48 in) from bumper corner to bumper corner. The accompanying crush profile was measured at mid-bumper level, minus free space, with the following results: C1 = 55 cm (22 in), C2 = 61 cm (24 in), C3 = 65 cm (26 in), C4 = 64 cm (25 in), C5 = 53 cm (21 in), C6 = 37 cm (15 in). Maximum crush was located at C3. The Collision Deformation Classification (CDC) for the damage pattern **(Figure 6)** was 12FDEW3.

Figure 6: Frontal damage from barrier-type crash.

Interior Damage

Interior damage included passenger compartment intrusion and occupant contact. On the left side, the knee bolster and mid-instrument panel were bowed outward and intruded. As seen in **Figure 7**, this intrusion was the result of the displacement of the left front wheel. On the right side, rearward crush resulted in the intrusion of the toe pan and components within the instrument panel. Accordingly, the glove box that was located below the instrument panel forward of the right front seating position had popped open and could not be closed.

Figure 7: Left side interior toe pan intrusion.

Intrusions measured as follows:

POSITION	COMPONENT	MAGNITUDE	DIRECTION
LF	Toe pan	28 cm (11 in)	Longitudinal
LF	Left side of center console	8 cm (3 in)	Lateral
LF	Mid-instrument panel	5 cm (2 in)	Longitudinal
RF	Toe pan	3 cm (1 in)	Longitudinal

The steering wheel consisted of 3-spokes, positioned at 3, 6, and 9 o'clock. There was forward deformation of the upper half of the wheel rim from the 3 to 9 o'clock positions, measuring 4 cm (2 in). Both of the lateral spokes were also bent forward, as seen in **Figure 8**. The lower half of the steering wheel was deformed forward 1 cm (0.5 in). The steering column had 0.5 cm (0.25 in) of displacement of left sheer capsule, but the right could not be seen.

Figure 8: Steering wheel deformation.

Occupant contact points from the driver were located on the knee bolster and instrument panel. There was an 8 cm (3 in) wide by 10 cm (4 in) tall

forward pocketing deformation to the knee bolster beginning 20 cm (8 in) left of vehicle centerline and 36 cm (14 in) below the top of the instrument panel. Toward the middle of the instrument panel on the left side of the driver seating position was a 13 cm (5 in) wide by 10 cm (4 in) tall area of scuffing and blue fabric transfer. This began 48 cm (19 in) left of vehicle centerline and 22 cm (9 in) below the top of the instrument panel.

Occupant contact points from the front right passenger were located on the knee bolster and instrument panel. Indentation and compression of the padded instrument panel was located immediately above the glove box, from 20 cm (8 in) to 27 cm (11 in) right of the vehicle centerline.

Manual Safety Belt Systems

All five seating positions were equipped with 3-point lap and shoulder safety belts utilizing continuous loop webbing with sliding latch plates. The front left safety belt was equipped with an Emergency Locking Retractor (ELR) with a retractor pretensioner. The right front seating position had an ELR and Automatic Locking Retractor (ALR) with pretensioner. All three rear safety belts utilized ELR/ALR retractors.

The driver was restrained by the 3-point lap and shoulder safety belt at the time of the crash. Evidence of loading was found on the webbing, latch plate, and D-ring during the SCI inspection. This consisted of 15 cm (6 in) of loading transfer on the webbing from the D-ring, extending toward the location of the driver's shoulder. There was also loading transfer from the latch plate that extended from 81 cm (32 in) to 86 cm (34 in) below the D-ring. The retractor pretensioner had actuated as a result of the crash.

The right front passenger was restrained by the 3-point lap and shoulder safety belt at the time of the crash. Evidence of loading was found on the webbing, latch plate, and D-ring during SCI inspection. This consisted of 29 cm (11.5 in) of loading transfer on the webbing from the D-ring, extending toward the location of the passenger's shoulder. There was also loading transfer from the latch plate that extended from 80 cm (31 in) to 85 cm (33 in) below the area of D-ring transfer. The latch plate and D-ring had abrasions from contact with the belt. An area of discoloration from occupant contact was located on the webbing from 39 cm (15 in) to 56 cm (22 in) below the area of D-ring transfer. Abrasions from the belt webbing were found on the manual seatback recline lever on the side of the seat. The retractor pretensioner had actuated as a result of the crash, locking the belt in the worn position.

Frontal Air Bag System

The Toyota was equipped with the CAC frontal air bag system that consisted for the driver and front right passenger positions, both of which deployed during the crash sequence.

Figure 9: Driver air bag.

The driver air bag was identified by the manufacturer's code GA120-15110 15116026159. The air bag had properly deployed through its designated flaps in the face of the steering wheel without damage. The 61 cm (24 in) diameter air bag had two center circles of green tether stitching measuring 18 cm (7 in) and 22 cm (9 in) in diameter, as seen in **Figure 9**. The associated tethers were at the 3 and 9 o'clock positions. There were two 4 cm (2 in) vertical vent slits in the back of the bag. A small 2 cm (1 in) diameter area of occupant contact was located 13 cm (5 in) above the horizontal centerline on the vertical centerline.

Figure 10: Front right passenger air bag.

The front right passenger air bag was mounted in the top of the instrument panel. Two vertical trapezoidal and two horizontal triangular flaps formed the rectangular cover. The upper and lower trapezoidal shaped flaps measured 22 cm (9 in) long outboard and 10 cm (4 in) long inboard. The right and left triangular flaps had 13 cm (5 in) vertical bases and extended 5 cm (2 in) inward. The 61 cm (24 in) tall air bag was trapezoidal in shape, measuring 46 cm (18 in) and 38 cm (15 in) wide at its upper and lower aspects, respectively. There were two 5 cm (2 in) diameter vents, centered 19 cm (8 in) aft of the hinge point of the lower flaps on either side. Two black vertical expansion marks were on the face of the air bag. Abrasions and damage were found above the front right passenger air bag to the inside of the windshield glazing, attributed to the bag's deployment during the crash. There was no direct occupant contact evidence found on the air bag, as seen in **Figure 10**.

Side Impact Air Bag System

The Toyota was equipped with seatback-mounted side impact air bags and roof side rail-mounted IC air bags. Forces from the collision triggered the deployment of this side air bag system only on the left side **(Figure 11)**. The left IC air bag was identified by the manufacturer's bar code TE2TYUSAAFD. Labeling at the B-pillar declared that this air bag was constructed of Automotive Safety Components International (ASCI) recognized PA 6.6 nylon material. Vertical dimensions of this air bag included 34 cm (13.5 in) tall at its forward aspect, 33 cm (13 in) tall at the B-pillar, and 28 cm (11 in) tall at its rear aspect. Coverage of the air bag extended 72 cm (28 in) forward of the B-pillar, and 83 cm (33 in) rearward. There was no contact evidence found on this air bag.

Figure 11: Deployed left side impact air bag system.

The left seatback-mounted side impact air bag was identified by the manufacturer's barcode number 603906101A TJMTZF02AIT. This rectangular shaped air bag was 36 cm (14 in) long by 27 cm (11 in) wide. There were no vents or tethers. The air bag deployed through 44 cm (17 in) of the stitching on the outboard aspect of the seatback. This was at the thoracic to lumbar level of the occupant. No contact evidence was found on this air bag.

Event Data Recorder

The air bag systems were controlled by an Air bag Control Module (ACM) located under the center console **(Figure 12)**. The ACM had EDR capabilities. The EDR data was removed from the vehicle by the SCI team and sent to NHTSA for imaging by Toyota. The EDR in the 2007 Toyota Solara had the capability and capacity to record and store two longitudinal and two lateral crash events. The events were designated "Latest" and "Next Most-Recent", and two 5 second pre-crash memory buffers stored data elements related to each individual event. The imaged EDR had one stored event, termed the "Latest" event, which appeared to be related to the subject crash. The "Latest" event data reported that both the driver and passenger belts were buckled, with the driver's seat in a rearward track position. This data was consistent with the SCI inspection. The deployment time was reported to be 26 milliseconds for both frontal air bags. They were deployed in the "Hi" stage. All times were reported with respect to the initial crash recognition.

Figure 12: EDR mounted in the Toyota.

The EDR had the capacity to record 150 milliseconds of delta-V data. The maximum reported longitudinal delta-V was 23.7 km/h (14.7 mph) at 150 milliseconds. The graph of the respective

crash pulse had a positive slope at the end of the recording. The delta-V was still increasing, indicating that the entire crash pulse was not recorded. This EDR did not have the capability to record pre-crash data per Toyota. The pre-crash fields in the imaged data were all zero.

Occupant Data

Driver Demographics

Age/Sex:	28-year-old / Female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Middle to rear
Safety Belt Usage:	Restrained by the 3-point lap and shoulder safety belt
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Egress prevented by induced damage to door, exited with assistance after emergency personnel pried open door
Type of Medical Treatment:	Transported by ground ambulance to a local hospital where she was admitted for three days

Driver Injuries

Injury	Injury Severity (AIS 2005/Update 08)	Injury Source
Superior mesenteric artery injury, NFS	Serious (521499.3,9)	Steering wheel
Mesentary hematoma/contusion	Moderate (542020.2,8)	Steering wheel
Laceration of the 3rd digit, left foot	Minor (890602.1,2)	Foot pedals
Lower abdominal abrasion	Minor (590202.1,8)	Safety belt
Right eyebrow abrasion	Minor (290202.1,1)	Air bag

Source - Medical Records

Driver Kinematics

The driver of the Toyota was seated in a rear-third seat track position and restrained by the manual 3-point lap and shoulder safety belt system. Evidence of loading on the belt system components and actuation of the pretensioner confirmed belt use.

The driver responded to the frontal impact events by initiating a forward trajectory. Loading of the belt system and occupant contact points could not be separated by event. During the sequence, her torso loaded the safety belt system, causing a minor severity lower abdominal abrasion. Her knees contacted the instrument panel and knee bolster, evidenced by the scuffing, fabric transfer, and deformation to the mid-instrument panel and knee bolster. As the vehicle crushed against the concrete retaining wall, deformation resulted in the longitudinal intrusion of the toe pan and vertical intrusion of the floor in the area of the vehicle foot pedal controls. This resulted in a minor severity laceration on the third digit of the driver's left foot. The driver loaded the deployed air bag and compressed the air bag against the steering wheel, which caused a minor severity abrasion injury to the driver's right eyebrow.

Her loading force was transmitted through the air bag and into the steering wheel rim and column. Her lower abdomen engaged the steering wheel, resulting in a mesenteric hematoma/contusion, and a superior mesenteric artery injury. The driver rebounded against the seatback as the vehicle came to rest. Deformation to the driver's door prevented her egress without the assistance of emergency services personnel. She was transported by EMS ground ambulance to a trauma center where she was hospitalized for three days in the intensive care unit.

Right Front Passenger Demographics

Age/Sex:	48-year-old / Female
Height:	Unknown
Weight:	Unknown
Seat Track Position:	Middle to rear
Safety Belt Usage:	Restrained by 3-point lap and shoulder safety belt
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Unknown
Type of Medical Treatment:	Transported by ground ambulance to a local hospital, treatment status unknown

Right Front Passenger Injuries

The right front passenger was transported to a local hospital by ground ambulance for the treatment of police reported non-incapacitating injuries. However, the exact injuries sustained by the right front passenger are unknown. Medical records could not be obtained, and the occupant could not be located for an interview by the SCI team.

Right Front Passenger Kinematics

The right front passenger of the Toyota was seated in a rear-third seat track position and restrained by the manual 3-point lap and shoulder safety belt system. Evidence of loading on the belt system components and actuation of the pretensioner confirmed belt use.

The right front passenger initiated a forward trajectory in response to the frontal impacts that involved the tires/wheels and landscape island. She continued a forward trajectory as a result of the major impact with the concrete wall. Her torso loaded the safety belt system and deployed frontal air bag. Her left knee contacted the instrument panel, evidence by the scuffmark and deformation on the left mid-instrument panel area in relation to the right front seat. These contacts resulted in unknown injuries. She then rebounded against the seatback as the vehicle came to rest. The right front passenger's method of egress from the vehicle following the crash is unknown. She sustained police reported non-incapacitating injuries and was transported by EMS ground ambulance to a local hospital for treatment.

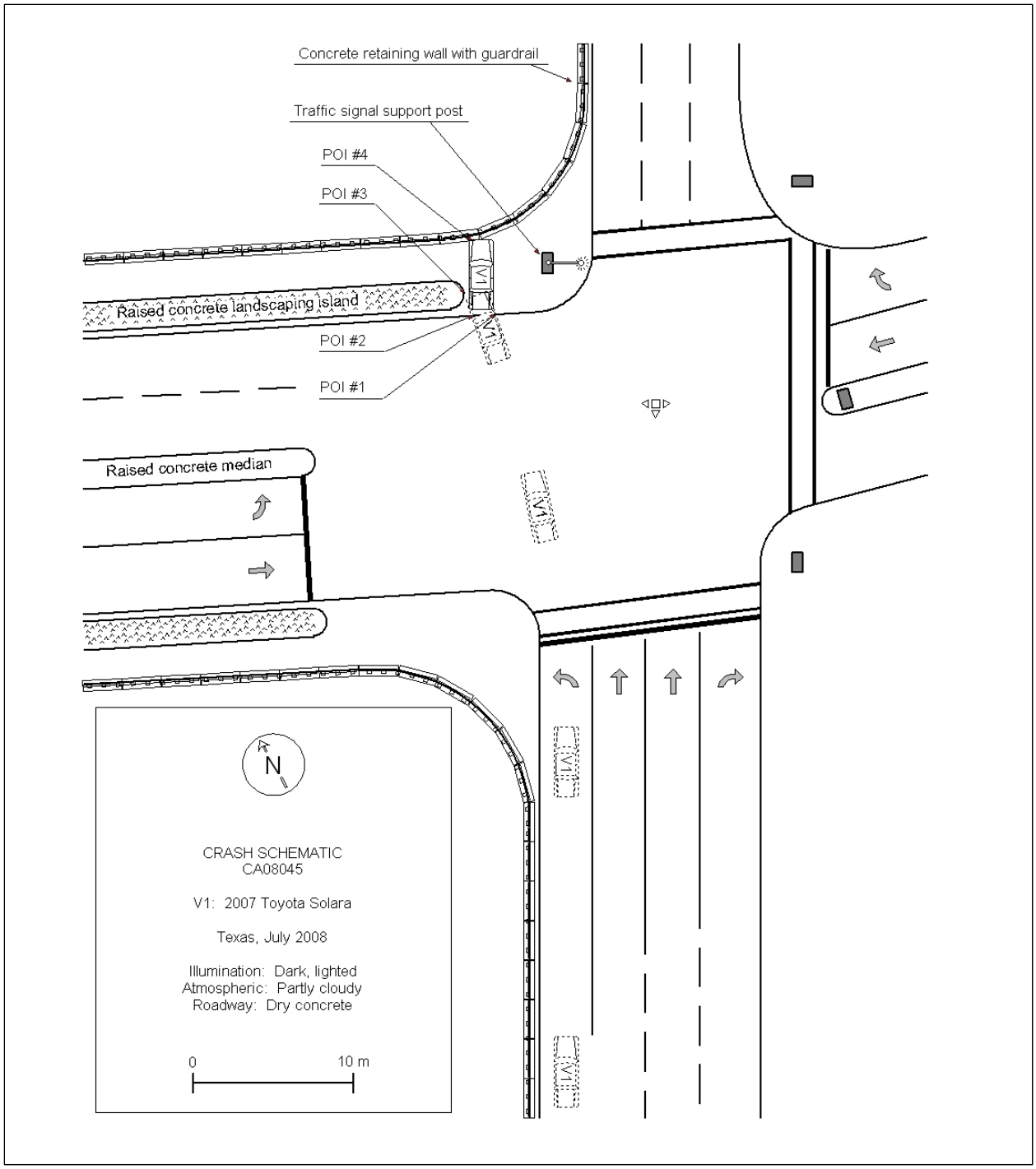

Figure 13: Crash Schematic