

CRASH DATA RESEARCH CENTER

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**CALSPAN ON-SITE CERTIFIED ADVANCED 208-COMPLIANT
VEHICLE CRASH INVESTIGATION**

SCI CASE NO: CA05-045

**VEHICLE: 2005 TOYOTA CAMRY
LOCATION: MARYLAND
CRASH DATE: JUNE 2005**

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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<p>16. Abstract</p> <p>This investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in a 2005 Toyota Camry and injury sources for the 49 year old female driver and the 19 year old female front right passenger. The advanced occupant protection system in the Toyota was comprised of dual-stage frontal air bags, front safety belt buckle switch sensors, front seat belt pretensioners, and a front right occupant detection sensor. The frontal air bags in the Toyota deployed as a result of a frontal impact with a roadside barrier. The deployment of these safety systems was controlled by the Air bag Control Module (ACM) located under the center console. The ACM had the capabilities to record crash event data. A secondary focus of the investigation involved the removal of the vehicle's air bag control module. The ACM was forwarded to the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) and NHTSA in-turn forwarded the ACM to the vehicle's manufacturer in order to download any available crash data.</p> <p>At the time of the crash, the Toyota was westbound in the right lane of a two-lane divided highway. The vehicle was driven by a 49 year old restrained female driver and was occupied by a 19 year old restrained female front right passenger. The driver swerved right to avoid another vehicle, passed through the outboard road shoulder and struck the roadside barrier. The force of the crash resulted in the deployment of the vehicle's frontal air bags. The driver was transported to a local hospital with police reported non-incapacitating injuries. The front right passenger was not injured.</p>			
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CRASH DATE: JUNE 2005**

BACKGROUND

This investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in a 2005 Toyota Camry, **Figure 1**, and injury sources for the 49 year old female driver and the 19 year old female front right passenger. The advanced occupant protection system in the Toyota was comprised of dual-stage frontal air bags, front safety belt buckle switch sensors, front seat belt pretensioners, and a front right occupant detection sensor. The manufacturer certified the CAC system met the requirements of the advanced Federal Motor Vehicle Safety Standard No. 208. The frontal air bags in the Toyota deployed as a result of a frontal impact with a roadside barrier. The deployment of these safety systems was controlled by the Air bag Control Module (ACM) located under the center console. The ACM had the capabilities to record crash event data. A secondary focus of the investigation involved the removal of the vehicle's air bag control module. The ACM was forwarded to the Crash Investigation Division of the National Highway Traffic Safety Administration (NHTSA) and NHTSA in-turn forwarded the ACM to the vehicle's manufacturer in order to download any available crash data.



Figure 1: Front right view of the Toyota Camry.

At the time of the crash, the Toyota was westbound in the right lane of a two-lane divided highway. The vehicle was driven by a 49 year old restrained female driver and was occupied by a 19 year old restrained female front right passenger. The driver swerved right to avoid another vehicle, passed through the outboard road shoulder and struck the roadside barrier. The force of the crash resulted in the deployment of the vehicle's frontal air bags. The driver was transported to a local hospital with police reported non-incapacitating injuries. The front right passenger was not injured.

The Crash Investigation Division of the NHTSA identified this crash through the General Estimate System (GES) of police reported crashes and assigned an on-site investigation of the crash to the Calspan Special Crash Investigations (SCI) team. The crash was assigned due to the agency's interest in the performance of the advanced safety systems installed on current model year vehicles. The Calspan SCI team initiated a follow-up investigation with the vehicle's insurance carrier and located the Toyota at an insurance salvage facility. The vehicle was available for inspection. The on-site portion of the investigation took place July 28, 2005.

SUMMARY

VEHICLE DATA

The 2005 Toyota Camry was identified by the Vehicle Identification Number (VIN): 4T1BE30K05U (production sequence deleted). The front-wheel drive, four-door sedan was manufactured in the United States in March 2005 and was equipped with the XLE level trim package. The power train consisted of a 2.4 liter/I4 engine linked to a four-speed automatic transmission with overdrive. The vehicle was equipped with power-assist, four-wheel disc brakes with ABS. The manual restraint systems consisted of three-point lap and shoulder belts for all five seat positions. The front seat belts were equipped with retractor pretensioners. The Toyota was equipped with a frontal air bag system certified by the manufacturer to have met the requirements of the advanced Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The frontal air bags deployed as a result of the crash. The vehicle was also equipped with an inflatable side impact protection system to include front seat back mounted thorax air bags and roof-rail mounted side curtains. The inflatable side impact protection system was not commanded to deploy in the frontal crash. The vehicle was equipped with Bridgestone Protenza RE92 P215/60R16 tires on OEM alloy wheels. The recommended tire pressure was 200 kPa (29 PSI) front and rear. The specific measured tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	221 kPa (32 PSI)	7 mm (9/32 in)	No	None
LR	262 kPa (38 PSI)	8 mm (10/32 in)	No	None
RF	214 kPa (31 PSI)	7 mm (9/32 in)	No	None
RR	221 kPa (32 PSI)	8 mm (10/32 in)	No	None

CRASH SITE

This single vehicle crash occurred during the afternoon hours of June 2005. At the time of the crash, it was daylight and the weather was not a factor. The asphalt road surface was dry. The crash occurred at a hillcrest on a two-lane section of an east/west divided interstate highway in an urban setting, **Figure 2**. There was a large radius left curve for westbound traffic. At the scene, the roadway reduced from three lanes to two lanes approximately 0.8 km (0.5 mile) upstream of the crash site due to the junction of two multi-lane traffic ways. An entrance ramp from the intersecting highway was located approximately 300 m (1000 ft) downstream from the crash site. The two-lane section of the highway consisted of two 3.7 m (12 ft) wide traffic lanes separated by a broken centerline. The outboard side of the traffic lanes was bordered by a 2 m (6 ft) wide shoulder and a concrete barrier. The inboard side of lanes was bordered by a 1 m (3 ft) wide shoulder and a W-beam guardrail. **Figure 3** is a view of the outboard roadside barrier in the area of the crash. The point of impact and final rest location of the vehicle were not documented during the police investigation. The speed limit on the area of the crash was 89 km/h (55 mph).



Figure 2: Trajectory view of the Toyota.



Figure 3: Area of the impact.

CRASH SEQUENCE

Pre-Crash

The 2005 Toyota Camry was westbound in the right lane driven by a 49 year old female. She was restrained by the vehicle's three-point lap and shoulder belt. The front right passenger was a 19 year old restrained female. The driver failed to react to the slowing/stopped traffic ahead of her until late in this pre-crash phase. The driver steered suddenly right to avoid a vehicle in her lane and lost directional control of the vehicle. The Toyota traveled through the outboard shoulder and struck the roadside barrier. A schematic of the crash is attached to the end of this report as **Figure 10**.

Crash

The crash occurred with the center and right aspects of the Toyota's frontal plane impacting the barrier. The force of the impact fired the front seat belt pretensioners and commanded the deployment of the frontal air bags in the vehicle. The offset right force of the crash to the front plane of the Toyota resulted in a clockwise rotation of the vehicle. The Toyota separated from the barrier and slid to rest facing north straddling the outboard fog line. The severity (delta V) of the impact was calculated using the Damage Algorithm of the WINSMASH collision model. The total delta V of the Toyota was 33 km/h (20.5 mph). The longitudinal and lateral delta V components were -33 km/h (-20.5 mph) and 0, respectively. This calculated value was in general agreement with the 37 km/h (22.8 mph) delta V recorded within the vehicle's ACM. Refer to the *Crash Data Recorder* section of this report for further detail.

Post-Crash

The police and ambulance personnel responded to the crash. The 49 year old driver of the Toyota remained in the vehicle and was assisted to an ambulance by EMS. She was transported to a local hospital that was located within 5 km (3 miles) of the crash site. The driver complained of left knee pain, right chest pain and left finger pain. She was examined in the hospital's emergency room and diagnosed with cervical sprain and a chest wall contusion. The complaints of knee and finger pain did not result in an identifiable injury. The front right passenger exited the vehicle under her own power and was not injured. The Toyota sustained disabling damage and had to be towed.

2005 TOYOTA CAMRY

Exterior Damage

Figures 4 and 5 are front views of the subject Toyota Camry. The Toyota sustained a combined width of direct and induced damage that extended across the vehicle's entire 147 cm (58 in) frontal end width. The direct contact damage of the bumper reinforcement measured 62 cm (28 in) in width. The direct contact began 13 cm (5 in) right of the vehicle's centerline and extended to the right corner of the front bumper. The front bumper fascia separated in the crash and was not with the vehicle. The hood buckled at the fold points. The length of the longitudinal direct contact damage to the surface of the hood measured 18 cm (7 in) at the hood's front right aspect. The maximum crush was located at the right front bumper corner (C6). The residual crush measured at the bumper elevation was as follows: C1 = 0, C2 = 9 cm (3.5 in), C3 = 20 cm (7.9 in), C4 = 30 cm (11.8 in), C5 = 36 cm (14.2 in), C6 = 39 cm (15.3 in). The right wheelbase was reduced 3 cm (1 in). The left wheelbase was unchanged. All the doors remained closed during the crash and were operational at the time of the SCI inspection. The windshield was not fractured and there was no damage to the side window glazings. The Collision Deformation Classification was 12-FZEW2.



Figure 4: Front view of the Toyota Camry.



Figure 5: Overhead view of the Camry depicting the extent of crush.

Interior Damage

The interior damage to the Toyota was limited to the deployment of the vehicle's safety systems. There was no intrusion or interior damage related to the exterior force of the crash. There was no residual evidence of occupant contact to the hard structures of the interior. **Figures 6 and 7** are the left and right interior views of the vehicle, respectively.

The six-way power driver seat was adjusted to a mid-track position that measured 16 cm (6.3 in) forward of full rear. The total seat track travel measured 24 cm (9.5 in). The seat back was reclined 22 degrees aft of vertical, measured 41 cm (16 in) above the seat bight. The anti-submarine angle of the seat cushion measured 15 degrees. The horizontal distance from the seat back to the steering wheel hub measured 51 cm (20 in). The tilt steering wheel was in the full up position. There was no evidence of loading or deformation to the steering wheel rim. There was no evidence of steering column shear capsule displacement.

The front right passenger seat was located in a mid-track position 13 cm (5.3 in) forward of full rear. The total seat track travel measured 25 cm (9.5 in). The seat back angle measured 25 degrees aft of vertical. This angle was measured 41 cm (16 in) above the seat bight. The anti-submarine angle of the seat cushion measured 15 degrees. The horizontal distance from the seat back to the rearmost protrusion of the instrument panel measured 66 cm (26 in). The horizontal distance from the seat back to the aft edge of the front passenger air bag module measured 80 cm (31.5 in).



Figure 6: Left interior view.

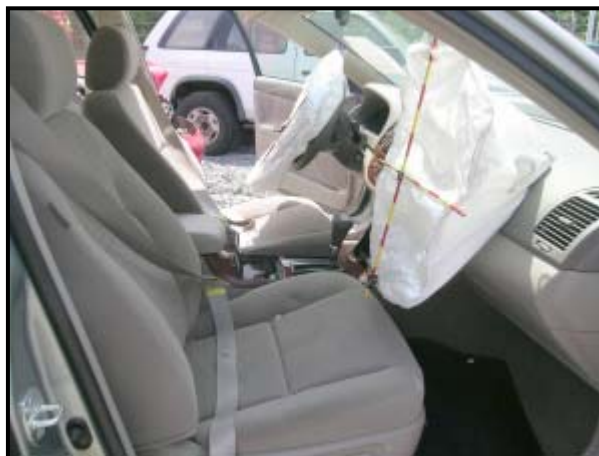


Figure 7: Right interior view.

Manual Restraint Systems

The manual restraint systems in the Toyota Camry consisted of three-point lap and shoulder safety belts in all five seat positions. The driver's restraint consisted of continuous loop webbing, a sliding latch plate, an adjustable D-ring, and a B-pillar mounted Emergency Locking Retractor (ELR). The retractor was equipped with a pretensioner that fired as a result of the impact. Upon initial inspection, the driver's restraint was in the extended position. The ELR retractor was locked due to the fired pretensioner and the webbing would not retract. The length of the extended webbing measured 184 cm (72.5 in). Examination of the webbing revealed it was creased in the area of the latch plate. The crease was centered 100 cm (39.5 in) from the outboard anchor. Examination of the latch plate revealed indicators of historical use. Additionally, the friction surface of the latch plate belt path was abraded indicative of loading. Corresponding transfer marks were observed on the webbing in the area of the crease. The D-ring was adjusted to the full up position. The surface of the D-ring did not reveal loading evidence. The evidence identified during the SCI examination of the driver's restraint indicated the restraint was in use at the time of the crash.

The front right passenger manual safety belt consisted of continuous loop webbing, a sliding latch plate, an adjustable D-ring and a switchable Emergency Locking/Automatic Locking Retractor (ELR/ALR). The front right retractor was also equipped with a pretensioner that fired as a result of the impact. Upon inspection, the webbing was extended in the used position and the retractor was locked due to the fired pretensioner. The length of the extended webbing measured 173 cm (68.0 in). The webbing was creased in the area of the latch plate. The center of the crease was located 91 cm (36.0 in) from the outboard anchor. Examination of the latch plate revealed abrasions to the friction surface of the belt guide consistent with this loading. The

seat belt webbing in the area of the crease was frayed due to the loading. Historical use indicators were present on the latch plate tongue consistent with its use. The adjustable D-ring was in the full-up position. The surface of the D-ring was not abraded. The physical evidence identified during the course of the SCI inspection confirmed the front right passenger was restrained at the time of the crash.

Certified Advanced 208-Compliant Air Bag System

The Certified Advanced 208-Compliant (CAC) frontal air bag consisted of advanced dual stage air bags for the driver and front right passenger, front safety belt buckle switches, front safety belt buckle pretensioners and a front right occupant detection sensor. The frontal air bag system was certified by the manufacturer to have met the requirements of the advanced FMVSS No. 208. The system was controlled and monitored by an Air bag Control Module located under the center console. Additionally, two crash sensors, symmetrically located on forward frame rails, were used to aid in crash detection and assess crash severity. **Figure 8** is an overall view depicting the deployed frontal air bags.



Figure 8: View of the deployed frontal air bags.

Figure 9 is a view of the deployed driver air bag. The driver air bag deployed from an H-configuration module located in the center hub of the steering wheel rim. The symmetrical upper and lower flaps measured 10 cm x 13 cm (4 in x 5 in), height by width, respectively. The flaps opened at the designed tear seams during the deployment sequence and were free from occupant contact. The deployed driver air bag measured 64 cm (25 in) in diameter. The bag was tethered by two 10 cm (4 in) wide straps in the 3/9 o'clock sectors and was vented by two 2 cm (0.8 in) diameter ports located in the 11/1 o'clock sectors. An 8 cm (3 in), vertically oriented, red lipstick transfer was identified in the 10 o'clock sector of the air bag. The transfer was located 19 cm (7.3 in) left of the vertical centerline of the air bag and 11 cm (4.5 in) above the bag's horizontal centerline. The orientation and position of the transfer was consistent with a 90 degree clockwise (right) rotation of the steering wheel at the time of the air bag inflation and occupant contact. This steering maneuver was consistent with the reconstruction of the crash dynamics.



Figure 9: Deployed driver air bag.

The front right passenger air bag was a top-mount design located in the right aspect of the instrument panel. The module was recessed 14 cm (5.5 in) forward of the face of the front right

aspect of the instrument panel. The air bag deployed from a module with a rectangular cover flap. The 20 cm x 8 cm (8 in x 3 in), width by height, flap was constructed of padded vinyl with a sheet vinyl backer. The flap was hinged on the aft side of the module (closest to the occupant) and rotated vertically during the deployment sequence. The face of the front right passenger air bag measured 51 cm x 61 cm (20 in x 24 in), width by height, in its deflated state. The rearward excursion of the bag measured 25 cm (10 in). The air bag was not tethered and was vented by two 5 cm (2 in) diameter ports located on the side panels. There was no evidence of occupant contact to the air bag.

Crash Data Recorder

The 2005 Toyota Camry was equipped with an Air bag Control Module (ACM) that had the ability to record data related to a crash event. The ACM was located on the center tunnel of the vehicle immediately forward of the transmission selector. At the time of the on-site inspection, the SCI investigator removed the ACM from the vehicle and forwarded the module to the Crash Investigation Division of NHTSA. NHTSA in-turn forwarded the module to the vehicle manufacturer in order to download the crash event data. A text copy of that data was then forwarded by the manufacturer to NHTSA and subsequently to the SCI team.

The module recorded a singular deployment event related to the subject crash. The data indicated that the event was completely written. The manual restraint status of both the driver and the front right passenger was recorded as belted. The air bag warning lamp in the instrument cluster was “OFF” and there were no diagnostic troubles in memory. The driver and front right passenger air bags were commanded to deploy 14 milliseconds after Algorithm Enable (AE) and the deployment stage for both air bags was “HI”. This was an indicator of a Stage 2 deployment. The module had the capability to record four pre-crash variables during the five seconds prior to AE, namely Speed, Engine RPM, Accelerator position, and Brake status; however the reported data in those fields were all zero. The module reported a delta V pulse 150 milliseconds in length. The maximum reported delta V was 37 km/h (22.8 mph) which occurred at 130 milliseconds after AE.

OCCUPANT DEMOGRAPHICS

	<i>Driver</i>	<i>Front Right Passenger</i>
Age/Sex:	49 year old / Female	19 year old / Female
Height:	Not reported	Not reported
Weight:	Not reported	Not reported
Seat Position:	Mid-track	Mid-track
Manual Restraint Use:	Three-point lap and shoulder	Three-point lap and shoulder
Usage Source:	SCI inspection	SCI inspection
Medical Treatment:	Treated and released	None, not injured

DRIVER INJURY

<i>Injury</i>	<i>Injury Severity (AIS 98 Update)</i>	<i>Injury Source</i>
Cervical Strain	Minor (640278.1,6)	Non-contact injury: Neck flexion over the shoulder belt
Right chest wall contusion	Minor (490402.1,1)	Shoulder belt

DRIVER KINEMATICS

Immediately prior to the crash, the 49 year old driver was seated in a mid-track position in a presumed upright posture. She was restrained by the vehicle's three-point lap and shoulder belt. The driver failed to recognize stopped/slow moving traffic in front of her and steered suddenly right to avoid a vehicle in her lane resulting in the crash.

Upon impact, the seat belt pretensioner fired, the ELR retractor locked, and the frontal air bags deployed. The fired pretensioner reduced the amount of slack in the belt system and tightened the webbing about the driver. The driver initiated a forward trajectory in response to the 12 o'clock direction of the impact force and loaded the seat belt system. As the driver began to ride down the force of the impact, the inertia of the unrestrained head caused the neck to flex forward over the shoulder belt resulting in the cervical strain. The driver's loading of the shoulder belt resulted in a contusion to the right chest wall. The driver's face and upper chest contacted and loaded the deployed driver air bag evidenced by the lip stick transfer. The driver then rebounded back into her seat and came to rest. She was removed from the vehicle by EMS and transported to a hospital where she was treated and released.

FRONT RIGHT PASSENGER INJURY

The 19 year old restrained front right passenger in the Toyota was not injured.

FRONT RIGHT PASSENGER KINEMATICS

The front right passenger was seated in a mid-track position in a presumed upright posture. She was restrained by the vehicle's three-point lap and shoulder belt system. Upon impact, the seat belt pretensioner fired, the ELR retractor locked, and the frontal air bags deployed. The fired pretensioner reduced the slack in the belt system and tightened the webbing about the occupant. The occupant initiated a forward trajectory in response to the 12 o'clock direction of the impact. The occupant loaded the locked belt system with her chest and pelvis and loaded the inflated air bag. The occupant rode down the force of the crash through the combined use of these safety systems and was not injured.

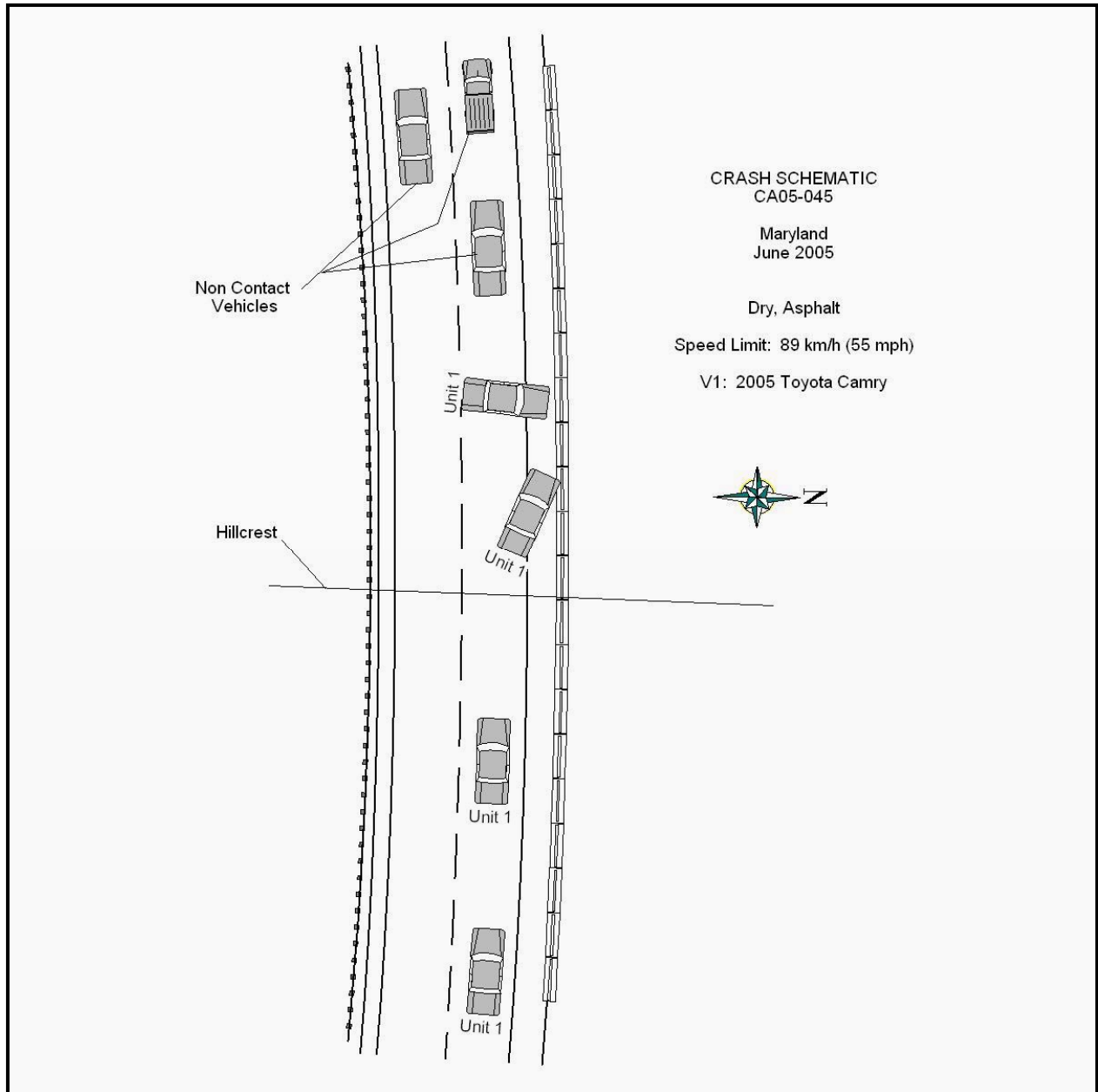


Figure 10: Crash schematic.