CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE POTENTIAL UNINTENDED ACCELERATION CRASH INVESTIGATION

OFFICE OF DEFECTS INVESTIGATION

SCI CASE NO.: CA10009

VEHICLE: 2007 TOYOTA RAV4

LOCATION: VIRGINIA

CRASH DATE: FEBRUARY 2010

Contract No. DTNH22-07-C-00043

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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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BACKGROUND

This on-site investigation focused on the potential Unintended Acceleration (UA) of a 2007 Toyota RAV4 Sport Utility Vehicle **(Figure 1)** and the imaging of its Event Data Recorder (EDR). The safety systems of the Toyota included a Certified Advanced-208 Compliant (CAC) frontal air bag system, front seat back-mounted side impact air bags, and Inflatable Curtain (IC) air bags. The Toyota was driven by a 39-year-old adult female driver. She was traveling in an easterly direction as she approached a line of standing traffic. The driver stated that she applied the brakes; however, the Toyota continued forward and struck the back plane of a 2000 Ford Explorer. The Ford was displaced forward into the back of a 2008 Nissan Altima. The frontal impact deployed the driver's frontal air bag in the Toyota. The driver of the Toyota sustained contusions and lacerations of the forehead and knees as a result of contact with frontal components.

Figure 1. Front right view of the 2007 Toyota RAV4.

The driver filed a complaint alleging UA through the Auto Safety Hotline on February 16, 2010. The Vehicle Owner's Questionnaire (VOQ) was forwarded to the Calspan Special Crash Investigations (SCI) team on March 8, 2010 for on-site follow-up. Telephone contact was initiated with the Toyota driver's husband on the day of notification. He returned the call on March 15, 2010 and cooperation was established with the owner and the driver of the Toyota. The Toyota was located at a regional insurance vehicle salvage facility. Cooperation was obtained from the insurance provider to inspect the Toyota and image the EDR. The on-site investigation was conducted on March 18-19, 2010 and involved a detailed inspection and documentation of the Toyota, inclusive of an inspection of the accelerator and brake pedals, floor mats, brakes; documentation of the crash site and a detailed interview with the driver of the Toyota.

SUMMARY

Crash Site

This crash occurred in a mid-block area of a five-lane divided roadway during daylight hours. At the time of the crash, the conditions were clear and the environmental surfaces were dry. In the vicinity of the crash site, the roadway was configured with two

eastbound lanes and two westbound through lanes with a left turn lane. All of the travel lanes were 3.7 m (12.1 ft) in width. The lanes were separated by a curbed median that was 1.5 m (4.9 ft) in width. Barrier curbs bordered both edge lines. The Toyota traveled through a second controlled intersection and was approaching a controlled intersection that was located approximately 100 m (328 ft) east of the crash site. A driveway to a commercial plaza was located opposite of the crash site at the south edge of the road. The roadway was straight and level with a posted speed limit of 56 km/h (35 mph). The Crash Schematic is attached as **Figure 14**.

Figure 2. Eastbound view of the crash site.

Vehicle Data

2007 Toyota RAV4

The 2007 Toyota RAV4 Limited Sport Utility Vehicle (SUV) was manufactured in March 2007 and was identified by Vehicle Identification Number (VIN): JTMBK31V975 (production number deleted). The driver stated the odometer reading at the time of the crash was approximately 32,000 km (20,000 miles). The Toyota was a 4-door SUV that was powered by a 3.5-liter, V-6 engine linked to a 5-speed automatic transmission with a console mounted shifter. The service brakes were power-assisted 4-wheel disc with antilock and electronic brakeforce distribution. The exterior was configured with a side-hinged rear door with an exterior mounted spare tire, an OEM roof rack and a sunroof. The Toyota was equipped with Yokohama Geolander G91 all-season tires, size 225/65R17 that were mounted on OEM 6-spoke alloy wheels. All four tires were original to the vehicle and were identified by Tire Identification Number (TIN): FDF5 NYC 0807. The manufacturer recommended tire size was 225/65R17 with a cold tire pressure rating of 221 kPa (32 PSI). The Toyota was equipped with a direct Tire Pressure Monitoring System (TPMS). The specific tire data recorded at the time of the SCI inspection was as follows:

Position	Measured Pressure	Measured Tread Depth	Damage
Left Front	193 kPa (28 PSI)	2 mm (3/32 in)	None
Right Front	200 kPa (29 PSI)	2 mm (3/32 in)	None
Left Rear	193 kPa (28 PSI)	6 mm (7/32 in)	None
Right Rear	193 kPa (28 PSI)	5 mm (6/32 in)	None

The interior of the Toyota was configured for five-passenger seating with front bucket seats and a forward folding, split-bench rear seat (60/40 right side wide). All seat positions were equipped with adjustable head restraints. The front left head restraint was adjusted to the full-down position and the front right was adjusted 5 cm (2.0 in) above the seat back. The three rear head restraints were adjusted to the full-down positions.

The interior safety systems consisted of 3-point lap and shoulder belts for the five seated positions. The front positions were equipped with the CAC frontal air bags, seat back-

mounted side impact air bags with Inflatable Curtain (IC) air bags providing protection to the four outboard positions.

2000 Ford Explorer

The 2000 Ford Explorer was sold at auction prior to the assignment of this SCI investigation; therefore the vehicle was not available for inspection. Based on the known information, the Ford was a 4-door, 4-wheel drive SUV that was powered by a 4.0-liter, V-6 engine linked to an automatic transmission. The braking system was power-assisted hydraulic with disc brakes at both axles. The safety systems consisted of manual safety belts and redesigned frontal airbags for the front seating positions. The PAR reported the following VIN: 1FMDU75E6YZ (production number deleted). **Figure 3** is an exemplar view of a 2000 Ford Explorer.

Figure 3. View of an exemplar 2000 Ford Explorer.

2008 Nissan Altima

The 2008 Nissan Altima (**Figure 4**) was inspected at the regional insurance salvage facility. The Nissan was a 4-door sedan that was manufactured in May 2008 and identified by VIN: 1N4AL21E28N (production number deleted). The odometer reading at the time of the SCI inspection was 23,332 km (14,492 miles). The Nissan was powered by a 2.5-liter transverse-mounted gasoline engine that was linked to a Continuously Variable Transmission (CVT). The service brakes were power-assisted 4-wheel disc with antilock. The Nissan was equipped with OEM Continental ContiPro Contact all-season tires; size P215/60R16 that were mounted on OEM steel wheels. These tires were the manufacturer recommended size and the cold tire pressure was placarded at 221 kPa (32 PSI) front and rear. The Nissan was equipped with a direct TPMS. The specific tire data at the time of the SCI inspection was as follows:

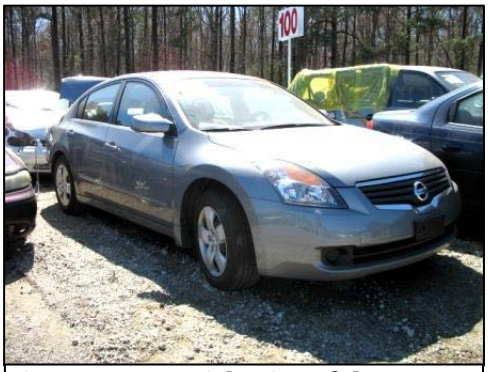

Figure 4. Front right view of the 2008 Nissan Altima.

Position	Measured Pressure	Measured Tread Depth	Damage
Left Front	248 kPa (36 PSI)	6 mm (7/32 in)	None
Right Front	248 kPa (36 PSI)	6 mm (7/32 in)	None
Left Rear	248 kPa (36 PSI)	6 mm (7/32 in)	None
Right Rear	262 kPa (38 PSI)	6 mm (7/32 in)	None

The interior of the Nissan was equipped with front bucket seats and a rear bench seat with a split forward folding back. The safety systems included manual 3-point lap and shoulder belts for the five designated positions, CAC frontal air bags, front seat back-mounted side impact air bags and IC air bags. None of the air bags deployed during this rear plane impact.

2007 Toyota RAV4 History

The driver's husband purchased the Toyota RAV4 as a new vehicle in May 2007. The service history was limited to routine oil changes and the replacement of the Toyota's battery in the summer of 2009. The brakes and tires were OEM at the time of the crash. The driver noted that the vehicle was not involved in any previous crashes. Several areas of superficial damage were noted to the right side doors (possible parking lot damage) and the back left bumper fascia. This bumper fascia damage possibly resulted from towing and/or placement in the salvage yard.

Crash Sequence

Pre-Crash

The driver of the Nissan was traveling in an easterly direction on the inboard lane of the roadway on an approach to the controlled intersection. Heavy traffic volume backed up from the intersection and the driver of the Nissan brought the vehicle to a controlled stop. The driver of the Ford Explorer was traveling behind the Nissan and stopped in the inboard lane behind the Nissan.

The driver of the Toyota was traveling eastbound and traveled through a controlled intersection located west of the stopped positions of the Nissan and the Ford. The driver estimated her travel speed at 56 km/h (35 mph). The Toyota's EDR recorded pre-crash speeds of 70.0 km/h (43.5 mph) at the 5 second pre-crash interval and 71.9 km/h (44.7 mph) at the 2 and 1 second intervals. The driver of the Toyota stated that she observed the stopped Ford and thought she had applied the brakes in sufficient time to avoid the crash. She estimated a gap distance of 5-6 car lengths between her Toyota and the Ford at the time of brake application. The Toyota driver stated that as she applied the brakes, the vehicle continued to travel forward. She could not determine if the Toyota accelerated, or if the brakes did not slow the vehicle. The EDR recorded the pre-crash accelerator pedal position as Off. The EDR recorded a brake application within the 1 second pre-crash interval, immediately prior to the crash.

Crash

The full frontal area of the Toyota impacted the back plane of the stopped Ford. The Toyota's EDR recorded a speed of 47.6 km/h (29.8 mph) immediately prior to impact. The impact configuration resulted in force directions of 12 o'clock for the Toyota and 6 o'clock for the struck Ford. The EDR recorded a post-crash velocity change of -37.0 km/h (-23.0 mph) for the Toyota during the 180-200 millisecond (ms) timeframe of the crash event. The impact deployed the Toyota driver's CAC frontal air bag and actuated the retractor pretensioner.

The initial impact accelerated the Ford forward into the back of the stopped Nissan. The bumper of the Ford overrode the back bumper of the Nissan resulting in crush at the level of the trunk lid and tail lamp areas. The damage was biased to the left indicating an offset engagement with the Nissan of approximately 50 percent of the back plane. The Missing Vehicle Algorithm of the WINSMASH program was utilized to compute a total delta V of 13 km/h (8 mph) for the Nissan with a longitudinal value of 13 km/h (8 mph) and 0 km/h lateral. The Ford's computed total delta V was 11 km/h (7 mph) with a longitudinal value of -11 km/h (-7 mph) and 0 km/h lateral. The Nissan was displaced forward by this secondary impact sequence.

The Ford initially came to rest in the travel lane rearward of the final rest position of the Nissan. The momentum of the Toyota allowed the vehicle to continue forward and the frontal area of the Toyota impacted the back of the Ford a second time. The Toyota and the Ford came to final rest engaged on the inboard travel lane in the approximate area of the second impact event.

Post-Crash

The drivers exited their respective vehicles unassisted at the crash site. A cellular call was placed to the 9-1-1 emergency response system. Police and fire department personnel responded to the call. The driver of the Toyota called her husband who responded to the crash site. Following the police investigation, the Toyota driver was transported by private vehicle to a local hospital where she was treated for soft tissue injuries and released. The drivers of the Ford and the Nissan were not injured and refused medical transport from the scene.

Vehicle Damage

2007 Toyota RAV4 – Exterior

The Toyota sustained moderate severity frontal damage from its impact events with the back plane of the Ford. The exterior damage was dismantled from the structure of the Toyota during the insurance appraisal process. The Toyota was deemed a total loss and was transferred to the regional vehicle salvage facility. None of the damaged parts were with the vehicle at the salvage facility. The dismantled parts included the front bumper system, radiator support, air conditioning condenser and the radiator, hood, left front fender, battery and battery tray, air intake box, and the electric cooling fans. The right front fender, although damaged remained in place. **Figure 5 and 6** are frontal views of the dismantled damage to the Toyota.

Based on the remaining structure, the damage was distributed across the full frontal width of the Toyota. It appeared that the damaged was biased to the right. The post-crash front overhang measurements indicated the right frame rail was displaced rearward 10 cm (3.75 in). There was no displacement of the wheelbases.

Figure 5. Front right view of the 2007 Toyota RAV4.

Figure 6. Close-up view of the dismantled damage at the front left area of the Toyota RAV4.

The windshield had a single crack that originated at the base of the left A-pillar and extended diagonally to the right over a distance of 36 cm (14 in). All other glazing remained intact. The four doors and the side-hinged tailgate remained closed during the crash and were operational post-crash. The Collision Deformation Classifications (CDC) were estimated at 12FDEW99 (99 = unknown extent zones) for both frontal events.

2007 Toyota – Interior

The interior of the Toyota sustained minor severity damage that was associated with air bag deployment and driver contact (**Figure 7**). There was no intrusion of the passenger compartment. The driver's CAC frontal air bag deployed from the tri-flap module within the center hub of the steering wheel. The cover flap opened at the designated tear points.

Figure 7. Overall view of the interior of the Toyota.

The unrestrained driver initiated forward trajectories in response to the frontal impacts. Her initial trajectory resulted in damage to the mid instrument panel, the knee bolster, and the energy absorbing steering column. The driver's left knee contacted the left mid instrument panel. The contact that compressed the plastic panel was located 53 - 66 cm (21 -26 in) left of the vehicle's centerline and 23 - 29 cm (9 - 11.4 in) below the top of the instrument panel. Her right knee engaged the knee bolster directly under the steering column. The contact deformed the bolster to a depth of 9 cm (3.5 in) over the full height of the panel. The bolster deformation was located 25 - 51 cm (10 - 20 in) left of the vehicle's centerline and 36 - 55 cm (14 - 21.7 in) below the top brow of the instrument panel. **Figure 8** depicts the knee contact points.

Figure 8. Knee contacts to the mid instrument panel and the knee bolster.

Figure 9. Forehead contact to the upper mid instrument panel.

The driver's torso loaded the deployed air bag and compressed the air bag against the steering assembly. Her loading force was transmitted into the energy absorbing steering column, evidenced by 1 cm (0.5 in) of shear capsule compression. There was no bending of the steering wheel, spokes, or the mounting flange.

The secondary frontal impact displaced the driver forward and right of the steering wheel and the deflating frontal air bag. Her face impacted the upper mid instrument panel and the vent louver for the HVAC system (**Figure 9**). The instrument panel was scuffed at the top surface of the vent louver and two of the four vent louvers were displaced. The scuff mark was located 5 - 10 cm (2.0 - 4.0 in) left of center and 0 - 3cm (0 - 1.2 in) below the top surface of the instrument panel. Nasal mucus was also present at the contact area on the lower mid instrument panel below the HVAC controls.

2000 Ford Explorer – Exterior

The Ford sustained unknown severity damage to the back and frontal planes from this multiple event crash. The vehicle was not inspected and the insurance company did not provide images of the vehicle for this investigation.

2008 Nissan Altima – Exterior

The Nissan sustained moderate severity damage to the back plane (**Figure 10**) from its impact event with the Ford. The damage and resultant crush was located above the level of the bumper. Maximum crush was 42 cm, (16.5 in) and was located at the inboard edge of the tail lamp sheet metal adjacent to the trunk lid opening, 30 cm (12 in) above the rear bumper beam. The bumper fascia was separated from the Nissan at the time of the inspection. The fascia was abraded full width from contact with the road surface. There was no discernable contact evidence from the impact event. The direct contact damage at the level of the trunk began 10 cm (4.0 in) right of the centerline and extended 85 cm (33.5 in) to the back left corner of the quarter

Figure 10. Back plane damage to the Nissan Altima.

panel. The left tail lamp assembly was disintegrated by the impact. The impact deformed the full width of the back sheet metal resulting in a combined induced and direct contact damage length of 145 cm (57 in). A crush profile was documented at the rear bumper beam level. After free space was subtracted, the crush profile results were zero for all six "C" locations. A second crush profile was documented at the level of the sheet metal 19 cm (7.5 in) above the bumper beam. This crush profile was as follows: C1 = 32 cm (12.6 in), C2 = 31 cm (12.2 in), C3 = 12 cm (4.7 in), C4 = 3 cm (1.2 in), C5 = 0 cm, C6 = 0 cm. These two crush profiles resulted in the following average: C1 = 16 cm (6.3 in), C2 = 16 cm (6.3 in), C3 = 0 cm, C4 = 0 cm, C5 = 0 cm, C6 = 0 cm.

The trunk latch released during the crash event and the backlight glazing disintegrated. All other glazing remained intact. The four doors remained closed and operational post-crash. The CDC was 06BYMW4.

2007 Toyota RAV4 Recall / Accelerator Pedal Data

The 2007 Toyota RAV4 was not included in recalls for accelerator pedal issues. The only recall listed in the NHTSA database pertained to load carrying capacity labeling for the 2007 Toyota RAV4. The NHTSA Campaign Identification Number for this issue is 09V223000.

The 2007 Toyota RAV4 was equipped with a Denso accelerator pedal. The pedal moved freely at the time of the SCI inspection without binding and did not engage the OEM carpet when fully depressed.

2007 Toyota RAV4 Floor Mats

The Toyota was equipped with the OEM carpet that covered the entire floor of the vehicle. There was no damage or wear to the carpet in the area of the accelerator pedal.

The OEM carpeted floor mats were installed in the Toyota throughout the driver's ownership of the vehicle. The front left floor mat was secured in position by two rear-facing hooks located at the aft edge of the mat. The forward edge of the mat was factory cut rearward of the accelerator and brake pedals. The floor mat did not interfere with pedals. **Figure 11** is a view of the foot pedals and the position of the floor mat.

Figure 11. View of the accelerator pedal and the carpeted floor mat.

2007 Toyota RAV 4 Event Data Recorder

The Toyota was equipped with an EDR that was incorporated into the vehicle's Air bag Control Module (ACM). The ACM was mounted to the center tunnel under the console-mounted armrest/storage compartment. The EDR was imaged using the Toyota ROT tool and software version 1.1 provided to NHTSA by Toyota. The frontal components and battery cabling were removed from the Toyota prior to transfer to the salvage facility;

therefore 12-volt power could not be applied to the vehicle to image the vehicle through the Diagnostic Link Connector (DLC). The Part Number was retrieved from the ACM and the appropriate cable was used to image the EDR directly from the module. External 12-volt power was applied to the hardware interface box to image the EDR data. The imaged data has been reread with software version 1.4.1.0 and is reported below.

A single crash event was recorded by the EDR. The pre-crash data was labeled as the "Latest Pre-Crash Page.0". The driver safety belt buckle switch was recorded as unbuckled and the front right position was unoccupied. The crash data was labeled as "Frontal Crash Page.0" and listed the level of the driver air bag deployment as "LOW" level. The data recorded air bag deployment and pretensioner actuation at 15 ms after Algorithm Enable (AE). The post-crash velocity change was 46.1 km/h (28.7 mph) at 180-200 ms timeframe of the crash event.

The recorded pre-crash data is provided in the following table:

Pre-Crash	**4.9-sec**	**3.9-sec**	**2.9-sec**	**1.9-sec**	**0.9-sec**	**(AE)**
Speed	70.0 km/h (43.5 mph)	70.0 km/h (43.5 mph)	70.0 km/h (43.5 mph)	71.9 km/h (44.7 mph)	71.9 km/h (44.7 mph)	47.9 km/h (29.8 mph)
Brake	Off	Off	Off	Off	Off	On
Accelerator	1.09 volts Off	1.09 volts Off	1.25 volts Off	1.21 volts Off	0.78 volts Off	0.78 volts Off
Engine	1600 rpm	1600 rpm	1600 rpm	1200 rpm	1200 rpm	800 rpm

The driver stated that she thought she had sufficient time to avoid the crash. The EDR data indicated the driver applied a braking force late in the pre-crash phase, immediately prior to impact. The vehicle speed was reduced from 71.9 km/h to 47.9 km/h (44.7 mph to 29.8 mph) by this pre-crash braking.

Brake System Inspection

The Toyota was equipped with power-assisted 4-wheel disc brakes. The owner of the vehicle stated that the brakes were OEM and that there were no reported problems with the braking system. During the SCI inspection, the right side tires of the Toyota were raised off the ground with a floor jack and the wheels were removed to inspect the brakes. Both right side rotors were covered with light surface rust.

The right side rotors did not display evidence of heat associated with excessive braking. The calipers were removed via the 14 mm hex head bolts. The pistons were slightly compressed to allow easy removal of the caliper and the brake pads from the rotors. The calipers were removed and the slides moved freely. The brake pads were removed from the calipers and exhibited no evidence of excessive wear or heat. The outer metallic brake pads were covered with light surface rust from exposure to the elements. There was no damage or evidence of prolonged braking to the right side brakes. **Figure 12 and 13** are views of the right front brake rotor and pads.

A visual inspection of the left side brakes was performed without removal of the wheels. Both left side rotors were in good condition with minimal surface rust. There was no

evidence of heat or damage to the rotors and the brake pads appeared to be of the same thickness as the right side pads with approximately 50 percent of the brake pad remaining on the backer plates.

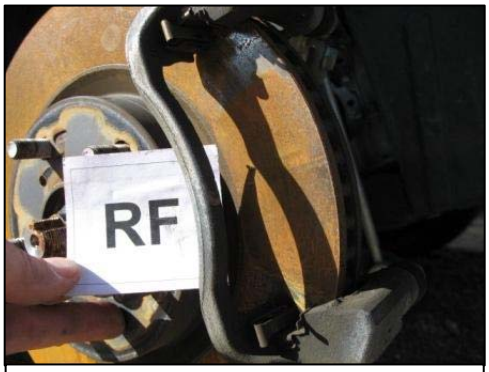

Figure 12. Right front brake rotor.

Figure 13. Right front brake pads.

Manual Safety Belt Systems

The Toyota was equipped with 3-point lap and shoulder belts for the five designated seating positions. The front seat belt systems utilized continuous loop webbing, sliding latch plates, adjustable D-rings, retractor pretensioners, and buckle switch sensors. The driver's retractor was an Emergency Locking Retractor (ELR) while the other four utilized switchable ELR/Automatic Locking Retractors (ALR). The driver's D-ring was adjusted to the full-down position while the front right was adjusted to the full-up position.

The driver was not restrained at the time of the crash. The driver's safety belt system was retracted against the B-pillar. The frontal crash deployed the driver's CAC frontal air bags and actuated the retractor pretensioner. The pretensioner locked the safety belt taut in its stowed position against the left B-pillar.

Frontal Air Bag System

2007 Toyota RAV4

The Toyota was equipped with a CAC frontal air bag system for the driver and front right passenger positions that consisted of dual stage air bags, seat track positioning sensors, safety belt switch sensors, safety belt retractor pretensioners, and a front right occupant weight sensor. The manufacturer of this vehicle has certified that the Toyota is compliant to the advanced air bag requirements of Federal Motor Vehicle Safety Standard No. 208. The system was controlled by a transmission tunnel mounted ACM that provided crash sensing, diagnostic functions, and EDR capabilities. The driver's air bag deployed during the frontal crash event.

The driver's air bag was concealed within the center hub of the steering wheel rim by a tri-flap module cover. The vertical and horizontal tear seams opened at the perforated locations. The overall width of the flaps was 10 cm (4 in) and the height was 15 cm (5.75 in). The driver's air bag was tethered by two wide band internal tethers at the 3 and 9 o'clock positions. The tethers were sewn to the face of the bag with two rows of

stitching with diameters of 18 cm (7.0 in) and 22 cm (8.5 in). The air bag was vented by two I slit-type vent ports located on the back side of the air bag at the 11 and 12 o'clock positions. The slits were 6 cm (2.5 in) in height. The top of the vent slits was located 3 cm (1.25 in) below the peripheral seam. There was no evidence of driver contact on the deployed air bag.

Driver Demographics/Data
2007 Toyota RAV4

Age/Sex:	39-year-old/Female
Height:	168 cm (66 in)
Weight:	57 kg (125 lb)
Safety Belt Use:	None
Usage Source:	SCI vehicle inspection
Eyewear:	None
Seat Track Position:	Middle to rear track position
Egress from Vehicle:	Exited unassisted
Mode of Transport From Scene:	Private vehicle to a local hospital
Type of Medical Treatment:	Treated for soft tissue injuries and released

Driver Injuries

Injury	Injury Severity (AIS 2005)	Injury Source
Small laceration of the mid forehead	Minor (210602.1,7)	Center instrument panel
Contusion of the mid forehead	Minor (210402.1,7)	Center instrument panel
Laceration of the left knee	Minor (810600.1,2)	Knee bolster
Contusion of the right knee	Minor (810402.1,1)	Knee bolster
Temporomandibular pain	Not codeable under AIS	Center instrument panel

Source – Driver interview

Driver Kinematics

The 39-year old female driver of the Toyota was seated in a rear-third track position with the seat back reclined to a measured angle of 25 degrees aft of vertical. The head restraint was adjusted to the lowest position. She was wearing tennis shoes (size 7M) and a matching exercise suit consisting of long sleeves and pants. The driver was not restrained by the manual safety belt system. The EDR output recorded the belt switch status as unbuckled and the pretensioner actuated, cinching the belt webbing taut against the B-pillar in the stowed position. The driver stated her cellular telephone was in the ON-mode in the vehicle; however, she was not using the phone at the time of the crash. She denied other distractions.

During the initial impact with Ford, the Toyota's CAC driver frontal air bag deployed and the retractor pretensioner actuated. The driver of the Toyota initiated a forward trajectory in response to the frontal impact force and loaded the deployed air bag with her torso. There was no contact evidence on the air bag. The loading force of the

unrestrained driver was transmitted through the deployed air bag into the energy absorbing steering column. Both shear capsules were compressed 1.3 cm (0.5 in). There was no bending of the steering wheel rim or deformation of the steering wheel mounting flange. The air bag likely prevented the driver from further facial and thoracic injury.

The driver's left knee engaged the left mid instrument panel directly above the level of the knee bolster. This loading minimally compressed the rigid plastic panel and produced stress loading to the panel (whitened). As a result of this contact, the driver sustained a laceration over the knee area.

The driver's right knee engaged the knee bolster under the steering column. The loading deformed the bolster panel 8.9 cm (3.5 in) forward over the height of the panel. She sustained a contusion of the right knee from this contact.

The Toyota driver rebounded from this initial impact event into the seat back. As the Toyota impacted the back of the Ford a second time, the driver was out of position to her right. She initiated a forward trajectory and glanced off the right side of the deflating air bag and steering column. Her head flexed forward and her forehead impacted the top center instrument panel at the left center vent louver. This contact scuffed the rigid instrument panel and fractured the vent louver. The driver sustained a forehead laceration and contusion from this contact sequence. The driver again rebounded into the seat back where she came to final rest. The driver also complained of temporomandibular joint pain that was probably associated with the center instrument panel contact.

Immediately following the crash, the driver exited the vehicle and used her cellular telephone to call her husband. He responded to the crash site and transported the driver to a local hospital following the police investigation. She was treated for her soft tissue injuries and released.

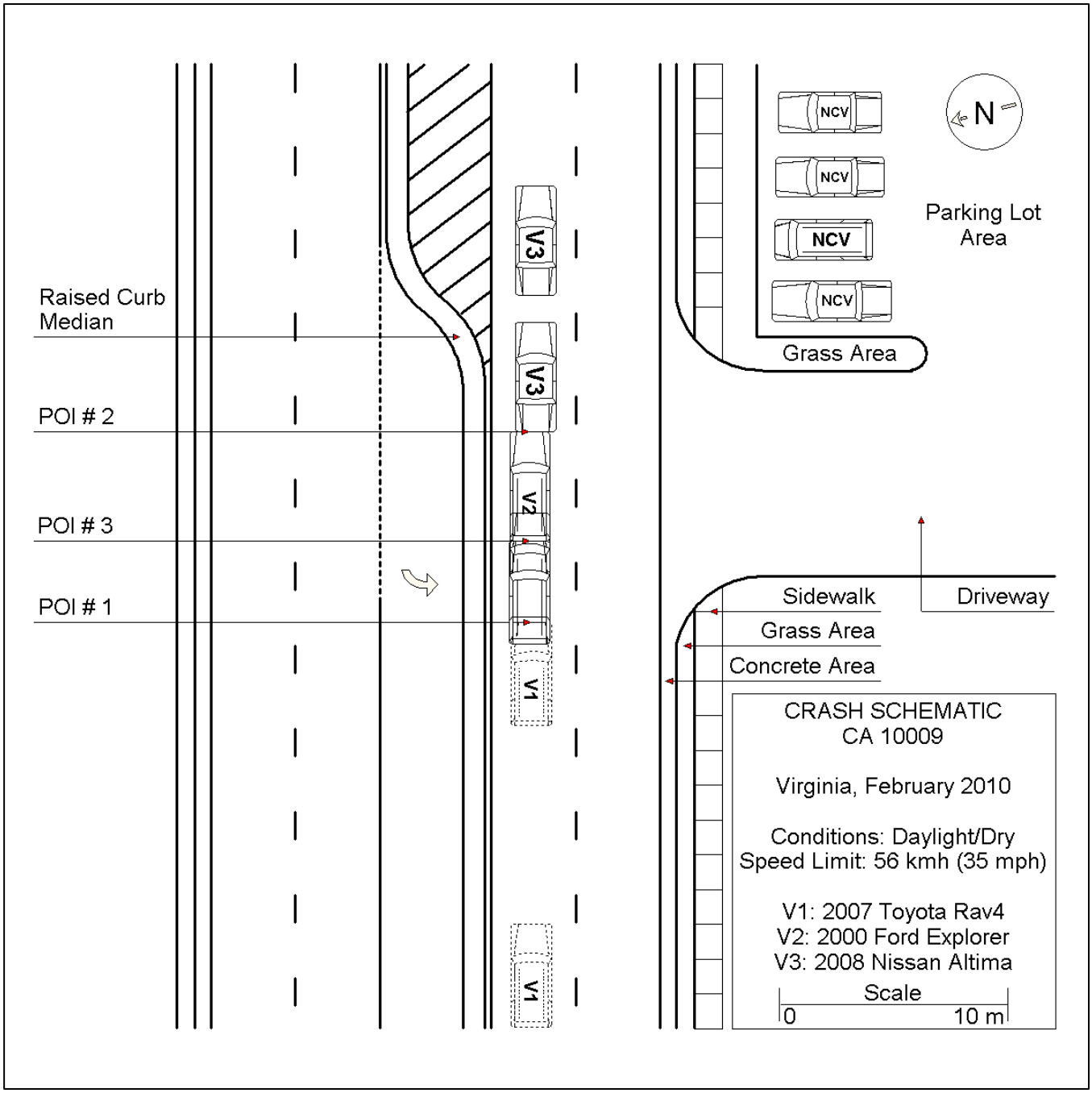

Figure 14. Crash Schematic