CRASH DATA RESEARCH CENTER
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OFFICE OF DEFECTS INVESTIGATION
CALSPAN ON-SITE POTENTIAL UNINTENDED ACCELERATION CRASH INVESTIGATION

SCI CASE NO.: CA10013

VEHICLE: 2002 TOYOTA HIGHLANDER

LOCATION: NEW HAMPSHIRE

CRASH DATE: OCTOBER 2009

Contract No. DTNH22-07-C-00043

Prepared for:

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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 alleged Unintended Acceleration (UA) of a 2002 Toyota Highlander sport utility vehicle. The 63-year-old male driver of the Toyota was allegedly traveling at a witness reported high-rate of speed and passing a non-contact vehicle on the right shoulder when he lost directional control while attempting to re-enter the travel lanes. The Toyota crossed the roadway centerline and impacted a 2005 Chevrolet Malibu that was traveling in the opposite direction. The severe head-on crash killed all three occupants of the Toyota, including the driver, a 61-year-old female front right passenger, and a 94-year-old female rear right passenger, as well as the 56-year-old male driver of the Chevrolet. All of the occupants were restrained by the safety belt systems of their respective vehicles at the time of the crash, and the frontal air bag systems equipped within each vehicle deployed. A family member of the Toyota driver filed a complaint of this crash through the Auto Safety Hotline on January 27, 2010. The Vehicle Owner's Questionnaire (VOQ) Number 10302616 was forwarded to the Calspan Special Crash Investigations (SCI) team on March 8, 2010 for follow-up investigation. Telephone contact was initiated immediately and cooperation was established with the family member. He consulted the attorney representing the estate of the Toyota's driver, and cooperation was subsequently established to allow the inspection of the Toyota on April 5, 2010.			
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BACKGROUND

This on-site investigation focused on the alleged Unintended Acceleration (UA) of a 2002 Toyota Highlander sport utility vehicle (**Figure 1**). The 63-year-old male driver of the Toyota was allegedly traveling at a witness reported high-rate of speed and passing a non-contact vehicle on the right shoulder when he lost directional control while attempting to re-enter the travel lanes. The Toyota crossed the roadway centerline and impacted a 2005 Chevrolet Malibu that was traveling in the opposite direction. The severe head-on crash killed all three occupants of the Toyota, including the driver, a 61-year-old female front right passenger, and a 94-year-old female rear right passenger, as well as the 56-year-old male driver of the Chevrolet. All of the occupants were restrained by the safety belt systems of their respective vehicles at the time of the crash, and the frontal air bag systems equipped within each vehicle deployed.

Figure 1: Left front oblique view of the Toyota**.** (*Local law enforcement on-scene image*)

A family member of the Toyota driver filed a complaint of this crash through the Auto Safety Hotline on January 27, 2010. The Vehicle Owner's Questionnaire (VOQ) Number 10302616 was forwarded to the Calspan Special Crash Investigations (SCI) team on March 8, 2010 for follow-up investigation. Telephone contact was initiated immediately and cooperation was established with the family member. He consulted the attorney representing the estate of the Toyota's driver, and cooperation was subsequently established to allow the inspection of the Toyota on April 5, 2010. The Toyota was secured at a regional insurance vehicle salvage yard. The National Highway Traffic Safety Administration's (NHTSA) Office of Defects Investigation (ODI) requested an on-site investigation of this crash through the SCI program with a focus on the Toyota's accelerator pedal, floor mats, and braking system. The investigation was scheduled for and conducted on May 20, 2010, and involved the thorough inspection and documentation of the Toyota Highlander's exterior damage, interior intrusion, occupant contact points, safety systems, accelerator pedal, throttle system, floor mats, and braking system. In addition to the

inspection process, an attempt was made to image the Toyota's air bag control module. This task was unsuccessful as this platform did not have Event Data Recorder (EDR) capabilities and was not supported by the proprietary Toyota hardware and software version 1.10.

SUMMARY

Crash Site

The subject crash occurred during daylight hours on a rural two-lane New Hampshire road in October of 2009. **Figure 2** depicts a northbound trajectory view of the crash site. According to the online weather database, the local weather conditions at the time of the crash were clear skies with a temperature of 7.2 Celsius (45 Fahrenheit) degrees, 46-percent relative humidity, and calm winds. The bituminous (asphalt) road surface was dry.

Figure 2: Northbound trajectory view of crash site.

The point of impact occurred at the transition of the roadway from a left curve to a straight section, with respect to the northbound trajectory of the Toyota. In this vicinity, the roadway consisted of north and southbound travel lanes supported by asphalt shoulders with a superelevation of positive 7.2 percent. The northbound lane was 3.5 m (11.5 ft) wide and supported by a 3.1 m (10.2 ft) wide shoulder, delineated by a single, solid white fog line. The southbound lane was 3.8 m (12.5 ft) wide and supported by a 2.7 m (8.8 ft) wide shoulder, also delineated by a single, solid white fog line. The roadside area west of the roadway was a steep, grass-covered embankment with slope greater than positive 50 percent. The embankment transitioned to a wooded area approximately 10 m (33 ft) uphill from the roadway edge.

For the pre-crash northbound travel trajectory of the Toyota, the roadway followed a slight left curve with a radius of curvature of approximately 625 m (2050 ft) and negative grade of 2.8 percent. Northbound traffic was restricted by a no-passing zone that transitioned to a passing zone at the culmination of the curve, as dictated by the yellow centerline. Southbound traffic, however, was restricted by a continuous solid-yellow centerline distinguishing a no-passing zone. In the vicinity of the southbound Chevrolet's pre-crash location prior to the curve, the straight roadway had a positive 2.5 percent grade. The posted speed limit in both travel directions was 89 km/h (55 mph). A schematic of the crash is attached as **Figure 19**.

Vehicle Data

2002 Toyota Highlander

Figure 3: Left side view of the Toyota**.** (*Local law enforcement on-scene image*)

The Toyota Highlander Limited was manufactured in January 2002 and identified by the Vehicle Identification Number (VIN): JTEHF21A820 (production number deleted). The Toyota was a four-door sport utility vehicle with all-wheel drive (**Figure 3**). Power was derived from a 3.0-liter, conventionally mounted V-6 gasoline engine linked to a 4-speed automatic transmission with a console-mounted shifter. The service brakes were power-assisted 4-wheel disc with anti-lock and Electronic Brakeforce Distribution (EBD). The parking brake was a cable activated drum system within the rear rotors. It is unknown if this Toyota was equipped with Electronic Stability Control or Brake Assist. Additional exterior features included an original equipment manufacturer (OEM) roof rack with two adjustable load bars positioned at the fore and aft ends of the rack system. The manufacturer's recommended tire size was P225/70R16 with front and rear axle cold tire pressures of 207 kPa (30 PSI). The Toyota was equipped with matching Wildcat Touring XLT tires of the recommended size, mounted on OEM 5-spoke alloy wheels. The tires were manufactured by Cooper, but were sold through the brand name of Dean Tires. Specific tire data recorded at the time of the SCI inspection was as follows:

Position	**Pressure**	**Tread**	**Damage**
LF	Flat	6 mm (7/32 in)	Fracture of the inner bead of the alloy wheel
RF	69 kPa (10 PSI)	5 mm (6/32 in)	Abrasions to bead area of wheel over the valve stem
LR	186 kPa (26.5 PSI)	6 mm (7/32 in)	None
RR	Flat	6 mm (7/32 in) outer 4 mm (5/32 in) inner	Inner wheel fractured, circumferential abrasions to outer spoke and bead areas

The interior of the Toyota was configured for five-passenger seating with cloth surfaced seats and interior trim. The two front seating positions were bucket seats with reclining seatbacks, and the driver's seat was equipped with manual 8-way electronic adjustment. Rear seating consisted of a three-passenger forward folding bench seat, split 60/40 left to right. All five seating positions were equipped with 3-point lap and shoulder safety belt systems with sliding latch plates, and manually adjustable head restraints. The front safety belt systems utilized load limiting retractors and retractor pretensioners. Other equipped safety features included a frontal air bag system with re-designed air bags.

At the time of the crash, the driver's head restraint was in a full-up position, while the front right and all three rear head restraints were adjusted to the full-down position. These positions were determined from a review of on-scene police images.

Service History

The driver/owner of the 2002 Toyota Highlander purchased the vehicle new on April 5, 2002 from a Toyota dealer in Massachusetts. The odometer reading at the time of purchase was 56 km (35 miles). An accident of unknown severity involving the center rear of the Toyota was recorded on 6/11/2003. The following service history was provided to the SCI team by the attorney representing the family of the Toyota driver:

Date	Service Performed	Recorded Odometer Reading
9/25/2002	Breather valve recall. Recommended service interval to include oil and filter change, check undercarriage	16,701 km (10,378 miles)
1/31/2003	Recommended service interval – balance and rotate tires, oil and filter change	27,812 km (17,282 miles)
6/12/2003	Oil and filter change	35,887 km (22,300 miles)
9/23/2004	Oil and filter change, replaced transmission fluid, coolant, tire replacement w/balancing and stems, wheel alignment	76,118 km (47,299 miles)
1/4/2005	Check engine light diagnosis, dislodged vacuum hose	93,264 km (57,953 miles)
6/26/2006	Oil and filter change	140,975 km (87,600 miles)
11/9/2006	Oil and filter change	156,289 km (97,116 miles)
8/7/2007	Replaced EVAP Charcoal Canister	182,622 km (113,479 miles)
9/24/2007	Replaced tires, balance, new valve stems	188,288 km (117,000 miles)
10/16/2007	Oil and filter change	191,856 km (119,217 miles)
8/14/2008	Replace battery	Not reported
9/13/2008	Oil and filter change, rotate tires	218,437 km (135,734 miles)
2/14/2009	Recommended Service Interval, oil and filter change, replaced rear brake pads and rotors, replaced brake light bulb, lubricated steering column bushing, replaced power steering fluid, 4-wheel alignment	231,305 km (143,730 miles)

Recall /Technical Service Bulletin Data

A review of NHTSA's website by the SCI team located 28 Technical Service Bulletins listed for this vehicle. The status of these bulletins relating to the involved Toyota is unknown. At the time of the crash, there were no active recalls for the model year 2002 Toyota Highlander. There also were no recalls relating to the accelerator pedal, floor mats, or unintended acceleration involving the model year 2002 Toyota Highlander.

2005 Chevrolet Malibu

The Chevrolet Malibu (**Figure 4)** was sold for salvage prior to this on-site investigation and was not available for inspection. As such, the following vehicle data was determined from the standard features on this platform's LS trim package and the VIN: 1G1ZT52825F (production number deleted). The 4-door Chevrolet sedan was equipped with a 3.5-liter, V-6 gasoline engine linked to a 4-speed automatic transmission. The service brakes were four-wheel disc with anti-lock and EBD. The Chevrolet was equipped with OEM alloy wheels at all four axle positions. A Bridgestone all-season radial tire, visible in the on-scene images, was mounted on the right front position.

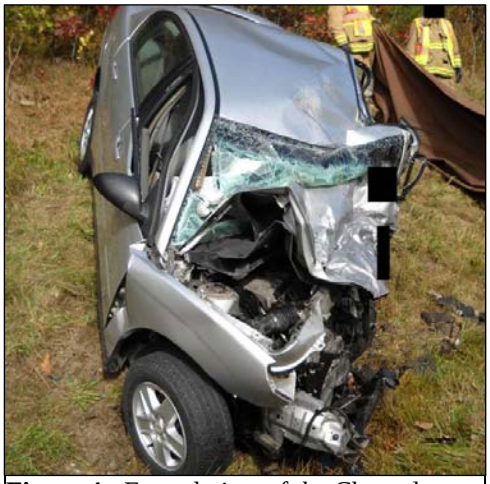

Figure 4: Frontal view of the Chevrolet. (*Local law enforcement on-scene image*)

The interior of the Chevrolet was configured with front bucket seats and a rear three-passenger bench seat. Equipped safety systems included dual-stage frontal air bags and 3-point lap and shoulder safety belt systems for the five seating positions.

Crash Sequence

Pre-Crash

The Toyota was northbound, operated by the 63-year-old male driver who was traveling behind two non-contact vehicles. While the three vehicles were negotiating the left curve, the Toyota accelerated and the driver steered the vehicle right, onto the outboard shoulder. The Toyota then passed the first non-contact vehicle as it traversed the shoulder. Witnesses reported that Toyota maintained speeds of 105-113 km/h (65-70 mph) over the course of this passing maneuver.

Coincident to the northbound Toyota and two non-contact vehicles, the Chevrolet was traveling in the southbound travel lane approaching the same curve. It was operated by the 56-year-old male driver and traveling at a witness' reported speed of 72 km/h (45 mph).

After the Toyota passed the first non-contact vehicle, the driver steered left in an attempt to regain the northbound travel lane behind the leading non-contact vehicle. The combination of vehicle speed and driver steering input initiated a slight counterclockwise (CCW) rotation, and the driver subsequently lost directional control of the vehicle. The CCW rotation instigated a slight yaw as the Toyota maintained its trajectory and crossed over the yellow roadway centerline. This movement aligned the Toyota on an imminent path with the Chevrolet in an offset, head-on configuration. There was a lack of evidence at the scene to support braking, steering, or other evasive action by the driver of the Chevrolet.

Crash

The initial impact event occurred when the frontal plane of the Toyota impacted the frontal plane of the Chevrolet (Event 1). The point of impact and post-impact trajectories of the two vehicles were evidenced by gouge marks, fluid spills, and damage patterns on the asphalt roadway surface and within the roadside grass embankment. The front plane of the Toyota was crushed longitudinally by the 12-o'clock direction of force from impact with the Chevrolet. In a similar fashion, the front plane of the Chevrolet was crushed by the collinear 12-o'clock direction of force from the Toyota.

The Damage Algorithm of the WinSMASH model was used to calculate the severity (delta-V) of the crash. Although the Chevrolet was unavailable for physical inspection, numerous images of the vehicle supplied by on-scene law enforcement and the salvage facility enabled the SCI team to estimate a crush profile. The resulting total delta-V of the Toyota was 83 km/h (51.6 mph). The longitudinal and lateral components were -83 km/h (-51.6 mph) and zero, respectively. The total calculated delta-V of the Chevrolet was 106 km/h (65.9 mph), with longitudinal component of -104.4 km/h (-64.9 mph) and lateral component of 18.4 km/h (11.4 mph).

Due to the pre-crash trajectory of the Toyota, and in conjunction with vehicle properties and crash dynamics, both vehicles initiated CCW rotation and experienced prolonged engagement. Subsequently, the vehicles transitioned from a head-on configuration to an L-shaped configuration as they experienced maximum engagement and rotated approximately 90 degrees. As a result, the Toyota rotated off of the Chevrolet as it proceeded into a right side leading translation. This created an instability due to the lateral drag-force load on the right side axle positions with respect to the Toyota's higher center of gravity. The moment of the associated forces instigated a trip-over into a right side leading rollover event (Event 2). This was evidenced by the yielding of the right rear axle mount and subsequent angled post-crash condition of the wheel assembly, as well as abrasion damage on the right side plane.

The Toyota maintained CCW rotation about its vertical axis as it rolled one-quarter turn about its longitudinal axis. Due to associated centrifugal forces, as the Toyota surpassed 180 degrees of rotation about its vertical axis, the rollover about its longitudinal axis was reversed. Accordingly, the Toyota rolled back onto its wheels as it completed 360 degrees of CCW rotation about its vertical axis. The vehicle slid to rest within the roadway, straddling the west fog line. This final rest position was reported by the investigating law enforcement officer to be 21 m (69 ft) north of the point of initial impact.

Severe frontal damage had compromised engine components of the Toyota. Various unspecified fluids began to pool underneath the vehicle. A fire was instigated as vapors from these fluids were ignited by high-temperature components, electrical sparks, and/or impact related sparks (Event 3).

As the vehicles engaged during the initial impact event, the greater inertial forces of the Toyota reversed the direction of the Chevrolet's pre-crash movement. Accordingly, the Chevrolet was projected rearward in a northwest direction from the point of impact. After the vehicles separated, the Chevrolet maintained this rearward trajectory as it departed the roadway and progressed up the steep slope of the west roadside embankment to final rest. The investigating law enforcement office reported the Chevrolet's final rest position to be 12 m (39 ft) northwest of the point of impact.

Post-Crash

The local emergency response system was notified of the crash and dispatched law enforcement, fire department, and emergency medical services (EMS) personnel to the scene. The first emergency services' individual on scene was an officer from the local law enforcement agency. He reported that upon his arrival, the Toyota was straddling the fog line delineating the southbound lane from its outboard shoulder with smoke and flames emanating from its engine compartment. He also identified the Chevrolet at rest on the steep, roadside-west embankment (**Figure 5**). Per his statements, the officer immediately retrieved a medical bag and fire extinguisher from his vehicle and successfully suppressed the fire after several attempts. He then located the male driver of the Toyota slumped over the steering wheel, entrapped and unresponsive. Unable to assist the driver, the officer proceeded to the passenger side of the vehicle where he located the front right female passenger in a semi-responsive state and the rear right passenger in an unresponsive state. The officer then observed the male driver of the Chevrolet with his left arm hanging partially out of the vehicle, approached the vehicle, and found the driver to be devoid of any life signs.

Figure 5: Final rest position of the Toyota and Chevrolet. (*Local law enforcement on-scene image*)

The fire department and EMS personnel arrived on scene and assessed all four victims. The right front female passenger was removed from the vehicle and positioned on a stretcher, but was thereafter pronounced deceased by EMS personnel. The male driver of the Toyota, female rear right passenger of the Toyota, and male driver of the Chevrolet were also pronounced deceased by EMS personnel.

Upon arrival of the Medical Examiner, fire department personnel commenced extrication of the three entrapped bodies at her direction using hydraulic rescue tools. During this process, the left B-pillar, left front door, and left rear door were cut and removed from the Toyota. To liberate the lower extremities of the entrapped driver, the lower A-pillar was cut and the hydraulic

spreaders were used to displace the instrument panel forward and upward. The driver's and rear right passenger's seat belt webbing of the Toyota was also cut.

The left front door, left rear door, left B-pillar, and entire roof of the Chevrolet were cut and removed. In a procedure similar to that of the Toyota, the lower left A-pillar and surrounding components were cut to enable the forward and upward displacement of the instrument panel to liberate the entrapped driver.

The bodies were removed from the scene by the Medical Examiner and transported to the morgue for autopsy. The Toyota and the Chevrolet were towed from the scene and impounded by the local law enforcement agency.

Vehicle Damage – 2002 Toyota Highlander

Exterior

The Toyota Highlander sustained severe frontal impact damage and deformation as a result of the crash (Event 1). **Figure 6** is a left front oblique view of the vehicle. The offset impact configuration resulted in a left bias to the damage with deformation to the left A-pillar area. The combined width of the direct and induced damage extended across the entire 160 cm (63 in) frontal end width. The direct damage began 38 cm (15 in) right of center and extended to the left bumper corner. The frontal crush was documented along the bumper reinforcement beam and was as follow: C1 = 112 cm (44.1 in), C2 = 109 cm (42.9 in), C3 = 103 cm (40.6 in), C4 = 89 cm (35.0 in), C5 = 64 cm (25.2 in), C6 = 42 cm (16.5 in). The left A-pillar was deformed in a near-vertical position. The force of the impact and the extent of the deformation resulted in buckling of the left sill at the B-pillar location. The left doors were jammed closed post-crash, but the right doors remained operational. The left wheelbase was reduced 49 cm (19.3 in). The Collision Deformation Classification (CDC) associated with the initial impact event was 12FDEW5.

Figure 6: Left oblique view of the Toyota**.**

The right plane of the vehicle sustained minor damage that was associated with the one-quarter turn rollover (Event 2). The damage consisted of minor vertically oriented abrasions dispersed over the right front and right rear doors. These abrasions extended from the sill to the hardware supports of the roof rack. In addition, the right rear axle mount yielded as a result of lateral loading of the tire/wheel during trip-over (**Figure 7**). The CDC of the rollover event was 00RYAO3.

Figure 7: Right side view of the Toyota's rollover damage. (*Local law enforcement on-scene image*)

Interior

The Toyota sustained extensive interior damage that was associated with exterior deformation, intrusion into the passenger compartment, occupant contact, air bag deployment, and extrication efforts by emergency response personnel. The documentation of the interior intrusion was hampered by the extrication, as the associated efforts consisted of cutting and removing a section of the left A-pillar and left B-pillar, forcing the roof vertically, and hydraulically lifting the instrument panel forward and upward (**Figure 8**).

Figure 8: Left interior view of the Toyota.

At the time of SCI inspection, the driver seat was located in a full-rear track position. The seat back had been removed during the extrication process. The floor pan deformation had caused the forward aspect of the driver seat to pitch down. Two driver knee contacts were noted to the bolster. The driver's left knee contacted the lower instrument panel 56 cm (22 in) left of center and fractured the fuse box cover that was located 34 cm (13.5 in) below the top of the instrument panel. The right knee contact consisted of a black scuffmark to the bottom aspect of the steering column extending onto the bolster panel. The 4-spoke steering wheel rim was deformed 9 cm (3.5 in) at the 5 o'clock sector, and the spoke at the 9 o'clock position was fractured. A scuffmark and blood transfer was noted to the left A-pillar. The scuff was located 18-23 cm (7 – 9 in) above the beltline. There was extensive intrusion of the toe pan and deformation of the floor pan.

The front right seat was located in a full-rear track position with a seat back angle that measured 5 degrees aft of vertical. The front right seatback exhibited indications of having been loaded

from behind by the rear right occupant, as it was deformed forward with a scuffmark that was attributed to the right lower extremity of the rear right occupant. The center console mounted shifter was fractured by contact from the left lower extremity of the front right occupant. Two large knee contacts were noted to the glove box door. The center aspect of the door was scuffed and deformed forward approximately 8 cm (3 in).

Brake System

The SCI inspection included the examination of the brake system to check for evidence of wear, damage, and/or heat build-up from prolonged braking during the pre-crash phase of the crash sequence. This was accomplished by jacking up the vehicle, removing the wheels, and performing a visual inspection of the brake components. The brake calipers were subsequently removed from the mounting brackets and the disc brake pads were removed from the caliper for inspection of wear and heat evidence. It should be noted that a thorough inspection of the left front brake assembly could not be accomplished as the frontal vehicle damage prohibited removal of the left front tire and wheel. The right rear was inspected without disassembly as the axle and rotor fractured, thus exposing the brake components.

The left rear tire and wheel were removed without difficulty. Initial inspection of the brake rotor, caliper, and brake pads revealed a significant build-up of surface rust that was attributed to the long duration of storage between the crash and inspection dates. The brake rotor was intact with no evidence of wear or damage (**Figure 9**). The brake pads, as viewed through the top of the caliper, were in good condition. Removal of the caliper supported this observation as the pads were in good condition without evidence, wear, or damage (**Figure 10**).

Figure 9: Left rear brake assembly.

Figure 10: Left rear brake caliper and shoes.

The right front tire and wheel were removed with minimal difficulty as the inflated tire was in contact with the aft edge of the right front fender. Initial inspection of the brake assembly (**Figure 11**) revealed that the lower caliper bolt was fractured and that the upper bolt was loose. The status of the lower caliper bolt was the result of the post-crash inspection by the

investigating police department. It is unknown if the upper caliper bolt was fractured during this inspection. The upper spindle casting for the caliper bracket was fractured at the mounting point. This damage appeared to have been impact related.

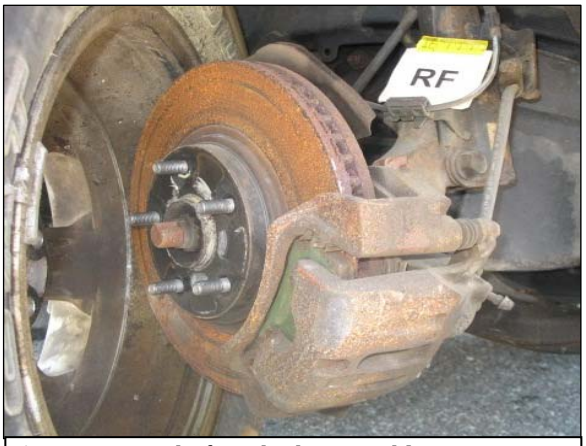

Figure 11: Right front brake assembly.

Figure 12: Right front brake pads.

The right front brake rotor, caliper, and brake pads were covered with surface rust similar as noted for the left rear. The rotor had two score lines on each side of the machined surface. The brake pads were removed from the rotor and were found to be in worn condition (**Figure 12**). The outer brake pad had 4 mm (5/32 in) of lining remaining on the pad while the inner (piston side) had 5 mm (6/32 in) of lining remaining. The rotor and linings did not display evidence of heat or damage.

The right rear disc brake (**Figure 13**) incorporated the drum-activated parking brake within the rotor. An on-scene image of the Toyota showed the right rear tire and wheel still attached to the axle, though angled inward at the lower aspect as a result of the rollover event dynamics. At the time of SCI inspection, the axle was completely fractured with the wheel removed from the hub assembly. The rotor was fractured into multiple pieces and the rear parking brake shoe was removed from the backer plate, with the brake cable still attached to the lower shoe clip. This disassembled state was the result of the prior police inspection process. The disc brake pads, although removed from the caliper, were in good condition with no evidence of heat or extreme wear. The rotor, although fractured, did not display evidence of brake-induced damage or wear.

Figure 13: Right rear disk brake assembly.

Foot Control Pedals

The foot controls of the Toyota consisted of the mechanical cable-actuated accelerator pedal and the conventionally mounted brake pedal. The pedals were intact, although the toe and floor pans were displaced rearward and vertically by intrusion that was associated with exterior deformation. The rubber pedal pads were in place and did not display excessive wear. **Figure 14** depicts the brake and accelerator pedals at the time of SCI inspection.

Figure 14: Brake pedal (left) and accelerator pedal (right) of the Toyota.

The accelerator pedal consisted of a pedal plate welded to the stalk. The stalk was mounted to the left side of a pivot arm that was attached to the toe pan with two vertically oriented bolts. A coil return spring was positioned between the pedal stalk and the mounting bracket. The throttle cable was attached to the top on the stalk, above the level of the pivot arm. As a result of the crash, the toe pan was intruded rearward against the accelerator pedal. Therefore, the pedal could not be depressed to test for evidence of binding or other anomalies.

The brake pedal was stalk mounted to a sub-instrument panel-mounted bracket, and was linked to the power brake booster and the hydraulic master cylinder. The pedal stalk was deformed by a combination of intrusion and probable driver contact during the crash sequence. As a result of this damage, the range of motion of the pedal was restricted.

The accelerator pedal was 4 cm (1.75 in) in width and 10 cm (3.8 in) in height. Post-crash, the lateral offset between the left edge of the accelerator pedal and the right edge of the brake pedal was 7 cm (2.8 in). Due to the intrusion, the face of the brake pedal was positioned 10 cm (4.0 in) above the height of the accelerator pedal. Dimensionally, the brake pedal pad was 7 cm (2.6 in) in height and 11 cm (4.2 in) in width at the top portion. The right edge of the brake pedal was on the altered (by intrusion) centerline of the steering column. The brake pedal was located 31 cm (12.0 in) forward of the leading edge of the driver's seat. It should be noted that the driver's seat was displaced vertically by buckling of the floor.

Floor Mats

The Toyota was equipped with OEM carpeted floor mats within the front seating positions. At the time of the SCI inspection, the forward edge of the driver's floor mat was positioned under the accelerator and brake pedals, lying flat against the OEM carpet floor covering. The mat was creased rearward of the foot pedals due to the deformation and intrusion of the respective toe and floor pans (**Figure 15**). The rearward edge of the floor mat was secured to the floor-mounted pegs located below the leading edge of the driver's seat. These pegs held the mat secure to the floor of the Toyota. There was no visible wear to the leading edge of the floor mat from contact with the accelerator pedal.

Figure 15: Left front floor mat of the Toyota.

Borescope Inspection

NHTSA's Office of Defects Investigation (ODI) dispatched two investigators to the inspection of the 2002 Toyota Highlander. The focus on this ODI inspection was to conduct a visual inspection of the accelerator pedal, the linkage cable from the pedal to the throttle body, and an internal inspection of the throttle body using an Everest XLG3 VideoProbe System borescope.

The borescope was inserted into the alloy throttle body to inspect and photograph the position of the throttle plate. The images were displayed on a remote handset monitor and stored on an image card. Figures 16 and 17 are images of the throttle plate provided by the ODI investigator. Based on the images provided by ODI; it appeared that the throttle plate was in the closed position within the throttle body. The throttle plate was stamped with the nomenclature 8-47. There was no visible damage to the throttle plate or to the surrounding alloy casting of the throttle body. A mechanical check of the operation of the throttle assembly post-crash was not performed.

Figure 16: Borescope view of the throttle plate within the 2002 Toyota. Image provided by ODI.

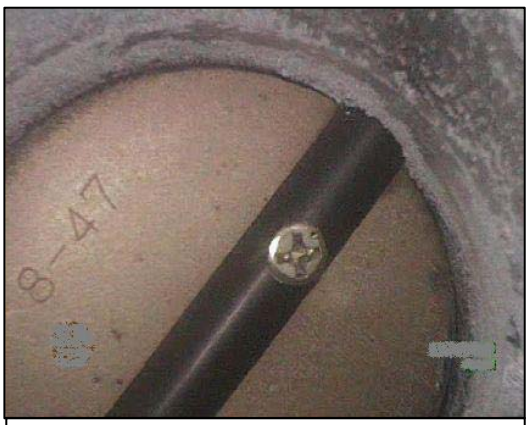

Figure 17: Close-up view of the throttle plate and the pivot rod. Image provided by ODI.

Supplemental Restraint Systems

The Toyota was equipped with a redesigned frontal air bag system that deployed as a result of the crash. The system consisted of a steering wheel hub-mounted driver air bag and a top instrument panel-mounted passenger air bag. An Air bag Control Module (ACM) controlled the system with two front frame rail-mounted satellite crash sensors and front safety belt retractor pretensioners. The Toyota was not equipped with the optional seatback-mounted side impact air bags.

The driver's air bag deployed from a conventional module with H-configuration cover flaps. The air bag was tethered at the 3 and 9 o'clock positions and vented by two ports located on the backside of the air bag at the 11 and 1 o'clock positions. In its deflated state, the deployed air bag measured 66 cm (26.0 in) in diameter. The air bag was stamped with the following nomenclature between the vents ports:

GA120-00200
202007800

The driver's air bag had scattered stains of dried body fluid across the face of the bag. A 5 cm (2.0 in) tear was noted at the 4 and 5 o'clock positions (lower right quadrant), inboard of the peripheral seam, toward the centerline of the air bag.

The front right passenger air bag deployed through the top-mounted H-configuration cover flaps. The overall dimensions of the air bag were 41 cm (16 in) in width and 61 cm (24 in) in height. The air bag was not tethered or directly vented into the passenger compartment. No damage was noted to the air bag, though a dried body fluid stain was present in the upper left quadrant. There was also an area of body fluid present on the face of the air bag at the right upper quadrant near the vertical centerline.

Event Data Recorder

The Toyota's ACM performed the functions of crash sensing, fault detection, and system deployment commands. The module was located on the center transmission tunnel, forward of the transmission shifter. According to information supplied by Toyota, the 2002 Toyota Highlander ACM did not have Event Data Recording (EDR) capabilities, nor was this year/make/model vehicle listed as a supported vehicle by the Toyota software. The module was manufactured by Denso and was identified by the Bar Coded Part No. 0246721TT and the following nomenclature:

89170048020
152300-4672
12V

During the SCI vehicle inspection process, an attempt was initiated to image the EDR using proprietary hardware and software version 1.10 that was provided to NHTSA by Toyota. The Toyota did not retain 12V electrical power as the electrical system had been compromised by severe damage sustained during the crash. The imaging attempt utilized a multi-pin cable that plugged directly into the ACM and was connected to an interface module linked to a Toyota supplied laptop computer with the current software application. Auxiliary 12V power was supplied to the interface box to provide electrical power to the ACM. Pass codes from a later model year Toyota Highlander were entered into the EDR application in an attempt to read data from the ACM. These attempts were unsuccessful, as the software could not communicate with the ACM.

Manual Safety Belt Systems

The Toyota was equipped with 3-point continuous loop, lap and shoulder safety belt systems for the five designated seating positions. All of the belt systems utilized sliding latch plates. The driver's safety belt retracted onto a lower B-pillar-mounted Emergency Locking Retractor (ELR). The front right and the three rear belt systems utilized switchable ELR /Automatic Locking Retractors (ALR). Both front retractors were equipped with pretensioners, which actuated during the crash. All three occupants of the Toyota were restrained by the manual safety belt systems at the time of the crash.

Loading evidence on the driver's safety belt webbing consisted of D-ring transfer and fractional abrasions of the lap belt webbing and latch plate. The D-ring transfer began 58 cm (23 in) above the retractor location, and was 25 cm (9.75 in) in length. The latch plate remained engaged in the seat frame-mounted buckle. Rescue personnel had cut the shoulder belt webbing at a point that was 91 cm (35.75 in) above the retractor.

The front right passenger's loading of the safety belt system produced an 11 cm (4.5 in) D-ring transfer. The transfer originated at the D-ring and extended forward of the pivot point. A subtle latch plate abrasion was present on the webbing, located 104 cm (41 in) above the outboard seat anchorage. The belt webbing remained intact and was locked in the worn position by the actuation of the retractor pretensioner.

During the removal of the body of the female rear right passenger by emergency response personnel, the safety belt webbing was cut 28 cm (11 in) above the C-pillar mounted lower anchor point. As a result of this process, the remainder of the belt webbing retracted into the C-pillar mounted ELR/ALR retractor. On-scene images of the vehicle provided by the investigating law enforcement agency revealed a lengthy body fluid transfer on the shoulder belt aspect of the webbing from engagement against the female passenger's right lateral neck.

Instrument Panel Gauges/Driver Controls

The Toyota was equipped with electronically controlled instruments and switches at the driver's position. However, there was no electrical power supplied to any of the systems of the vehicle as the battery had been destroyed by the frontal crush during the crash. At the time of the SCI inspection, the fuel gauge needle was stuck at the full-position and the temperature gauge needle was at the cold (lowest) position. The analog speedometer needle was stuck at 132 km/h (82 mph), and the tachometer needle was at the 6,700 RPM position. It should be noted that the redline position of the Toyota's tachometer was 6,250 RPM.

The Toyota was equipped with driver control switches for an OEM security system, power windows, power door locks, an 8-way power adjustable driver's seat, cruise control with steering wheel-mounted controls, and power adjustable heated exterior mirrors. At the time of the SCI inspection, the only discernable post-crash switch position was that of the power window lockout switch, which was in the activated (on) position.

Occupant Data - 2002 Toyota Highlander

Driver

Age/Sex:	63-year-old/Male
Height:	191 cm (75 in)
Weight:	109 kg (241 lb)
Eyewear:	Unknown
Seat Track Position:	Full-rear
Safety Belt Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection, on-scene police images
Egress From Vehicle:	Body removed by the rescue personnel
Type of Medical Treatment:	None; pronounced deceased at scene

Driver Injuries

Injury	Injury Severity (AIS 2005/ Update 08)	Injury Source
Aortic valve laceration with a transversely oriented laceration through the proximal aorta	Critical (420212.5,4)	Steering wheel rim and hub
Bilateral flail chest (left ribs 3-8 fractured anteriorly, left 4-9 fractured anterolaterally and left ribs 6-8 fractured posteriorly and right side ribs 1-7 fractured anteriorly, right 3rd rib fractured anterolaterally, right 11th rib fractured posteriorly) with bilateral pulmonary contusions and right side hemothorax, 750 mL)	Critical (450266.5,3)	Steering wheel rim and hub

Injury	Injury Severity (AIS 2005/ Update 08)	Injury Source
Cerebral contusion on the right lateral aspect of the temporal lobe	Serious (140604.3,1)	Left A-pillar
Right subarachnoid hemorrhage NFS	Serious (140684.3,1)	Left A-pillar
Left distal tibia open fracture NFS	Serious (853405.3,2)	Intruding toe pan
Right comminuted proximal tibia fracture	Serious (853405.3,1)	Intruding knee bolster
Left proximal tibia fracture NFS	Moderate (853404.2,2)	Intruding knee bolster
Left distal fibula fracture NFS	Moderate (851605.2,2)	Intruding toe pan
Right open ankle fracture NFS	Moderate (852002.2,1)	Intruding toe pan
T7 vertebral body transverse fracture	Moderate (650430.2,7)	Indirect fracture from steering wheel/hub loading
Sternum fracture (transversely oriented, at the level of the 3rd rib)	Moderate (450804.2,4)	Steering wheel rim and hub
Comminuted mandible fracture	Moderate (250610.2,9)	Steering wheel rim
Full thickness laceration to the tip of chin	Minor (290600.1,8)	Steering wheel rim
Nasal fracture NFS	Minor (251000.1,4)	Steering wheel rim
Fractured teeth	Minor (251404.1,8)	Steering wheel rim
Lacerations inside of mouth (mucosal)	Minor (243099.1,8)	Steering wheel rim
Lower abdominal abrasions (leathery-like, band- like spanning the lower abdomen)	Minor (590202.1,8)	Lap belt webbing

Source – Autopsy

Driver Kinematics

The driver of the Toyota was seated with the seat track adjusted to the full-rear position and the head restraint adjusted approximately 8 cm (3 in) above the seat back. He was restrained by the manual 3-point lap and shoulder safety belt system, with the D-ring adjusted to its lowest position. Restraint usage was determined from on-scene images provided by the investigating law enforcement agency and the presence of loading evidence on the safety belt system. At the time of the crash, the driver was wearing a fleece-type jacket. Toxicology screening for alcohol and drugs was negative.

At impact with the Chevrolet, the Toyota's redesigned frontal air bag system deployed and the retractor pretensioners actuated. The severe frontal engagement resulted in intrusion of the left A-pillar, instrument panel, steering assembly, and the toe pan into the driver's space. The

rearward displacement of the steering column rotated the upper end of the column (steering wheel and air bag) upward.

The driver initiated a forward trajectory in response to the 12 o'clock direction of force and loaded the safety belt system and the deployed frontal air bag. His loading force spooled webbing from the load limiting retractor as he engaged and compressed the air bag against the steering wheel. The belt loading evidence consisted of the 25 cm (9.75 in) D-ring transfer on the upper aspect of the shoulder belt and a full-width frictional abrasion across the latch plate. A soft tissue band-like abdominal abrasion spanned the driver's anterior abdomen from loading the lap belt portion of the safety belt system.

His loading was transmitted through the safety systems and into the four-spoke steering wheel and steering column. The full circumference of the steering wheel was deformed forward with a maximum forward displacement of 9 cm (3.5 in) at the 5-7 o'clock sectors of the wheel rim, inclusive of the spokes. This deformation resulted in significant loading of the hub portion of the steering assembly. As a result of wheel loading, the driver sustained an aortic valve laceration with transverse laceration of the proximal aorta, unilateral left flail chest with multiple bilateral rib fractures, a sternum fracture, bilateral pulmonary contusions, a right hemothorax, and an indirect fracture of the T7 vertebrae.

The thoracic loading of the safety belt and the steering wheel caused the driver's head to flex forward and downward as the Toyota began to rotate in a CCW direction. His head/face contacted the upper steering wheel rim and the lower left A-pillar. A scuffmark with body fluid evidenced the pillar contact. The wheel rim contact resulted in a comminuted mandible fracture, a nasal fracture, a full-thickness laceration to the tip of the chin, fractured teeth (NFS), and lacerations of the mucosal. The head impact to the pillar resulted in a cerebral contusion of the right lateral aspect of the frontal lobe and right subarachnoid hemorrhage.

The driver sustained a left proximal tibia fracture as his left knee/lower leg contacted the left side of the bolster, fracturing the rigid plastic panel and engaging the underlying components. His right knee/lower leg contacted the base of the steering column, resulting in a comminuted fracture of the proximal right tibia. The driver's feet and lower legs subsequently loaded the intruding toe pan and foot pedals, resulting in left distal tibia and fibula fractures, and an open right ankle fracture.

The driver rebounded and translated right laterally as the Toyota overturned onto is right side. During this trajectory, body fluid was transferred to the deflated air bag. The driver maintained a co-linear trajectory with the vehicle as it subsequently up-righted and continued its CCW rotation to final rest. He came to rest with the shoulder belt positioned under his left arm, slumped to his right with his right arm on the center console.

Emergency response personnel determined that the driver was deceased on their arrival. Extrication efforts to remove his body included utilization of hydraulic rescue tools to cut and remove the left side doors and B-pillar from the vehicle. Additionally, because the driver's lower extremities were entrapped within the floor area below the instrument panel and knee bolster, emergency response personnel cut the lower left A-pillar and displaced the instrument panel upward and forward. The driver's seatback was cut from the vehicle, and his body was removed. An autopsy was performed five days following the crash.

Front Right Passenger

Age/Sex:	61-year-old/Female
Height:	170 cm (67 in)
Weight:	68 kg (150 lb)
Eyewear:	Unknown
Seat Track Position:	Full-rear
Safety Belt Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection
Egress From Vehicle:	Removed from vehicle by rescue personnel
Type of Medical Treatment:	None, pronounced deceased at scene

Front Right Passenger Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Bilateral flail chest (left ribs 1-5 and 7-11 fractured anteriorly, left ribs 4-11 fractured anterolaterally, Right ribs 1-10 anterolaterally, right 2nd and 4th ribs posteriorly, and right ribs 1, 2, 4-6 posteriorlaterally, with bilateral lung contusions NFS)	Critical (450266.5,3)	Shoulder belt
Left lung lacerations (small, with bilateral hemothorax, 100mL in both right and left pleural cavities and hemopericardium)	Serious (441430.3,2)	Shoulder belt
Spleen laceration (stellate laceration of the posterior edge that extends deep into the splenic parenchyma)	Serious (544224.3,2)	Lap belt/Shoulder belt juncture
Left olecrannon open fracture	Serious (752604.3,2)	Transmission shifter
Right clavicle fracture	Moderate (752200.2,1)	Shoulder belt
Sternum fracture (transversely oriented at the level of the 4th ribs)	Moderate (450804.2,4)	Shoulder belt
Right open displaced ankle fracture	Moderate (852002.2,1)	Intruding toe pan
Non-displaced fracture of C1	Moderate (650216.2,6)	Air bag, indirect

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Forehead lacerations (2 roughly parallel full-thickness lacerations at the center of the forehead, approximately 6 cm each)	Minor (290602.1,7)	Unknown
Forehead abrasion (5 x 3 cm) extending into hairline	Minor (290202.1,7)	Air bag
Scalp abrasion	Minor (190202.1,5)	Ground
Scalp contusion (over vertex and occipital region)	Minor (190402.1,5)	Ground
Left eyelid contusion	Minor (297402.1,2)	Air bag
Neck laceration (anterior neck, laceration to the right side strap muscles)	Minor (390600.1,5)	Shoulder belt
Right clavicle area abrasion (extending obliquely downward from the midpoint of the clavicle) 10 x 3 cm	Minor (790202.1,1)	Shoulder belt
Left chest abrasion (just below the left clavicle area, 3 x 3 cm)	Minor (490202.1,2)	Air bag
Left elbow contusion (8 x 8 cm) surrounding the left olecrannon fracture	Minor (790402.1,2)	Transmission shifter
Small right wrist abrasion of the medial aspect	Minor (790202.1,1)	Air bag
Left medial knee (6 x 2 cm) and lower leg abrasion (2 x 0.6 cm)	Minor (890202.1,2)	Glove box door
Left foot contusion (3 x 1 cm, dorsum of foot)	Minor (890402.1,2)	Lower instrument panel
Right knee and lower leg contusion, Left thigh contusion (posteromedial aspect, 6 x 5 cm just above the popliteal fossa)	Minor (890402.1,3)	Glove box door

Source – Autopsy Report

Front Right Passenger Kinematics

The front right passenger was seated upright with the seat track adjusted to the full-rear track position and the head restraint adjusted to the full-down position. She was restrained by the manual safety belt system, with the shoulder belt positioned over the right shoulder/clavicle region. The D-ring was adjusted to the full-down position. Manual restraint use and position were determined from loading evidence on the belt system and occupant injuries.

At impact with the Chevrolet, the redesigned frontal air bag system deployed and the safety belt pretensioner actuated. The front right passenger initiated a forward trajectory and loaded the safety belt and the deployed frontal air bag as she responded to the high delta-V crash forces. Her loading force against the belt webbing produced frictional abrasions on the webbing at the D-ring and the latch plate locations. As a result of belt loading, the front right passenger sustained a bilateral flail chest with multiple rib fractures, bilateral pulmonary contusions and

lacerations, a bilateral hemothorax, hemopericardium, a right clavicle fracture with an overlying abrasion, a sternum fracture at the level of the 4th rib, and a right lateral neck laceration. The juncture of the lap belt and shoulder belt produced a stellate laceration of the spleen. Belt loading allowed the passenger's head to translate forward and downward (neck flexion) as her face engaged the deployed air bag. This flexion resulted in a non-displaced fracture of C1. Facial contact with the air bag produced an abrasion of the left upper chest and right wrist, and a contusion of the left eyelid. It is unknown if the passenger was wearing eyeglasses at the time of the crash. She sustained two parallel lacerations of the forehead from an unknown source.

The front right passenger's knees and lower extremities engaged the intruding glove box door within the right instrument panel. These bilateral contacts deformed the rigid component and produced contusions of the knees, distal left thigh, and the right lower leg. Her loading of the intruding toe pan and the sub-area of the lower instrument panel resulted in an open fracture of the right ankle and a contusion of the dorsum of the left foot.

As the Toyota briefly overturned onto its right side, the right front door glazing disintegrated. The front right passenger's head was probably partially ejected through the window opening and contacted the asphalt surface, resulting in abrasions of the forehead and scalp and a scalp contusion. She also sustained an open fracture of the left olecrannon with a surrounding contusion from possible contact with the automatic transmission shift lever. The shifter was scuffed and fractured.

The final rest position of the front right passenger within the vehicle is unknown. She was removed from the vehicle by emergency response personnel and placed on an ambulance stretcher, but was pronounced deceased at the scene of the crash.

Rear Right Passenger

Age/Sex:	94-year-old/Female
Height:	142 cm (56 in)
Weight:	32 kg (71 lb)
Eyewear:	Prescription glasses
Seat Track Position:	Fixed
Safety Belt Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection
Egress From Vehicle:	Body removed by rescue personnel
Type of Medical Treatment:	None, deceased at scene

Rear Right Passenger Injuries

Injury	Injury Severity (AIS 2005/Update 08)	Injury Source
Bilateral flail chest (left side ribs 1-9 interiorly and 1-10 anterolaterally, right side ribs 1-4 anteriorly, right 2-10 anterolaterally and right ribs 1-11 posteriorly, with bilateral pulmonary contusions and right hemothorax, 100mL)	Critical (450266.5,3)	Shoulder belt webbing
Proximal aorta laceration (transversely oriented)	Severe (420206.4,4)	Shoulder belt webbing
Left distal femur fracture (open and comminuted, just above the knee)	Serious (851801.3,2)	Indirect fracture from loading the front right seat back
Right mid tibia fracture (open)	Serious (853422.3,1)	Front right seat back
Left medial clavicle fracture	Moderate (752200.2,2)	Direct from loading shoulder belt webbing
Right mid fibula fracture (open)	Moderate (851606.2,1)	Front right seat back
Left distal tibia fracture	Moderate (853404.2,2)	Front right seat frame
Left distal fibula fracture	Moderate (851605.2,2)	Front right seat frame
Left foot fracture NFS	Moderate (852000.2,2)	Front right seat frame
Neck laceration (major) gaping laceration at base of neck involving right side strap muscles and exposure of deep arteries, veins and nerves	Moderate (390604.2,1)	Shoulder belt webbing
Right forearm laceration (midway between elbow and wrist)	Minor (790602.1,1)	Front right seat back
Bilateral knee (medial aspect) and left shin contusion	Minor (890402.1,3)	Front right seat back
Left lower leg laceration (pretibial region) triangular avulsive laceration	Minor (890802.1,2)	Front right seat back
Left ankle laceration (over the Achille's tendon)	Minor (890602.1,2)	Front right seat frame
Right hip abrasion (over anterior iliac region, obliquely oriented)	Minor (890202.1,1)	Lap belt webbing
Left side forehead laceration (crescent shaped, full thickness, near hairline)	Minor (290600.1,7)	Front right seat back
Left scalp contusion (left fronto-parietal region, subadjacent to the left forehead laceration)	Minor (190402.1,2)	Front right seat back

Source – Autopsy report

Rear Right Passenger Kinematics

The petite rear right female passenger was seated in an unknown posture and was restrained by the manual safety belt system. Restraint usage was determined from loading evidence on the belt system and on-scene photographic evidence of the passenger's position within the Toyota at final rest. Evidenced by the images provided by the investigating law enforcement agency, she was wearing a fleece-type medium weight jacket and the shoulder belt webbing was positioned over her right shoulder.

At impact with the Chevrolet, the rear right passenger initiated a forward trajectory in response to the frontal crash forces. Her torso and right lateral neck loaded the shoulder belt webbing as the ELR engaged. As a result of the neck loading, the passenger sustained a gaping laceration of the right lateral neck with penetration into the strap muscles, with exposure of arteries, veins, and nerves. Body fluid was present on the belt webbing to support this interaction. The passenger's thoracic loading of the shoulder belt webbing resulted in the multiple rib fractures with unilateral flail chest, aortic laceration, bilateral pulmonary contusions, and right hemothorax. The right side loading of the shoulder belt caused her left shoulder and arm to rotate forward, resulting in a left clavicle fracture.

The thoracic loading of the shoulder belt, in combination with the chest compression and CW rotation of her torso, allowed her head to translate forward and downward. Her left forehead and scalp regions contacted the front right seat back, resulting in a full-thickness laceration of the forehead and a contusion to the left fronto-parietal scalp.

The rear right passenger's lower extremities loaded the lower front right seat cushion frame and seatback. The seat frame loading produced fractures of the left distal tibia, left distal fibula, and left foot (NFS), and a laceration above the left ankle. The loading of the seat back resulted in mid-shaft fractures of the right tibia and fibula, and an indirect open fracture of the distal left femur. A scuffmark with compression of the setback cushion above the outboard hinge point evidenced contact from her left knee. Superficial injuries included an abrasion over the right hip from lap belt loading and a right forearm laceration from probable contact against the seatback. The forearm laceration may have been caused by displacement of jewelry during the setback contact.

At rest within the vehicle, the rear right passenger remained in her seat position and was slumped forward, supported by the shoulder belt of the locked, inertia-activated safety belt system. Her head was slumped forward to the anatomical limits of her neck, near the inboard aspect of the front right seatback. Her right arm was extended between the front right seatback and the right B-pillar, as if in a bracing position.

The rear right female passenger was pronounced deceased upon arrival of the emergency response personnel. To remove her body, the safety belt webbing was cut at the outboard aspect of the lap belt. An autopsy was performed four days following the crash.

Vehicle Damage – 2005 Chevrolet Malibu

Exterior Damage

As previously stated, the Chevrolet Malibu was sold as salvage prior to SCI's involvement in this investigation; therefore it was not inspected. An assessment of the vehicle's damage was based on a review of the images provided by the insurance salvage yard and the investigating police agency, **Figure 18** is a front view of the Chevrolet. The exterior of the Chevrolet sustained severe impact damage as a result of the frontal crash. The width of the direct and induced damage extended across the entire 147 cm (58 in) end-width of the vehicle. The direct contact damage began an estimated 36 cm (14 in) right of center and extended 109 cm (43 in) to the left corner. The maximum crush was located at the left corner and was an estimated 91 cm (36 in). The estimated crush profile of the frontal damage was C1 = 91 cm (36 in), C2 = 74 cm (29 in), C3 = 55 cm (22 in), C4 = 38 cm (15 in), C5 = 18 cm (7 in), C6 = 0. The left bias of the impact configuration resulted in crush to the left A-pillar area. The left A-pillar was deformed to a vertical orientation. The roof was buckled above the driver's position with associated buckling that continued to the left C-pillar. The left front door compressed an estimated 30 cm (12 in), and was buckled. The left wheelbase was significantly reduced. The CDC of the impact was 12FDEW5.

Figure 18: Front left oblique view of the Chevrolet. (*Image supplied by the insurance salvage facility*)

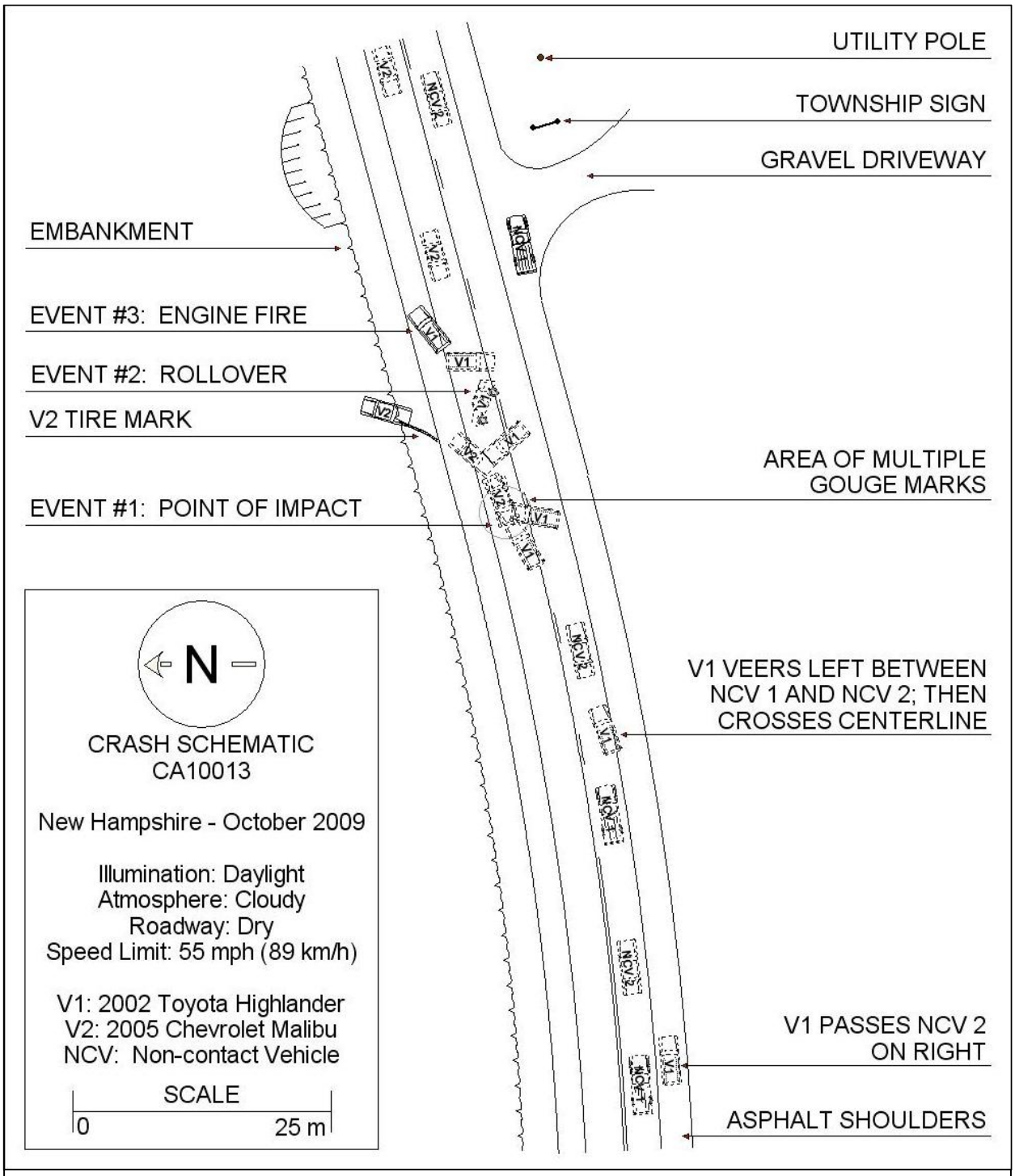

Figure 19: Crash schematic.