INDIANA UNIVERSITY

TRANSPORTATION RESEARCH CENTER
School of Public and Environmental Affairs
501 South Morton Street Suite 105
Bloomington, Indiana 47403-2452
(812) 855-3908 Fax: (812) 855-3537

ON-SITE SIDE IMPACT INFLATABLE OCCUPANT PROTECTION INVESTIGATION

CASE NUMBER - IN09036
LOCATION - MISSOURI
VEHICLE - 2008 TOYOTA HIGHLANDER
CRASH DATE - September 2009

Submitted:

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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 be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

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

Technical Report Documentation Page

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15. *Supplementary Notes*
On-site side impact inflatable occupant protection investigation involving a 2008 Toyota Highlander and a 1997 Dodge Caravan LE.

16. *Abstract*

This on-site investigation focused on the rollover/side impact air bag system of a 2008 Toyota Highlander. Additional focus was on the crash dynamics and the sources of the injuries for the driver and second row passengers. The Toyota was occupied by a restrained 34-year-old female driver, a 2-year-old male second row left passenger, and a 6-month-old male second row right passenger. The second row left passenger was restrained in a forward-facing Britax Marathon Convertible Child Restraint System (CRS). The second row right passenger was restrained in a rear-facing Graco Snug Ride Infant Safety Seat. The Toyota was traveling southwest on a 2-lane state highway and the driver was negotiating a left curve. The Toyota was impacted on the left side plane (event 1) by the front plane of a northeast-bound 1997 Dodge Caravan LE. The direction of force on the Toyota was within the 11 o'clock sector and the impact force was sufficient to trigger the deployment of the left rollover/side impact inflatable curtain (IC) air bag and the driver's seat-mounted side impact air bag. The Toyota rotated counterclockwise and rolled over (event 2) right side leading 6 quarter turns. The Toyota's right IC air bag also deployed during the crash. The driver of the Toyota sustained moderate injuries and was transported by ambulance to a hospital where she was treated and released. Both second row passengers of the Toyota sustained minor injures and were transported by ambulance to a hospital where they were treated and released. The driver of the Dodge was also transported to a hospital. Both vehicles were towed due to damage.

17. *Key Words* Side Impact Air Bag Air Bag Deployment Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public		
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TABLE OF CONTENTS

IN09036

Page No.

This on-site investigation focused on the rollover/side impact air bag system of a 2008 Toyota Highlander (**Figure 1**). Additional focus was on the crash dynamics and the sources of the injuries for the driver and second row passengers. This crash was brought to the attention of the National Highway Traffic Safety Administration (NHTSA) on October 14, 2009 by this contractor. The investigation was assigned on October 22, 2009. This crash involved the Toyota and a 1997 Dodge Caravan LE. The crash occurred in September, 2009, at 1030 hours, in Missouri and was investigated by the Missouri State Highway Patrol. Both vehicles and the crash scene were inspected on October 27-28, 2009. The driver of the Toyota was interviewed on October 23 and 30, 2009. This report is based on the police crash report, scene and vehicle inspections, exemplar vehicle inspection, interview information, occupant kinematic principles, and evaluation of the evidence.

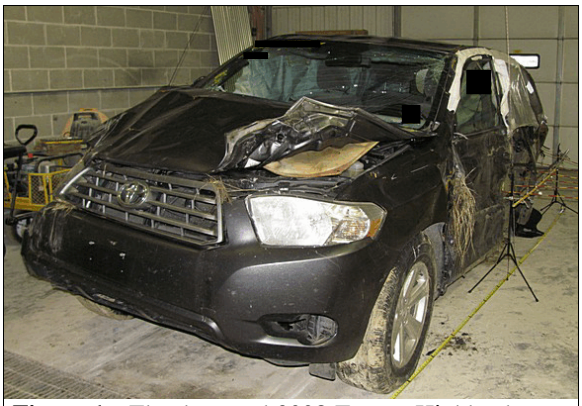

Figure 1: The damaged 2008 Toyota Highlander

CRASH CIRCUMSTANCES

Crash Environment: The trafficway that both vehicles were traveling on was a 2-lane, undivided, state highway, traversing in a northeast-southwest direction. The roadway was curved with one travel lane in each direction and was bordered by bituminous shoulders. Each travel lane was approximately 3.5 m (11.5 ft) in width and the shoulders were 3.3 m (10.8 ft) in width. A ditch was located on each side of the road. The Toyota rolled over on the northwest side of the road, and the depth of the ditch was 1.1 m (3.5 ft). At the time of the crash the light condition was daylight and the weather was clear. The roadway surface was dry, level bituminous and the speed limit was 89 km/h (55 mph). The Crash Diagram can be seen on page 14 of this report.

Pre-Crash: The Toyota was occupied by a restrained 34-year-old female driver, a 2-year-old male second row left passenger, and a 6-month-old male second row right passenger. The second row left passenger was restrained in a forward-facing Britax Marathon Convertible Child Restraint System (CRS). The second row right passenger was restrained in a rear-facing Graco Snug Ride Infant Safety Seat (ISS). The driver of the Toyota stated during the SCI interview that she was traveling southwest negotiating a left curve (**Figure 2**) at approximately 80 km/h (50 mph) and intended to continue southwest. The driver of the Dodge was traveling northeast negotiating the curve (**Figure 3**) and intended to continue

Figure 2: Approach of the Toyota; arrow shows area of impact

northeast. The driver of the Dodge told police that he attempted to throw a cigarette out of the window and it blew back into the vehicle. He became distracted trying to find the cigarette allowing the Dodge to cross the centerline into the southwest-bound travel lane. The driver of the Toyota attempted to avoid the crash by initiating a right steering maneuver. The crash occurred 2.9 m (9.5 ft) into the southwestbound travel lane (**Figure 4**).

Figure 3: Approach of the Dodge to the area of impact (arrow)

Figure 4: Approach of Toyota to impact; arrow in foreground shows location of impact with the Dodge; arrow in background shows location of rollover initiation for the Toyota

Crash: The left side plane of the Toyota (**Figure 5**) was impacted by the front plane of the Dodge (**Figure 6**, event 1). The direction of force on the Toyota was within the 11 o'clock sector and the impact force was sufficient to trigger the deployment of the left rollover/side impact inflatable curtain (IC) air bag and the driver's seat-mounted side impact air bag. The right IC air bag also deployed during the crash. As the engagement continued down the left side plane of the Toyota, the left front wheel of the Dodge engaged the left rear wheel of the Toyota. As a result, the left rear wheel of the Toyota was torn off the vehicle and the left front wheel of the Dodge was dislodged from the differential. The Toyota rotated counterclockwise and rolled over right side leading (event 2). The vehicle came to final rest on its top plane on the northwest side of the roadway heading south (**Figure 7**). The Dodge was redirected to northeast. It traveled 40 m (131.2 ft) and came to final rest on the southwest shoulder.

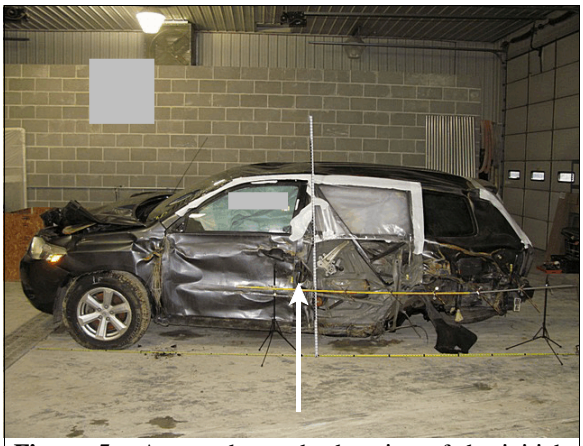

Figure 5: Arrow shows the location of the initial contact with the front of the Dodge; damage from the rollover overlaps the damage from this impact

Post-Crash: The driver of the Toyota unbuckled the safety belt and crawled into the second row where she removed the second row left passenger from the CRS. A passer-by assisted the driver in removing the child from the vehicle through the left rear window opening. The driver then released the second row left passenger's ISS from the base. The second row right passenger remained in the ISS as the driver passed it through the left rear window opening to the same passer-by. The driver then crawled out of the left rear window. A passer-by notified the police of the

crash at 1031 hours and they arrived at the crash scene at 1042 hours. The drivers of both vehicles and the two passengers of the Toyota were transported by ambulance to a hospital. Both vehicles were towed from the crash scene due to damage.

Figure 6: Damage to the front and left side plane of the Dodge from the impact with the left side plane of the Toyota

Figure 7: View through the final rest position of the Toyota (arrow) back to the location of rollover initiation (arrow in background)

ROLLOVER DISCUSSION

The rollover mitigation features of the Toyota consisted of rollover sensing and Electronic Stability Control (ESC). The vehicle has been given a four star rollover rating on a five star scale by NHTSA and a Static Stability Factor of 1.22[1]. A four star rating indicates that the vehicle has a 10%-20% chance of a rollover when involved in a single vehicle crash. The specific chance of a rollover for this vehicle model was given as 17%. The Static Stability Factor (SSF) is a calculation based on the vehicle's track width and height of its center of gravity. The result of the calculation is a measure of a vehicle's resistance to a rollover. A higher SSF indicates a more stable vehicle. The majority of passenger vehicles have an SSF of 1.30 to 1.50[2]. The test vehicle also did not tip-up during the dynamic steering maneuver test in which the test vehicle was put through a fishhook-shaped steering maneuver (i.e., hard left and hard right steer) at between 56 km/h-80km/h (35-50 mph).

The rollover of the Toyota (event 2) was initiated following the left side plane impact with the front of the Dodge (event 1). The impact with the Dodge caused the Toyota to rotate counterclockwise 115 degrees as it traveled 22 m (72.2 ft) toward the northwest edge of the road (**Figure 8**). The vehicle tripped and rolled over right side leading when the right rear wheel (**Figure 9**) furrowed into the ground and the right front wheel rim (**Figure 10**) gouged the bituminous surface of the shoulder (**Figure 11**). The vehicle rolled over 6 quarter turns across a distance of 30 m (98.4 ft) and came to final rest near the top of the back slope of the ditch (**Figure 7**).

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[1] www.safercar.gov, 11/5/09

[2] "Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans", NHTSA Technical Report, DOT HS 809 868, June 2005

Figure 8: Yaw marks from the right side tires of the Toyota as the vehicle rotated counterclockwise approaching location of rollover initiation (arrow); yaw mark on left is from the left front tire, yaw mark on right is from the right rear tire

Figure 9: Grass in right rear wheel rim (arrow) from furrowing ground on approach to trip point; dirt in rim is from ground contact during the rollover

Figure 10: The numbered tape [each increment is 1 in (2.5 cm)] outlines the abrasion on the right front wheel rim due to gouging the bituminous surface of the shoulder

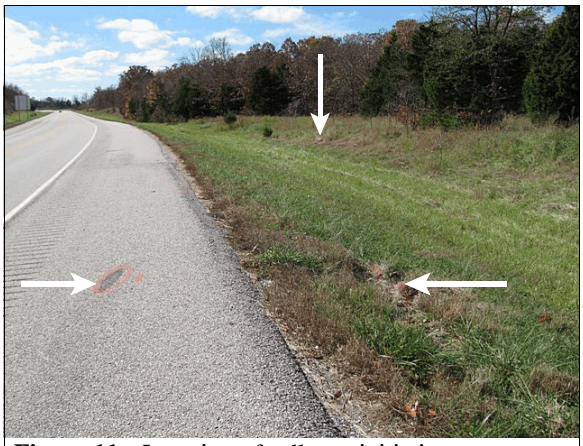


Figure 11: Location of rollover initiation; arrow on left shows gouge on shoulder from right front wheel; arrow on right shows furrow on ground from right rear wheel; arrow in background shows the location of the final rest of the Toyota

CASE VEHICLE

The 2008 Toyota Highlander was an all-wheel drive, 7-passenger, 4-door sport utility vehicle (VIN: JTEES41AX82------) equipped with a 3.5-L, V-6 engine, a 5-speed automatic transmission, ESC, 4-wheel anitlock brakes, rollover sensing, and a tire pressure monitoring system. The front row was equipped with bucket seats, adjustable head restraints, lap-and-shoulder safety belts, driver and passenger frontal air bags, driver knee air bag, front seat-mounted side impact air bags, and rollover/side impact IC air bags, which provided protection to all three seating rows. The second row was equipped with a split bench seat with folding backs, lap-and-shoulder safety belts, adjustable head restraints, and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. The third row was equipped with a bench seat with folding back, folding head restraints, and lap-and-shoulder safety belts. The vehicle's mileage could not be determined at the time of the inspection since it was without power and equipped with

an electronic odometer. The driver estimated the vehicle's mileage as approximately 29,000 miles (46,671 kilometers). The specified wheelbase was 279 cm (109.8 in).

CASE VEHICLE DAMAGE

Exterior Damage: The impact with the front plane of the Dodge involved the left side plane of the Toyota. The left rear door, left B-pillar, left rear wheel, and quarter panel were directly damaged (**Figure 12**). The left rear wheel was also torn off the vehicle. The direct damage began 159 cm (62.6 in) rear of the left front axle and extended 192 cm (65.4 in) rearward along the left side. A crush profile could not be measured for this impact since the sheet metal of the left rear door had been torn off and there was overlapping damage on the quarter panel from the rollover. The crush gauge was positioned on the left side plane to illustrate the location of the damage (**Figure 12**).

The direct damage from the rollover involved the top plane, both side planes, and the right portion of the front plane (**Figures 12-14**). The direct damage on the left side plane extended from the front bumper fascia to the back of the quarter panel and involved the full height of the side plane. The direct damage on the right side plane involved the front bumper and roof side rail. The direct damage on the front plane was 55 cm (21.7 in) in length and began at the right bumper corner. The direct damage on the top plane extended from the front of the hood to the back of the vehicle and involved the full width of the roof, 121 cm (47.6 in). The maximum vertical crush (**Figure 15**) was 7 cm (2.8 in) and occurred on the roof over the driver's seat 16 cm (6.3 in) inboard of the left roof side rail. The maximum residual lateral crush (**Figure 16**) was 5 cm (2 in) and occurred on the right roof side rail immediately forward of the right D-pillar.

Figure 12: Damage on the left side plane of the Toyota from the impact with the Dodge and the rollover

Figure 13: Damage on the front and right side planes from the rollover

Figure 14: Direct damage to the front portion of the roof from the rollover

Figure 15: The maximum vertical crush was located on the roof over the driver's seat

Figure 16: The maximum lateral crush occurred on the right roof side rail immediately forward of the right D-pillar

Damage Classification: The Collision Deformation Classifications (CDC) were 11LZAW2 (340 degrees) for the left side plane impact with the Dodge (event 1) and 00TDDO2 for the rollover (event 2). The Missing Vehicle algorithm of the WinSMASH program calculated the total Delta V for the left side plane impact with the Dodge as 14 km/h (8.7 mph). The longitudinal and lateral velocity changes were -13.8 km/h (-8.6 mph) and 2.4 km/h (1.5 mph), respectively. The results are based only on the damage sustained by the Dodge and should be considered borderline. The severity of the rollover damage was moderate based on the extent of the crush on the roof.

The vehicle manufacturer's recommended tire size was P245/65R17. The Toyota was equipped with the recommended size tires. The vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	207	30	207	30	10	12	None	No	No
LR	Flat	Flat	207	30	8	10	Sidewall cut, tire separated from rim	No	Yes
RR	172	25	207	30	8	10	None	No	No
RF	207	30	207	30	10	12	None	No	No

Vehicle Interior: The inspection of the Toyota's interior revealed evidence of occupant contact on the forward upper quadrant of the left front door panel and on the steering wheel rim. The occupant contact evidence on the left front door consisted of a scuff mark on the armrest grab handle that was probably due to contact by the driver's left forearm. The control panel for the electric windows and door locks was displaced, probably due to contact by the driver's left knee.

The lower left steering wheel rim was also scuffed, probably due to contact by the driver's left hand. There was no other discernable evidence of occupant contact. There was no deformation of the steering wheel rim or displacement of the energy absorbing steering column.

The vehicle's left rear door was jammed shut, while the other doors remained closed and operational. The pre-crash status of all the window glazings was either closed or fixed. The windshield was in place and cracked due to impact forces. The left rear window glazing, second left rear window glazing, and the backlight glazing were disintegrated by impact forces. The remaining glazings were undamaged.

The vehicle sustained multiple intrusions into the passenger compartment. The most severe intrusion into the driver's space involved the roof and windshield header. Both components intruded 6 cm (2.4 in). The C-pillar and rear lower quadrant of the left rear door intruded 7 cm (2.8 in) into the second row left passenger space.

AUTOMATIC RESTRAINT SYSTEM

The Toyota was equipped with a frontal air bag system that was certified by the manufacturer to be compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. The vehicle also was equipped with a driver knee air bag. The frontal air bags and the driver knee air bag did not deploy in this crash.

The Toyota was equipped with a side air bag system that consisted of roof rail-mounted rollover/side impact IC air bags and front seat-mounted side impact air bags. Based on the Holmatro Rescuer's Guide to Vehicle Safety Systems, the side impact sensors were located within the lower B-pillars and quarter panels. The IC air bag inflators are located within the roof side rails between the C and D-pillars. The driver's seat-mounted side impact air bag and both IC air bags deployed in this crash.

Figure 17: The front portion of the left IC air bag and driver's seat-mounted side impact air bag

The left IC air bag was located along the roof side rails inside the headliner and extended from the A-pillar to the D-pillar. The IC was designed with inflation chambers adjacent to the outboard seating positions. There was a non-inflatable fabric panel on the second row portion of the IC air bag that was 38 cm (15 in) in width and 41 cm (16.1 in) in height. There were no visible external vent ports. The deployed left IC air bag (**Figures 17** and **18**) was 234 cm (92.1 in) in width and 58 cm (22.8 in) in height. It was attached to the A-pillar by a 12 cm (4.7 in) nylon rope. A triangular-shaped fabric panel was present at the front of the IC air bag that was 16 cm (6.3 in) in width and 34 cm (13.4 in) in height. The IC air bag extended vertically 24 cm (9.4 in) below the beltline. Inspection of the

deployed IC air bag revealed no discernable evidence of occupant contact. A 1 cm (0.4 in) diameter hole was present on a non-inflatable section of the IC air bag located between the second seat back and the left rear door. It was located 69 cm (17.6 in) forward of the back of the IC air bag and 6 cm (2.4 in) above the bottom of the IC air bag. The source of the hole was probably glass fragments from the disintegrated second left rear window glazing. The right IC air bag was of the same features and dimensions. There was no discernable evidence of occupant contact and no damage on the right IC air bag adjacent to the second row right passenger's seating position (**Figure 19**).

Figure 18: The second row left portion of the left IC air bag

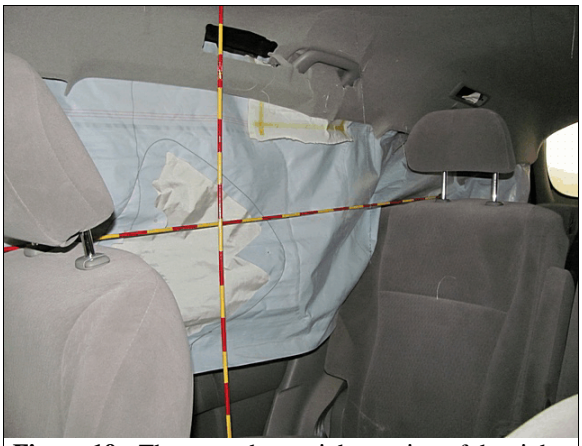


Figure 19: The second row right portion of the right IC air bag

The driver's seat-mounted side impact air bag was located in the outboard side of the seat back and deployed through a tear-seam (**Figure 20**). The deployed air bag (**Figure 21**) was 30 cm (18.6 in) in width and 36 cm (14.2 in) in height. The inspection of the air bag revealed no discernable evidence of occupant contact and no damage.

MANUAL RESTRAINT SYSTEM

Figure 20: The location of the left front seat-mounted side impact air bag

The Toyota was equipped with lap-and-shoulder safety belts for all the vehicle's seating positions. The driver's safety belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), sliding latch plate, and an adjustable upper anchor that was in the full-down position. The front right safety belt was similarly equipped but had a switchable ELR/Automatic Locking Retractor (ALR). The adjustable upper anchor was also located in the full-down position. Both front row safety belts were equipped with retractor-mounted pretensioners. The second and third row safety belts were similarly equipped as the front right safety belt and had fixed upper anchors. The second row center safety belt was integrated within the seat. The second and third row safety belts were not equipped with pretensioners.

The inspection of the driver's safety belt assembly revealed historical usage scratches on the latch plate, and the belt webbing was slightly stretched. Load abrasions were also present on the latch plate belt guide. The retractor was jammed with a length of belt extended out of the retractor consistent with usage by the driver. The jammed retractor also indicated that the retractor-mounted pretensioner actuated. Based on this evidence, the driver was restrained by the lap-and-shoulder safety belt at the time of the crash.

Figure 21: The driver's seat-mounted side impact air bag

Inspection of the second row left and right safety belt assemblies revealed no evidence of usage in this crash. The driver stated during the SCI interview that both the second row left CRS and second row right ISS were secured in the vehicle by their respective LATCH systems. The vehicle's safety belts were not used to secure them. Inspection of the vehicle's LATCH anchors in both seat positions revealed that they were scratched consistent with past usage. The remaining seat positions were unoccupied.

CHILD RESTRAINT SYSTEM

Based on the driver interview, the second row left passenger was seated in a forward-facing Britax Marathon CRS. The CRS was manufactured on February 8, 2008 and the model number was E9L0669 The CRS was equipped with a 5-point harness, lower anchor attachments, and a tether. The harness straps were routed through the top slots and the harness retainer clip was positioned immediately below the child's armpit level. The driver's husband installed the CRS in the vehicle via both the lower anchor attachments and tether. The CRS was not damaged during the crash.

The second row right passenger was seated in a rear-facing Graco Snug Ride ISS. The ISS was manufactured on February 14, 2007 and the model number was 8646GRT3. The ISS was equipped with a 5-point harness and lower anchor attachments but no tether. The harness straps were reportedly routed through the top slots and the harness retainer clip was positioned immediately below the child's armpit level. The driver's husband installed the ISS in the vehicle via the lower anchor attachments. The ISS was not damaged during the crash.

CASE VEHICLE DRIVER KINEMATICS

Based on the SCI interview, the driver of the Toyota [34-year-old female; 170 cm (67 in) and 54 kg (118 lbs)] was seated in an upright posture with her back against the seat back and both hands on the steering wheel at the 10 and 2 o'clock positions. The seat track was adjusted to the middle position and the seat back was slightly reclined. The tilt steering column as located in the center position. The driver was not wearing contact lenses or glasses at the time of the crash.

The left side plane impact with the front plane of the Dodge initially displaced the driver forward and left opposite the 11 o'clock direction of force and she loaded the safety belt. As the vehicle rotated counterclockwise, she was probably redirected to the right within the safety belt due the vehicle's deceleration as it rotated. As the vehicle rolled over right side leading, the driver was redirected toward the roof. She remained restrained within the safety belt throughout the rollover. She was suspended upside down by the safety belt when the vehicle came to final rest on its top plane. The driver sustained a contusion and sprain of the left shoulder from loading the safety belt and a laceration on the left hand, possibly from flying glass. She reported a laceration on the top of her head and a disc injury at C^5 and C^6 from contacting the roof-mounted console. She also reported a contusion on the left knee from contact with the left front door armrest.

CASE VEHICLE DRIVER INJURIES

The driver sustained moderate injuries and was transported by ambulance to a hospital where she was treated in the emergency room and released. The driver missed no work days due to the crash and received one follow-up visit to a doctor.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Laceration top of head, not further specified	minor 190600.1,5	Roof, console/map light	Probable	Interviewee (same person)
2	Injury, disc (bulging) at C_5-C_6, not further specified	moderate 650299.2,6	Roof, sunroof/ components	Probable	Interviewee (same person)
3	Sprain, acute, left shoulder; has pain with movement, not further specified	minor 751020.1,2	Torso portion of safety belt system	Probable	Emergency room records
4	Contusion left shoulder, not further specified	minor 790402.1,2	Torso portion of safety belt system	Certain	Interviewee (same person)
5	Laceration left hand, not further specified	minor 790600.1,2	Noncontact injury: flying glass, unknown glazing	Possible	Interviewee (same person)
6	Contusion lateral (left side) left knee	minor 890402.1,2	Left front hardware/armrest, forward upper quadrant	Probable	Interviewee (same person)

The second row left passenger [2-year-old male; 86 cm (34 in) and 13 kg (28 lbs)] was seated in an upright posture in the CRS. The passenger's seat track was adjusted to the rear position and the seat back was fixed in a slightly reclined position.

The impact with the Dodge initially displaced the passenger forward within the 5-point harness. He remained restrained in the CRS during the rollover sequence. When the vehicle came to final rest on the top plane, the passenger was suspended upside down in the CRS until he was removed from it by the driver. The passenger sustained multiple small lacerations on both sides of the face and under both eyes from flying glass fragments from the disintegrated second row left window glazing. He sustained a contusion on the left knee, probably from contacting the inside surface of the CRS. The passenger also sustained a blunt head trauma and an abrasion on the top of his head, possibly from contact with the left C-pillar.

CASE VEHICLE SECOND ROW LEFT PASSENGER INJURIES

The second row left passenger sustained minor injuries and was transported by ambulance to a hospital where he was treated in the emergency room and released. The passenger received one follow-up visit to a pediatrician.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Blunt head trauma–pediatric[3]; no specific contact evidence noted	unknown 115099.7,0	Left C-pillar	Possible	Emergency room records
2	Abrasion top of head, not further specified	minor 190202.1,5	Left C-pillar	Possible	Interviewee (driver)
3 4	Lacerations, small, multiple, both sides of face, including under both eyes	minor 290602.1,1 290602.1,2	Noncontact injury: flying glass, left rear glazing	Certain	Interviewee (driver)
5	Contusions, minor, left knee, not further specified; no complaints	minor 890402.1,2	Child restraint system's left side surface	Probable	Emergency room records

CASE VEHICLE SECOND ROW RIGHT PASSENGER KINEMATICS

The second row right passenger [6-month-old male; 71 cm (28 in) and 9 kg (19 lbs)] was seated in a reclined posture in the rear facing ISS.

[3] According to this patient's medical records, emergency medical technicians reported a brief episode en route to hospital where patient became "unresponsive" with eyes open but then began crying again; child acting age appropriate upon arrival. Child was observed in emergency room and neurologic checks were requested of parents every two hours on discharge.

The impact with the Dodge initially displaced the passenger forward into the back the ISS. The passenger remained restrained in the ISS as the Toyota rotated counterclockwise and rolled over. When the vehicle came to final rest on the top plane, the passenger was suspended upside down in the ISS until the driver removed it. The passenger sustained a blunt head trauma injury, which was possible from contact with the IC air bag. He also sustained an abrasion on the inside of his upper right arm, which was possibly due to contact with the side of the ISS.

CASE VEHICLE SECOND ROW RIGHT PASSENGER INJURIES

The second row right passenger sustained minor injuries and was transported by ambulance to a hospital where he was treated in the emergency room and released. The passenger received one follow-up visit to a pediatrician.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Blunt head trauma–pediatric[4]; possible contact evidence noted	unknown 115099.7,0	Air bag, second row right passenger's side IC	Possible	Emergency room records
2	Abrasion inside upper right arm, not further specified	minor 790202.1,1	Child restraint system's right side surface	Possible	Interviewee (driver)

OTHER VEHICLE

The 1997 Dodge Caravan LE was a front wheel drive, 7-passenger, 4-door minivan (VIN: 1B4GP55R4VB------) equipped with a 3.3-L, V-6 engine and a 4-speed automatic transmission. The Dodge was also equipped with 4-wheel, antilock brakes and driver and front passenger frontal air bags.

Exterior Damage: The impact with the Toyota involved the front plane of the Dodge (**Figure 22**). The front bumper, grille, hood, and left headlamp/turn signal assembly, left fender, left front wheel, and left front door were directly damaged. The direct damage began at the front left bumper corner and extended 19 cm (7.5 in) across the bumper and hood. The direct damage also extended down the left side plane 219 cm (86 in) ending near the back of the left front door. The crush measurements were taken at the bumper

Figure 22: Damage to the front of the Dodge from the impact with the left side plane of the Toyota

[4] A small, dime-sized, reddened area was noted to top of head without any swelling or bleeding.

level and the residual maximum crush on the bumper bar was 6 cm (2.5 in) occurring at C_1. The table below shows the front crush profile.

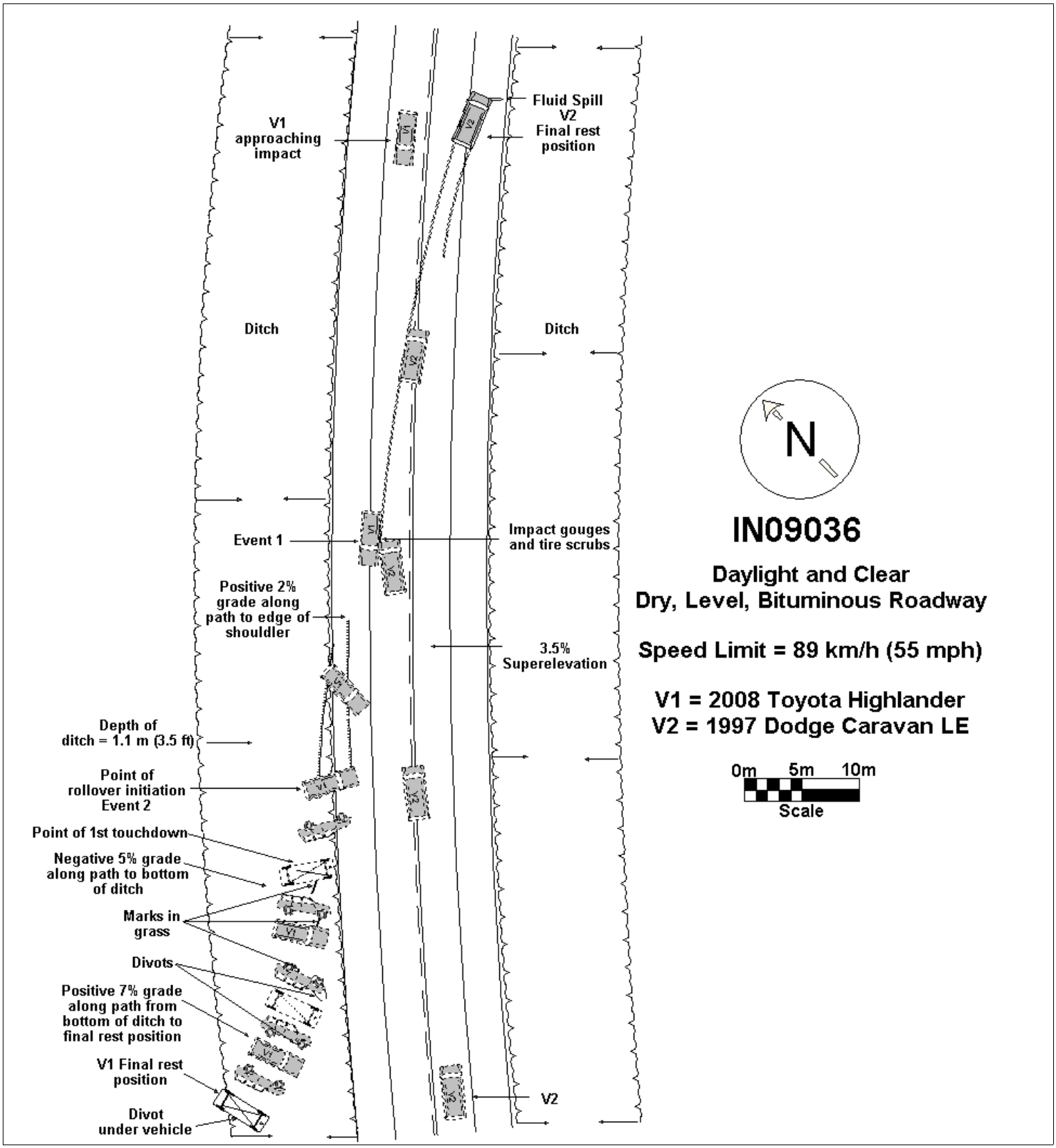
Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	19	6	139	6	1	1	0	0	0	-60	0
in		7.5	2.4	54.7	2.4	0.4	0.4	0.0	0.0	0.0	-23.6	0.0

Damage Classification: The CDC for the front impact with the Toyota was 12FLEE8 (350 degrees). The Missing Vehicle algorithm of the WinSMASH program calculated the total Delta-V for the front impact with the Toyota as 15 km/h (9.3 mph). The longitudinal and lateral velocity changes were –14.8 km/h (-9.2 mph) and 2.6 km/h (1.6 mph), respectively. The results should be considered borderline since the impact was a narrow end engagement on the Dodge and the results are based only on the crush sustained by the Dodge.

The vehicle manufacturer's recommended tire size was P215/65R15. The Dodge was equipped with the recommended size tires. The vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	Flat	Flat	241	35	5	6	Sidewall cut, tire debeaded	No	Yes
LR	207	30	241	35	6	8	None	No	No
RR	207	30	241	35	7	9	None	No	No
RF	241	35	241	35	6	7	None	No	No

Other Vehicle's Occupants: The police crash report indicated that the driver of the Dodge (56-year-old male) was restrained by the lap-and-shoulder safety belt and sustained an A (incapacitating) injury. Both frontal air bags deployed as a result of the crash.


V1 approaching impact
Fluid Spill
V2
Final rest position
Ditch
Ditch
Event 1
Impact gouges and tire scrubs
Positive 2% grade along path to edge of shouldler
3.5% Superelevation
Depth of ditch = 1.1 m (3.5 ft)
Point of rollover initiation Event 2
Point of 1st touchdown
Negative 5% grade along path to bottom of ditch
Marks in grass
Divots
Positive 7% grade along path from bottom of ditch to final rest position
V1 Final rest position
Divot under vehicle
V2
N
IN09036
Daylight and Clear
Dry, Level, Bituminous Roadway
Speed Limit = 89 km/h (55 mph)
V1 = 2008 Toyota Highlander
V2 = 1997 Dodge Caravan LE
0m 5m 10m
Scale