

CRASH DATA RESEARCH CENTER
Calspan Corporation
Buffalo, NY 14225

CALSPAN ON-SITE CHILD RESTRAINT SYSTEM CRASH INVESTIGATION
SCI CASE NO: CA10001

VEHICLE: 2008 TOYOTA YARIS

LOCATION: NEW YORK

CRASH DATE: JANUARY 2010

Contract No. DTNH22-07-C-00043

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

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

TECHNICAL REPORT STANDARD TITLE PAGE

<p>1. <i>Report No.</i> CA10001</p>	<p>2. <i>Government Accession No.</i></p>	<p>3. <i>Recipient's Catalog No.</i></p>	
<p>4. <i>Title and Subtitle</i> Calspan On-Site Child Restraint System Crash Investigation Vehicle: 2008 Toyota Yaris Location: New York</p>		<p>5. <i>Report Date:</i> March 2011</p>	
		<p>6. <i>Performing Organization Code</i></p>	
<p>7. <i>Author(s)</i> Crash Data Research Center</p>		<p>8. <i>Performing Organization Report No.</i></p>	
<p>9. <i>Performing Organization Name and Address</i> Calspan Corporation Crash Data Research Center P.O. Box 400 Buffalo, New York 14225</p>		<p>10. <i>Work Unit No.</i></p>	
		<p>11. <i>Contract or Grant No.</i> DTNH22-07-C-00043</p>	
<p>12. <i>Sponsoring Agency Name and Address</i> U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590</p>		<p>13. <i>Type of Report and Period Covered</i> Technical Report Crash Date: January 2010</p>	
		<p>14. <i>Sponsoring Agency Code</i></p>	
<p>15. <i>Supplementary Note</i> An investigation of the side impact crash of a 2008 Toyota Yaris and a 1996 Chevrolet Tahoe.</p>			
<p>16. <i>Abstract</i> This on-site investigation focused on the rear-facing Child Restraint System (CRS) that was used to restrain a 5-month-old female infant in the second row center position of a 2008 Toyota Yaris 4-door sedan. The Toyota was driven by a 22-year-old female that lost traction control on a snow-covered roadway. The vehicle subsequently rotated counterclockwise into the path of a 1996 Chevrolet Tahoe large utility vehicle. The frontal area of the Chevrolet impacted the right side (B-pillar area) of the Toyota, which resulted in severe intrusion into the Toyota's passenger compartment. The Toyota Yaris was equipped with a Certified Advanced 208-Compliant frontal air bag system. It was not equipped with inflatable side impact protection. The infant passenger remained secured within the CRS by the integrated harness system; however, she sustained intrusion-related fatal blunt force injuries. The driver was displaced laterally right as a result of the impact, her torso slid laterally under the shoulder belt toward the intruding right side structure and her head impacted the front of the Chevrolet. The two occupants of the Toyota were transported by ground ambulance to a local hospital where they expired following arrival.</p>			
<p>17. <i>Key Words</i> Side impact crash Intrusion Rear-facing Child Restraint System CRS Double fatality</p>		<p>18. <i>Distribution Statement</i> General Public</p>	
<p>19. <i>Security Classif. (of this report)</i> Unclassified</p>	<p>20. <i>Security Classif. (of this page)</i> Unclassified</p>	<p>21. <i>No. of Pages</i> 16</p>	<p>22. <i>Price</i></p>

TABLE OF CONTENTS

BACKGROUND	1
SUMMARY	2
Vehicle Data.....	2
2008 Toyota Yaris.....	2
1996 Chevrolet Tahoe.....	2
Crash Site	3
Crash Sequence.....	3
Pre-Crash.....	3
Crash	3
Post-crash.....	4
2008 Toyota Yaris.....	4
Exterior Damage	4
Interior Damage	5
Lateral	6
Manual Restraint System	6
Frontal Air Bag System	7
Child Restraint System Data.....	7
2008 Toyota Yaris Occupants.....	9
Driver Demographics.....	9
Driver Injuries.....	9
Driver Kinematics.....	10
Second Row Center Passenger Demographics	11
Second Row Center Passenger Injuries	11
Second Row Center Passenger Kinematics	13
1996 Chevrolet Tahoe.....	14
Exterior Damage.....	14
Crash Schematic.....	15

CALSPAN ON-SITE CHILD RESTRAINT SYSTEM CRASH INVESTIGATION
SCI CASE NO: CA10001
VEHICLE: 2008 TOYOTA YARIS
LOCATION: NEW YORK
CRASH DATE: JANUARY 2010

BACKGROUND

This on-site investigation focused on the rear-facing Child Restraint System (CRS) that was used to restrain a 5-month-old female infant in the second row center position of a 2008 Toyota Yaris 4-door sedan. The Toyota (**Figure 1**) was driven by a 22-year-old female that lost traction control on a snow-covered roadway. The vehicle subsequently rotated counterclockwise into the path of a 1996 Chevrolet Tahoe large utility vehicle. The frontal area of the Chevrolet impacted the right side (B-pillar area) of the Toyota, which resulted in severe intrusion into the Toyota's passenger compartment.



Figure 1: Right front oblique view of the 2008 Toyota Yaris 4-door sedan.

The Toyota Yaris was equipped with a Certified Advanced 208-Compliant frontal air bag system. It was not equipped with inflatable side impact protection. The infant passenger remained secured within the CRS by the integrated harness system; however, she sustained intrusion-related fatal blunt force injuries. The driver was displaced laterally right as a result of the impact, her torso slid laterally under the shoulder belt toward the intruding right side structure and her head impacted the front of the Chevrolet. The two occupants of the Toyota were transported by ground ambulance to a local hospital where they expired following arrival.

The Calspan Special Crash Investigations (SCI) team identified the crash through local media coverage. The news link and details of the crash were forwarded to the Crash Investigation Division of the National Highway Traffic Safety Administration on January 6, 2010. The SCI team established cooperation with the investigating police agency and determined the two vehicles and the CRS were available for inspection in police impound. The case was assigned as an on-site investigation on January 7, 2010 and the on-site aspect of this investigation was conducted on January 8, 2010. The SCI investigation involved the inspection and documentation of the two vehicles, the CRS and the crash site.

SUMMARY

Vehicle Data

2008 Toyota Yaris

The 2008 Toyota Yaris, 4-door sedan was identified by the Vehicle Identification Number (VIN): JTDBT923181 (production sequence deleted). The date of manufacturer was May 2008. The digital electronic odometer was inoperative and the mileage was unknown. The powertrain consisted of a 1.5-liter, 4-cylinder engine linked to a 4-speed automatic transmission with front-wheel drive. The Toyota was equipped with a front disc/rear drum brake system, which included an indirect tire pressure monitoring system. The Toyota's OEM steel wheels were outfitted with Bridgestone ECSTA Potenza RE92, P185/60R15 tires. This was the vehicle manufacturer's recommended size. The vehicle manufacturer recommended front and rear cold tire pressure was 221 kPa (32 PSI). The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	200 kPa (29 PSI)	3 mm (4/32 in)	No	None
LR	207 kPa (30 PSI)	2 mm (2/32 in)	No	None
RR	207 kPa (30 PSI)	2 mm (2/32 in)	No	None
RF	200 kPa (29 PSI)	3 mm (4/32 in)	No	None

1996 Chevrolet Tahoe

The 1996 Chevrolet Tahoe pickup truck was identified by the Vehicle Identification Number (VIN): 1GNEC13R1TJ (production sequence deleted). The powertrain consisted of a 5.7-liter, 8-cylinder engine linked to a 4-speed automatic transmission with rear wheel drive. The Chevrolet was equipped with a 4-wheel ABS front disc rear/drum brake system. The Chevrolet was equipped with Goodyear Treva Radial HT tires on the front axle and Kelly Wintermark Steel Radial HT tires mounted on the rear axle. All four tires were the vehicle manufacturer's recommended size of P235/75R15 and were mounted on OEM alloy wheels. The vehicle manufacturer recommended front and rear cold tire pressure was 241 kPa (35 PSI). The specific tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	276 kPa (40 PSI)	8 mm (10/32 in)	Yes	None
LR	255 kPa (37 PSI)	7 mm (9/32 in)	No	None
RF	Flat tire	8 mm (10/32 in)	Yes	Puncture in tread
RR	262 kPa (38 PSI)	7 mm (9/32 in)	No	None

Crash Site

The crash occurred during the nighttime hours in January of 2010. At the time of the crash, there was a light snowfall that had already covered the bituminous roadway. The crash took place within a 2-way, 2-lane undivided portion of roadway that was oriented in a northwest/southeast direction and situated in a rural environment. The roadway alignment was straight, level and configured with one travel lane in each direction. The northwest travel lane measured 3.7 m (12.1 ft) wide. The southeast travel lane measured 3.6 m (11.8 ft) wide. Bituminous shoulders bordered the outside edge of both lanes. Each shoulder measured 2.6 m (8.5 ft) wide. The southeast travel lane was marked as a passing zone north of the crash location. The northwest travel lane was marked with a single dashed yellow line separating oncoming traffic south of the crash location. The posted speed limit was 72 km/h (45 mph). No discernable physical scene evidence resulting from this crash was identified. **Figure 2** is a northwest view of the Toyota's pre-crash path of travel. The Crash Schematic is included as **Figure 12** of this report.



Figure 2: Northwest pre-crash trajectory of Toyota.

Crash Sequence

Pre-Crash

The Toyota was traveling northwest, driven by a 22-year-old restrained female at a police-estimated at 48-64 km/h (30-40 mph). The driver of the Toyota was operating this vehicle with minimal tread remaining on the rear tires. The Chevrolet was traveling southeast, driven by a 43-year-old restrained male at a driver-estimated speed of 64-72 km/h (40-45 mph). The Chevrolet was towing a loaded trailer. The Toyota lost traction on the snow covered roadway, began to rotate counterclockwise (CCW), and entered the southeast travel lane, directly in front of Chevrolet's path of travel. There was no evidence of pre-crash evasive avoidance actions that could be attributed to either driver.

Crash

The crash occurred when the Chevrolet's entire front plane impacted the right side passenger compartment of the Toyota (Event 1). The directions of the impact force were in the 12 o'clock sector for the Chevrolet and 3 o'clock sector for the Toyota. This impact did not result in the actuation of the safety belt pretensioner system, or the deployment of the air bag system within the Toyota. The steering wheel-mounted frontal air bag in the Chevrolet deployed.

The Missing Vehicle Damage Algorithm of the WinSMASH program was used to calculate delta-V due to the Chevrolet's unknown gross weight and the weight distribution that was created by the attached single axle trailer and contents. The total delta-V of the Toyota was 71

km/h (44.1 mph). The longitudinal and lateral delta-V components were -12.3 km/h (-7.6 mph) and 69.9 km/h (43.4 mph), respectively. The Chevrolet's total delta-V was 24 km/h (14.9 mph) with longitudinal and lateral components of -23.6 km/h (-14.7 mph) and 4.2 km/h (-2.6 mph), respectively. For the purposes of comparison, the Damage Algorithm of the WinSMASH program was used in conjunction with an estimated cargo weight in order to represent the Chevrolet's attached trailer and contents, which produced the following results. The total delta-V of the Toyota was 93 km/h (57.8 mph). The longitudinal and lateral delta-V components were -16.1 km/h (-10.0 mph) and 91.6 km/h (56.9 mph), respectively. The Chevrolet's total delta-V was 31 km/h (19.3 mph) with longitudinal and lateral components of -30.5 km/h (-19.0 mph) and 5.4 km/h (-3.4 mph), respectively.

The force and direction of this impact, slightly rearward of the Toyota's center of gravity, caused the vehicle to rotate clockwise (CW) approximately 100 degrees from initial impact to its final rest position. On-scene media images depict the Toyota's final rest south of the initial point of impact within the west shoulder area facing a northerly direction. The Chevrolet rotated approximately 5 degrees CW from impact to its final rest position. The Chevrolet came to final rest within its original travel lane facing a southeasterly direction with the Toyota located at the rear aspect of its right plane as depicted in **Figure 3**.



Figure 3: On-scene image of the vehicles' final rest location.

Post-crash

Police, fire and ambulance personnel responded to the crash site. The two occupants of the Toyota were reportedly unconscious after suffering incapacitating head injuries and were transported by ground ambulance to a local hospital for medical treatment. Shortly after arrival, both occupants were pronounced deceased. The two occupants of the Chevrolet were evaluated by on-scene medical personnel and found to be uninjured. Both vehicles sustained disabling damage and were towed from the crash site.

2008 Toyota Yaris

Exterior Damage

Figure 4 is a right oblique view of the damage to the Toyota's right plane. The direct contact damage began 25 cm (9.8 in) forward of the right rear axle and extended 189 cm (74.4 in) forward. The impact resulted in lateral deformation to the right fender, doors, sill, roof side rail and the A-, B-, C-pillars. Six equidistant crush measurements were documented longitudinally along the mid-door level which produced the following profile: C1 = 0 cm, C2 = 25 cm (9.8 in), C3 = 71 cm (28 in), C4 = 57 cm (2.4 in), C5 = 25 cm (9.8 in), C6 = 0 cm. The maximum crush was located at C3. The right doors were jammed in a closed position and the left doors remained

closed during the crash and were operational post-crash. The windshield was fractured with a partial bond separation in the upper right corner that extended vertically down the right A-pillar. The glazing located in the right side doors and backlight areas were disintegrated from impact forces; however, the glazing in the left side doors was intact and undamaged. The Collision Deformation Classification (CDC) for this damage pattern was 03RPAW5.

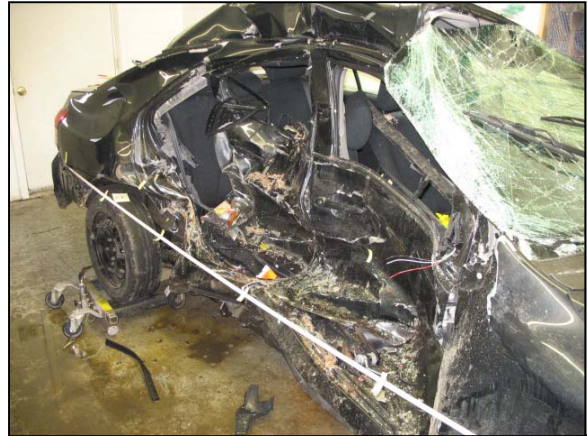


Figure 4: Close-up view of the Toyota's right side impact damage.

Interior Damage

The interior damage to the Toyota consisted of occupant compartment intrusions and occupant contact points. Interior component damage attributed to the driver was identified in four separate areas. The first area of damage was located in the rear upper quadrant of the interior front right door panel (**Figure 5**), and consisted of embedded hair strands and compression-type blood transfer marks from contact with the driver's face and head. The center console-mounted transmission selector lever was bent to the right from contact with the driver's right thigh area (**Figure 6**). Multiple scuff marks were identified on the left aspect of the center console, which were associated with occupant loading of this component with the driver's right knee and lower leg, as depicted in **Figure 5**. The fourth contact point was detected on the driver safety belt system, which exhibited outward deformation of the rigid stalk belt buckle created by the driver's right hip loading this component, as depicted in **Figure 6**. Descriptions of the Toyota's measured intrusions, when compared to exemplar measurements, are listed in the following table.



Figure 5: Left lateral view of Toyota's front row depicting the driver interior contacts.

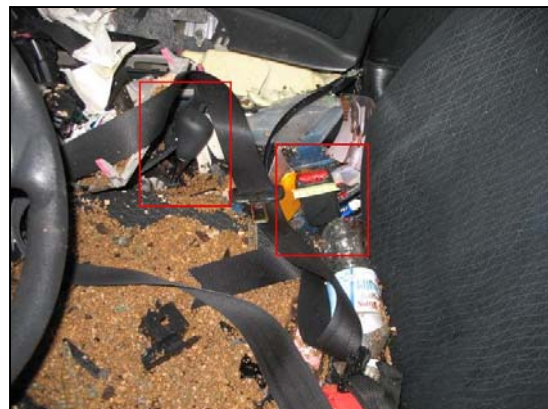


Figure 6: Left lateral view of Toyota's front row depicting the driver contacts to the buckle stalk and transmission selector.

Position	Component	Intrusion	Direction
Front row, right	A-pillar (at windshield header)	36 cm (14.2 in)	Lateral
	B-pillar (at beltline)	45 cm (17.7 in)	Lateral
	Right front door (rear upper quadrant)	46 cm (18.1 in)	Lateral
	Roof side rail	46 cm (18.1 in)	Lateral
	Side panel forward of A-pillar (Kick panel)	12 cm (4.7 in)	Lateral
Row 1, Center	Right front door (rear upper quadrant)	18 cm (7.1 in)	Lateral
	Roof side rail	25 cm (9.8 in)	Lateral
	Right front seatback	9 cm (3.5 in)	Lateral
Row 2, Right	C-pillar	39 cm (15.4 in)	Lateral
	Roof side rail	33 cm (13.0 in)	Lateral
	Right rear door (rear upper quadrant)	46 cm (18.1 in)	Lateral
Row 2, Center	Right rear door (rear upper quadrant)	25 cm (9.8 in)	Lateral

Based on measurements of an exemplar vehicle, the driver seat was adjusted in a mid-to-forward track position; 6 cm (2.4 in) aft of full-forward. The total seat track travel measured 20 cm (7.8 in). The adjustable head restraint was located 6 cm (2.25 in) above the top of this seatback. The adjustable steering wheel tilt position was in a center position. There was no deformation of the steering wheel rim and no displacement of the shear capsules. The longitudinal distance between the center of the steering wheel and the driver seatback measured 50 cm (19.5 in).

Manual Restraint System

The Toyota was equipped with manual 3-point lap and shoulder safety belts for all five seating positions. The driver's safety belt system consisted of continuous loop webbing, a sliding latch plate, a rigid-stalk buckle, an adjustable D-ring, a retractor-mounted pretensioner and an Emergency Locking Retractor (ELR). The D-ring was located in the full-up position. The safety belt webbing was found in an extended position with a total measured length of 195 cm (76.75 in); however, the retractor-mounted pretensioner did not actuate as a result of the impact forces. Further inspection of the safety belt webbing revealed two extrication tool cuts, which severed the webbing into three pieces. The exposed shoulder portion of webbing was cut at the D-ring

and extended 97 cm (38.25 in). The exposed lap portion of the webbing measured a total of 65 cm (25.5 in) originating at the lower cut position, 33 cm (13 in) above the floor board anchor point. An inspection of the latch plate revealed frictional abrasions to the full width of the plastic surface as a result of the webbing being loaded by its occupant during this crash. A loading crease was identified on the belt webbing, which was attributed to sustained contact with the corresponding latch plate. Based upon the post-crash condition of this safety belt system, the driver was restrained at the time of the crash.

The second row center occupant's safety belt system consisted of continuous loop webbing, a sliding latch plate, a webbing loop mounted buckle, a non-adjustable upper anchorage and a switchable ELR/Automatic Locking Retractor (ALR). The exposed webbing measured 100 cm (39.25 in) from the lower anchor, located at the seat bight, to the extrication tool cut that severed the webbing into two pieces. The upper portion of webbing was found threaded through the plastic belt guide mounted to the top of the seatback and was held in place by the deformation of the second row bench seat. When pulling force was applied to the webbing the belt retractor was found in ELR mode. A loading crease was identified on the belt webbing 42 cm (16.5 in) from the seat bight, which was attributed to loading of the installed CRS base. Based on the SCI inspection of this seat belt system, the exposed portion of webbing was used to install the plastic base of the rear facing CRS.

Frontal Air Bag System

The Toyota was equipped with a CAC air bag system that included dual-stage frontal air bags for the driver and right front passenger, seat track positioning sensors, safety belt buckle switch sensors, and a front right occupant weight sensor. The vehicle manufacturer certified that the frontal air bags in the Toyota were compliant with the advanced air bag requirements of the Federal Motor Vehicle Safety Standard No. 208. The driver's CAC air bag was located in the center hub of the steering wheel rim. The front right seating position contained a CAC air bag mounted within the top aspect of the right instrument panel. The CAC air bag system did not deploy in this crash.

Child Restraint System Data

The investigating police agency was in possession of the CRS and provided it for the SCI inspection. This child seat was identified as a Graco Snug Ride rear-facing infant seat with the assigned Model Number 1755755. The date of manufacture was February 01, 2009. This type of CRS was designed for rear-facing use with two main components: the plastic base section that is secured to the vehicle and the infant carrier section mounted to the base. The CRS was intended to be used by infants with a height less than 74 cm (29 in) and weight between 2 and 10 kg (5 and 22 lbs). This CRS was an appropriate choice for use considering the height and weight of the second row center passenger.

This CRS was installed in the second row center position and its base was held in place by the Toyota's corresponding 3-point safety belt system with the retractor in the ELR mode at the time of the crash. Police-reported first responder statements corroborate this assertion. An inspection of the base (**Figure 7**) revealed that the adjustable foot was in the lowest position of three available slots. With respect to the Toyota's orientation, loading evidence in the form of stress marks within the plastic was identified on the face of the foot, the right inboard edge of the belt path and the right side of the base from midpoint to the leading edge.

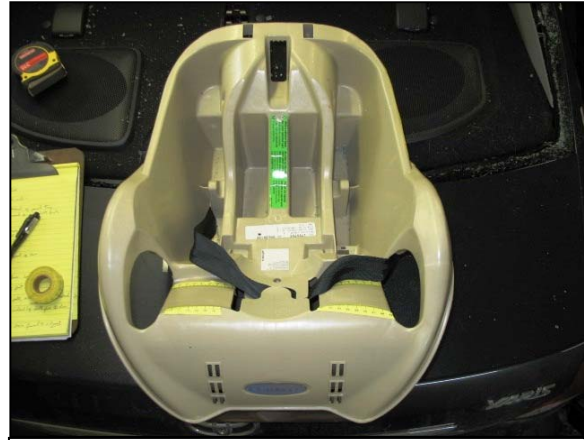


Figure 7: Top view of the CRS base.

The infant carrier (**Figures 8 and 9**) was designed with a 5-point safety belt harness that was routed through the top shoulder slots. Relative to the occupant, the chest clip was found in place with a one-half twist in the left side harness webbing. The right side webbing was stained with multiple types of bodily fluid. The top carrier handle was fractured on the left side and located in a vertical (up) position. The right side of this handle was set in the full-down position. Bodily fluid had pooled in the right side of the carrier cushion. Stress marks were identified on the left side of the carrier shell and the handle's left side pivot hinge from contact with the vehicle's intruding right rear door panel. The left side of the carrier was visibly compressed and deformed laterally inward towards its center.



Figure 8: Top view of the CRS infant carrier.



Figure 9: Left side view of the CRS infant carrier.

2008 Toyota Yaris Occupants

Driver Demographics

Age/Sex: 22-year-old/Female
 Height: 160 cm (63 in)
 Weight: 59 kg (130 lb)
 Seat Track Position: Mid-to-forward track position
 Safety Belt Usage: 3-point lap & shoulder
 Usage Source: SCI vehicle inspection
 Egress from Vehicle: Removed by emergency medical services
 Type of Medical Treatment: None, Transported to a local hospital (pronounced deceased)

Driver Injuries

Inj. No.	Injury	Injury Severity AIS 2005/08	Injury Source	Confidence
1	Brain stem lacerations at junction of the midbrain and pons and junction of the pons and medulla	Maximum (140212.6,8)	Hood of the Chevrolet	Certain
2	Pulmonary bronchus transection	Severe (440210.4,1)	Right front door panel	Certain
3	5 cm laceration of the hilum of the right lung involving main branches of the pulmonary artery and bronchus	Serious (441430.3,1)	Right front door panel	Certain
4	Pulmonary artery laceration	Serious (421004.3,1)	Right front door panel	Certain
5	Right hemothorax (1000ml)	Serious (442200.3,1)	Right front door panel	Certain
6	Atlanto-occipital joint fracture-dislocation	Moderate (650216.2,6)	Hood of the Chevrolet	Certain
7	Three 3 cm lacerations of spleen anterior surface (depth unknown)	Moderate (544220.2,2)	Safety belt (lap portion)	Probable
8	2 cm laceration of the right kidney	Moderate (541620.2,1)	Safety belt buckle	Probable
9	15 cm occipital scalp laceration (depth unknown)	Minor (110602.1,6)	Hood of the Chevrolet	Certain
10	Occipital scalp subgaleal hemorrhage	Minor (110402.1,6)	Hood of the Chevrolet	Certain
11	8x3 cm contusion complex on chin	Minor (210402.1,8)	Right front door panel	Probable

<i>Inj. No.</i>	<i>Injury</i>	<i>Injury Severity AIS 2005/08</i>	<i>Injury Source</i>	<i>Confidence</i>
12	Multiple small contusions of the anterior left arm and forearm	Minor (710402.1,2)	Seat cushion	Probable
13	Multiple abrasions to the left elbow	Minor (710202.1,2)	Seat cushion	Probable
14	10x10 cm complex of abrasions and lacerations on the back of the right hand and fingers	Minor (710202.1,1) (710602.1,1)	Seat cushion	Probable
15	10x3 cm contusion near the right femoral region	Minor (810402.1,1)	Transmission selector	Certain
16	8x5 cm contused abrasion complex of the right lower leg	Minor (810402.1,1) (810202.1,1)	Center console	Certain
17	Multiple scattered small contusions to the bilateral lower extremities	Minor (810402.1,3)	Knee bolster	Probable

Source of Injury Data: Medical Examiner's Autopsy Report

Driver Kinematics

The 22-year-old female driver of the Toyota was seated in a mid-to-forward track position and was restrained with the available 3-point safety belt system. At impact, the ELR safety belt retractor locked the belt webbing in place. The driver responded to the 3 o'clock direction of force by initiating a slightly forward and predominately right collinear trajectory as she loaded the lap portion of the restraint system with her pelvis. The driver slid from under the shoulder portion of the webbing due to the lateral direction of her principal movement. The driver's right knee and lower leg contacted the center console (**Figure 5**) as evidenced by the scuff marks to this component. As the driver continued to move to the right, her right thigh contacted the center console mounted transmission selector lever (**Figure 6**) causing it to deform laterally. Her right lower leg was contused and abraded from these contacts.

As the driver rode down the force of the crash, the vehicle experienced a reduction of the occupant compartment as the right side vehicular components consisting of the kick panel, A-, B-, and C-pillars, the door panels, the sill and the roof side rail intruded laterally to the left.

At maximum engagement the lower portion of the driver's body was held in place by the lap portion of the safety belt and the center console, however, the driver's upper body continued to move to the right. Due to her lower body anchoring, the driver's head and upper torso then began to pitch in a downward, vertical direction. The lap belt loading was evidenced by the lacerated spleen and kidney. Prior to her upper body becoming parallel with the front right seat, the right side of the driver's head and face contacted the rear upper quadrant of the intruding right front door panel (**Figure 5**) and the exterior surface of the Chevrolet as it was engaged

against the Toyota. The driver’s head contacted to the hood edge of the Chevrolet resulting in fatal brain and head (skull) injuries. The right torso and shoulder area of the driver impacted the intruding front door panel resulting in the severe pulmonary injuries. Compression type transfer marks with embedded hair strands on the interior surface of the door panel.

After maximum engagement the driver’s lower extremities came to final rest within her original seating position while her upper body came to rest slumped over to the right in an unconsciousness state. During the extrication efforts, the driver’s safety belt webbing was cut in two places and the driver was removed through the left front door opening. She was transported via ground ambulance to a local hospital where she was pronounced deceased.

Second Row Center Passenger Demographics

Age/Sex: 9-months-old/Female
 Height: 67 cm (26.3 in)
 Weight: 8 kg (17.8 lb)
 Seat Track Position: Non-adjustable track
 Safety Belt Usage: Restrained by a 5-point harness within a rear-facing CRS
 Usage Source: SCI vehicle and CRS inspection
 Egress from Vehicle: Removed by emergency medical services
 Type of Medical Treatment: None, Transported to a local hospital (pronounced deceased)

Second Row Center Passenger Injuries

<i>Inj. No.</i>	<i>Injury</i>	<i>Injury Severity AIS 2005/08</i>	<i>Injury Source</i>	<i>Confidence</i>
1	Scattered deep central white matter and basil ganglia petechial-like hemorrhages in the bilateral cerebral hemisphere	Critical (140646.5,3)	CRS shell (reinforced by door panel and Chevrolet)	Certain
2	Focal deep white matter petechial hemorrhages of the brain stem	Critical (140210.5.8)	CRS shell (reinforced by door panel and Chevrolet)	Certain

<i>Inj. No.</i>	<i>Injury</i>	<i>Injury Severity AIS 2005/08</i>	<i>Injury Source</i>	<i>Confidence</i>
3	Basilar skull linear fracture along the anterior right petrous ridge, fracture of the posterior medial aspect of the left lesser wing of the sphenoid bone, 1 cm area of depressed fracture at the lateral aspect of the left sphenoid greater wing	Severe (150206.4,8)	CRS shell (reinforced by door panel and Chevrolet)	Certain
4	Focal deep white matter petechial hemorrhages of the cerebellum	Serious (140426.3,6)	CRS shell (reinforced by door panel and Chevrolet)	Certain
5	Multiple bilateral pulmonary contusions (most prominent on left)	Serious (441410.3,3)	CRS harness	Probable
6	Odontoid process fracture disarticulation	Serious (650228.3,6)	CRS shell (reinforced by door panel and Chevrolet)	Certain
7	Subcutaneous contusion left fronto-parietal scalp (underlying the V-shaped avulsion laceration)	Moderate (110403.2,2)	CRS fractured handle	Certain
8	Subarachnoid hemorrhage of the lateral and posteriolateral left cerebral hemisphere	Moderate (140693.2,2)	CRS shell (reinforced by door panel and Chevrolet)	Certain
9	Diastatic fracture of the left fronto-parietal suture	Moderate (150402.2,2)	CRS shell (reinforced by door panel and Chevrolet)	Certain
10	Splenic capsule tear at the hilum; 5-10 cc peritoneal blood secondary to the spleen laceration	Moderate (544222.2,2)	CRS harness	Certain
11	Anterior right lobe of the liver focal subscapular contusion, 3 cm greatest diameter	Moderate (541822.2,1)	CRS harness	Certain
12	Focal spleen contusion	Moderate (544210.2,2)	CRS harness	Certain
13	Atlanto-occipital disarticulation	Moderate (650208.2,6)	CRS shell (reinforced by door panel and Chevrolet)	Certain

<i>Inj. No.</i>	<i>Injury</i>	<i>Injury Severity AIS 2005/08</i>	<i>Injury Source</i>	<i>Confidence</i>
14	3 cm V-shaped avulsion laceration to the antero-lateral left forehead	Minor (210802.1,7)	CRS fractured handle	Certain
15	Multiple linear abrasions to the left face	Minor (210202.1,2)	CRS shell (reinforced by door panel and Chevrolet)	Certain
16	Contusion to the left face	Minor (210402.1,2)	CRS shell (reinforced by door panel and Chevrolet)	Certain
17	3 cm contusion to the posteriolateral right lower back	Minor (410402.1,6)	CRS shell (reinforced by door panel and Chevrolet)	Certain
18	Focal sub-endocardial contusion	Minor (441002.1,4)	CRS harness	Probable
19	Two parallel 1x2cm contusions to the anterior left thigh	Minor (810402.1,2)	CRS harness	Certain
20	Thymus contusion (This injury is coded as Unknown Thoracic Injury per AIS rules; No specific Thymus code available)	Unknown (442999.9,9)	CRS harness	Probable

Source of Injury Data: Medical Examiner's Autopsy Report

Second Row Center Passenger Kinematics

The 9-month-old female passenger was located in the second row center position in a rear-facing CRS and secured with the integrated 5-point safety belt harness. The infant CRS was attached to its plastic base, which was secured to the bench seat with the vehicle's available 3-point safety belt system in ELR mode without the use of a locking clip. The safety belt was routed through the rear-facing belt path of the CRS.

At impact, the ELR safety belt retractor locked the belt webbing in place. This occupant responded to the 3 o'clock direction of force by initiating a right trajectory (with respect to the vehicle). Based on the rear-facing orientation of the CRS, the left side of the infant's body and head contacted the left interior surface of the CRS. Coincident to this kinematic pattern, the right door panel of the Toyota intruded into the right and center aspects of the occupant compartment. The door panel contacted and fractured the carrier handle of the CRS. This fractured handle lacerated left forehead of the infant and contused the underlying fronto-parietal scalp.

The infant loaded the CRS shell coincident to the right rear door panel and the Chevrolet loading the CRS. The infant's loading of the CRS resulted in the identified fatal brain and head injuries and associated blunt force injuries. During the lateral kinematic pattern, the infant loaded the

harness straps of the CRS resulting in the contusion and laceration of the spleen and the liver laceration. **Figure 10** depicts the residual intrusion of the right rear door into the center aspect of the second row and the reconstructed position of the CRS.



Figure 10: View of the post-crash location of the intruded right rear door within the Toyota's second row.

After maximum engagement the infant came to final rest restrained within the CRS. The impact forced the child restraint system into a laterally left rotated position, with respect to the vehicle's orientation, with the right rear vehicle door in contact with the left side of the CRS. This assertion was based on the location of pooled bodily fluid within the right crease of carrier cushion (**Figure 8**)

in conjunction with the post crash location of the intruded door panel (**Figure 10**). During the extrication efforts, the Toyota's safety belt webbing was cut and the CRS was removed through the left rear door opening with the passenger restrained within. The child was subsequently transported to a local hospital and where she was pronounced deceased.

1996 Chevrolet Tahoe

Exterior Damage

The 1996 Chevrolet Tahoe sustained moderate severity frontal damage (**Figure 11**) as a result of the impact with the Toyota. The direct contact damage began at the left bumper corner and extended laterally to the right bumper corner. The damage consisted of longitudinal crush of the frontal components, which included the front metal bumper, radiator, headlight assemblies, and the leading edge of the hood and front fenders. SCI observations of the Chevrolet's deformed hood identified an imprint of the Toyota's B-pillar within the damage pattern. Immediately to the right of the B-pillar imprint, a circular dent in the hood face was observed.



Figure 11: Right front oblique view of the frontal damage to the Chevrolet.

Immediately to the right of the B-pillar imprint, a circular dent in the hood face was observed. The circular dent was attributed to contact from the Toyota driver's head during the crash. Six equidistant crush measurements were documented along the Chevrolet's deformed metal bumper, which produced the following profile: C1 = 14 cm (5.5 in), C2 = 10 cm (3.9 in), C3 = 22 cm (8.7 in), C4 = 9 cm (3.5 in), C5 = 10 cm (3.9 in), C6 = 11 cm (4.3 in). The maximum crush was located at C3. The CDC for the Chevrolet's impact with the Toyota (Event 1) was 12FDEW1.

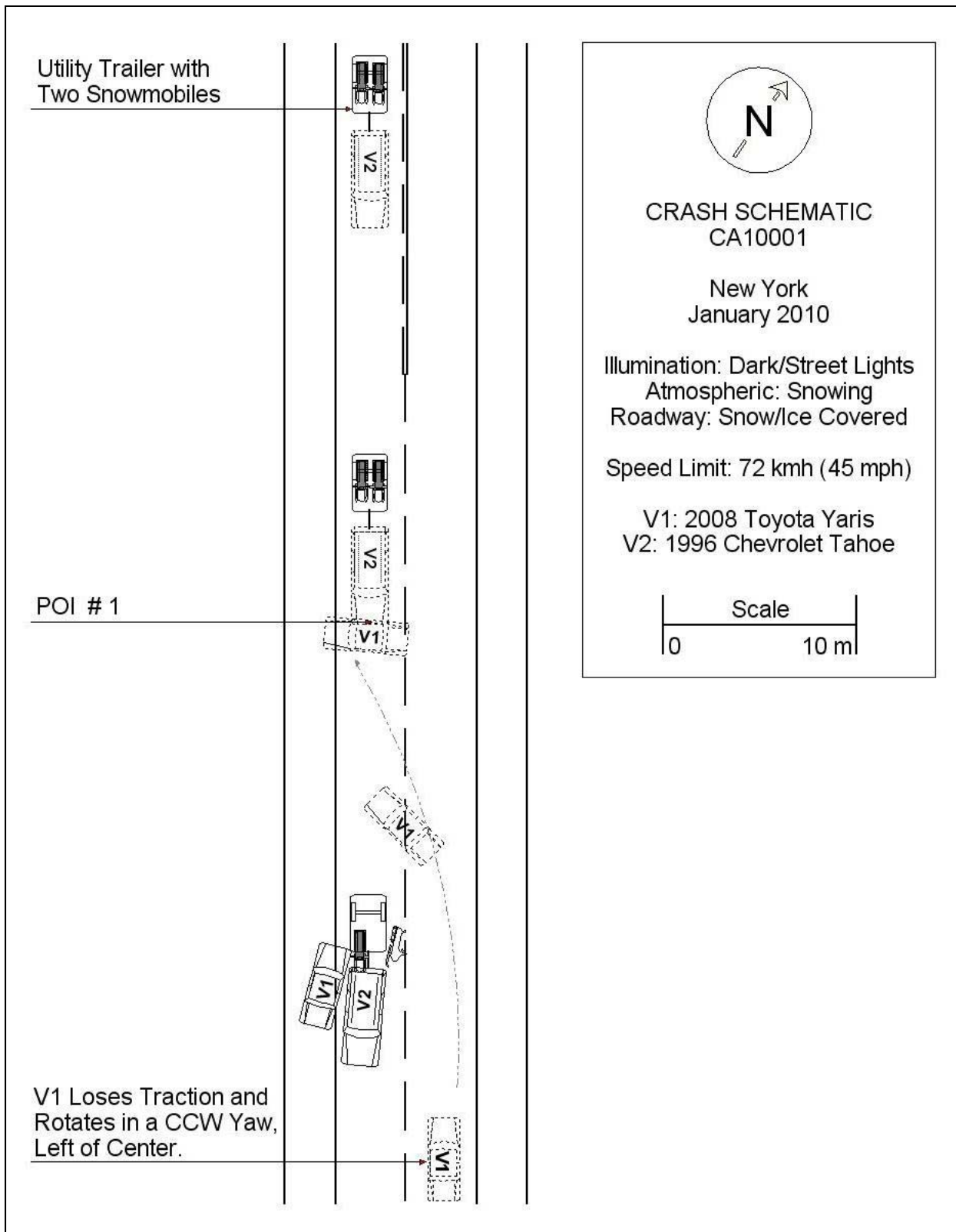


Figure 12: Crash Schematic.