

**TRANSPORTATION SCIENCES
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**ON-SITE CHILD SAFETY SEAT INVESTIGATION
CENTURY SMART MOVE SE CONVERTIBEL CHILD SAFETY SEAT
GENERAL DYNAMICS CASE NO: CA03-033**

**VEHICLE – 1990 TOYOTA 4 RUNNER
LOCATION - COLORADO
CRASH DATE – JUNE 2003**

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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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<i>16. Abstract</i> <p>This on-site investigation focused on the installation and performance of a Century Smart Move SE convertible child safety seat (CSS) that was installed in a forward facing mode in the right rear position of a 1990 Toyota 4Runner sport utility vehicle. The Toyota sustained severe damage to the greenhouse (volume above the belt line) as the result of high speed rollover crash. The CSS was occupied by a 2-year old male child. The child sustained only minor facial abrasions and a wrist contusion. The 22 year old restrained male driver and 22 year old restrained female front right passenger sustained serious injuries and were admitted to a trauma center for treatment. A secondary focus of the investigation was a tread separation of the Toyota's left rear tire that contributed to the driver's loss of control and subsequent crash.</p> <p>The Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) received notification of this crash from the investigating police officer the day following the crash. NHTSA in-turn assigned an on-site investigation of the crash to the General Dynamics Special Crash Investigations team. The crash was assigned due to the agency's interest in the child passenger safety and the field performance of child safety seats. The Toyota 4Runner, the separated tread and tire and the child safety seat were impounded by the investigating police agency and were available for this SCI inspection.</p>			
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TABLE OF CONTENTS

BACKGROUND	1
SUMMARY	
Crash Site	1
Pre-Crash.....	2
Crash	3
Post-Crash	4
VEHICLE DATA	
1990 Toyota 4 Runner.....	4
Exterior Damage	6
Interior Damage	7
Manual Restraint System.....	8
CHILD SAFETY DATA	10
REAR RIGHT CHILD DEMOGRAPHICS	11
REAR RIGHTCHILD INJURIES	11
REAR RIGHTCHILD KINEMATICS.....	11
DRIVER DEMOGRAPHICS	12
DRIVER INJURIES	12
DRIVER KINEMATICS	13
FRONT RIGHT PASSENGER DEMOGRAPHICS.....	13
FRONT RIGHT PASSENGER INJURIES	13
FRONT RIGHT PASSENGER KINEMATICS.....	14
CRASH SCHEMATIC	15

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BACKGROUND

This on-site investigation focused on the installation and performance of a Century Smart Move SE convertible child safety seat (CSS) that was installed in a forward facing mode in the right rear position of a 1990 Toyota 4 Runner sport utility vehicle, **Figure 1**. The Toyota sustained severe damage to the greenhouse (volume above the belt line) as the result of high speed rollover crash. The CSS was occupied by a 2-year old male child. The child sustained only minor facial abrasions and a wrist contusion. The 22 year old restrained male driver and 22 year old restrained female front right passenger sustained serious injuries and were admitted to a trauma center for treatment. A secondary focus of the investigation was a tread separation of the Toyota's left rear tire that contributed to the driver's loss of control and subsequent crash.



Figure 1: Left side view of the Toyota 4 Runner.

The Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) received notification of this crash from the investigating police officer the day following the crash. NHTSA in-turn assigned an on-site investigation of the crash to the General Dynamics Special Crash Investigations team. The crash was assigned due to the agency's interest in the child passenger safety and the field performance of child safety seats. The Toyota 4 Runner, the separated tread and tire and the child safety seat were impounded by the investigating police agency and were available for this SCI inspection.

SUMMARY

Crash Site

This single vehicle crash occurred during the afternoon hours in June 2003. At the time of the crash, it was daylight and the weather was not a factor. The crash occurred on the northbound lanes of an interstate highway. At the crash site, the highway was under going reconstruction and an active construction zone was in place. The interstate was configured with two travel lanes in the respective travel directions separated by a 30 m (100 ft) wide depressed grass median. The northbound travel lanes measured 3.7 m (12.0 ft) in width and were delineated by standard painted markings. The width of the outboard and inboard shoulders bordering the travel lanes measured 3.0 m (10.0 ft) and 1.2 m (4.0 ft), respectively. Within the wide median, the

construction crew had constructed a 4.6 m (15.0 ft) wide berm of recycled asphalt and earth that was being used for the highway reconstruction. The berm was an estimated 2.4 m (8.0 ft) in height and was oriented parallel to the roadway. The center of the berm was located 14 m (46 ft) west of the pavement edge of the northbound lanes. The highway speed limit in the construction zone was reduced to 105 km/h (65 mph) from the posted 121 km/h (75 mph) interstate speed limit. **Figures 2 and 3** are views of the roadway configuration and center median.



Figure 2: Northbound view on the interstate.



Figure 3: Northwest view across the median from the edge of the northbound lanes.

CRASH SEQUENCE

Pre-Crash

The 1990 Toyota 4 Runner was traveling northbound driven by a 22 year old male. He was restrained at the time of the crash by the vehicle's 3-point lap and shoulder belt system. The Toyota was occupied by a 22 year old restrained female front right passenger and a restrained 2 year old male rear right passenger. The 2 year old male was restrained within a forward facing Century Smart Move SE convertible child safety seat installed in the right rear position.

At the time of the crash, the traffic was reported as moderate. There were several witnesses to the crash traveling behind the Toyota occupying both the inboard and outboard lanes. The Toyota was traveling on the inboard (left) lane at a reported speed of approximately 121 to 129 km/h (75 to 80 mph). The witnesses further reported that the tread of the Toyota's left rear tire suddenly separated and that seconds later the driver lost control of the vehicle. The detreaded left rear tire altered the vehicle dynamics of the Toyota and it became an unstable over-steering vehicle. The witnesses reported that the Toyota veered to the right into the outboard lane. The driver steered left (counterclockwise) to regain the original travel lane and correct the errant trajectory. However, in the process of the maneuver, the driver over-corrected and the vehicle began to rotate counterclockwise (CCW). The Toyota rotated to a near broadside orientation and then began to rollover. The reconstruction of the crash determined the vehicle had rotated 70 degrees CCW with respect to the travel lane at the onset of the rollover.

Inspection of the crash scene identified two yaw marks that began in the outboard (right) lane. The marks were attributed to the right side tires of the Toyota. The front right yaw mark measured 50 m (165 ft) in length. The length of the rear right yaw mark measured 40 m (130 ft).

The average radius of curvature of the yaw marks was determined to be approximately 156.7 m (514.0 ft). This average radius was measured over the first 18 m (60 ft) of the yaw trajectory. The surface friction of the road was an estimated 0.75. A critical speed calculation for this yawing trajectory was calculated to be approximately 122 km/h (76 mph). (It should be noted that the critical speed calculation is a minimum speed calculation.) This calculation was consistent with the reported travel speed of approximately 121 to 129 km/h (75 to 80 mph).

Crash

Figure 4 is an on-scene police photograph of the yaw marks looking along the Toyota's northwestward trajectory. At the end of the yaw marks, the Toyota initiated an untripped right side leading rollover. There were no pavement gouges at the end of the yaw marks normally associated to a tripped rollover. The area of first touchdown was located 9 m (30 ft) northwest of the end of the yaw marks on the inboard road shoulder, **Figure 5**. The touchdown zone was identified by a series of small gouges and abrasions dispersed over a 2.4 m x 0.9 m (8.0 ft x 3.0 ft) area. This contact was attributed to the right roof rail and roof area of the Toyota. Two 1.5 m (5.0 ft) long abrasion marks, located on the inboard shoulder 14 m (45 ft) beyond the end of the yaw marks, denote the point where the Toyota entered the median. An area measuring 1.2 m x 5.5 m (4.0 ft x 18.0 ft) located 42.7 m (140.0 ft) beyond the end of the yaw marks was documented during the police investigation as the second point of (significant) impact by the Toyota. The vehicle then vaulted over the 2.4 m (8.0 ft) berm of construction materials. A review of the on-scene police photographs depicted that the berm remained undisturbed throughout the area of the Toyota's trajectory indicative that the vehicle did not significantly contact the berm. The Toyota came to rest on its left side facing south, **Figure 6**. The final rest of the vehicle was located 20 m (230 ft) northwest of the end of the yaw marks and 23 m (74 ft) west of the northbound lanes. Reconstruction of the rollover indicated the Toyota completed 2-3/4 revolutions (11 quarter turns) during the event. A schematic of the crash sequence is attached to the end of this narrative report, **Figure 20**.



Figure 4: Northwest view of the yaw marks.



Figure 5: View of the area of first touchdown



Figure 6: View of the final rest position of the Toyota.

Post-Crash

Numerous witnesses to the event stopped their vehicles and rendered first aid. These individuals were the source of crash notification through the 9-1-1 system. These witnesses reported that the police and EMS personnel arrived on-scene within five to ten minutes and initiated rescue operations. Due to the serious nature of the injuries sustained by the driver and front right passenger, the right side pillars of the Toyota were cut and the roof was hinged open to access the interior (refer to Figure 6 above). The driver of the Toyota was removed from the vehicle and transported by air ambulance to a Level 1 trauma center located approximately 32 km (20 miles) from the crash site. He sustained facial lacerations, a left scapula fracture, left rib fractures with left pneumothorax, bilateral pulmonary contusions, multiple chest abrasions, and a left femur fracture. He was transported by air ambulance and admitted to the intensive care unit of the regional trauma center. The front right passenger was removed from the vehicle and was transported by ground ambulance and was admitted for treatment at the trauma center. She reportedly sustained a forehead laceration, right clavicle fracture, left hand laceration and bilateral arm abrasions. The 2 year old child passenger was removed from the vehicle in the child safety seat and transported to the trauma center as a precaution. He was examined and released approximately 3 hours after arrival in the Emergency Room. The child only suffered minor facial abrasions and a right wrist contusion in the event.

VEHICLE DATA

1990 Toyota 4 Runner

The 1990 Toyota 4 Runner was identified by the Vehicle Identification Number (VIN): JT3VN39W0L (production sequence deleted). The four-wheel drive sport utility vehicle was manufactured with a 262.4 cm (103.3 in) wheelbase. The Gross Vehicle Weight Rating (GVWR) of the Toyota was 2,427 kg (5,350 lb). The power train consisted of a 2.9 liter, V-6 engine linked to a four-speed automatic transmission. The service brakes were power assisted front disc/rear drum without ABS. The manual restraint system consisted of 3-point lap and shoulder belts in the four outboard seat positions. The center rear position was equipped with a lap belt. The vehicle was not equipped with a frontal or side impact air bag system. The odometer read 321,202 km (199,585 miles) at the time of the inspection. The vehicle registration records indicated it was purchased used by the driver in March 2003 from a private individual.

The subject vehicle was equipped with Michelin LTX A/T tires on the front left, front right and rear right positions. The spare tire was also a Michelin LTX A/T. The Michelin tires were Load Range C. The rear left tire was a Bridgestone Desert Dueler with a Load Range B. All the tires were of the same size: 31x10.5R15 LT. This tire size was listed as the manufacturer's optional size for this vehicle. The vehicle manufacturer's recommended tire pressure was 200 kPa (29 PSI). The specific measured tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	241.4 kPa (35.0 PSI)	6.3 mm (8/32)	No	None
LR	Tire flat	9.5 mm (12/32)	No	Tread Separation
RF	231.0 kPa (33.5 PSI)	7.1 mm (9/32)	No	None
RR	Tire flat	5.5 mm (7/32)	No	None

An oil and filter service receipt recovered from the vehicle's interior during the police investigation indicated the tire pressures were serviced 15 days prior to the crash with 276 kPa (40 psi) front and rear.

The left rear tire sustained a 90 percent tread separation immediately prior to the crash. Witness reported that the tread instantly separated. Examination of the left rear wheel well did not yield evidence that the tire tread impacted the inner fender of the truck in a repetitive manner. The majority of the separated tread was recovered by the police investigators from the crash site.

Figure 7 is a view of the left rear tire. The tire was deflated at the time of the inspection; however, the tire bead was still seated. **Figure 8** is a view of the recovered tread. The tread section measured 229 cm (90 in) in length. The depth of the tread was a consistent 9.5 mm (12/32) across its face. Examination of the tread and tire casing indicated the tread appeared to have separated between the steel plies.



Figure 7: View of the left rear tire.



Figure 8: View of the recovered tire tread.

The manufacturer's nomenclature on the sidewall of the left rear tire was as follows:

Bridgestone Desert Dueler M+S
31 x 10.5 R 15 LT Tubeless Steel Belted Radial
DOT H482 CDJ349
Plies: Tread: 2 Steel + 2 Polyester
Sidewall: 2 Polyester
Load Range B
Max. Load 1775 lbs at 35 psi Cold
Made in Japan K8801 D682UZ

Exterior Damage

Figures 9 through 11 are the views of the Toyota's left side, greenhouse and right side, respectively. The vehicle sustained damage consistent with a 2 3/4 revolution (11 quarter turn) lateral rollover crash event. The primary vehicle damage was to the forward aspect of the roof resultant to its impact with the ground. The right A-, B-, and C-pillars, and the left A-, and B-pillars deformed vertically and were displaced laterally to the right. The residual vertical deformation at the left A-pillar measured 23 cm (9 in). It should be noted that the dynamic vertical deformation would have been greater than the static post-crash intrusion due to the effects of restitution. Inspection of the left aspect of the instrument panel (IP) identified a region of direct contact between the windshield header and top surface of the instrument panel and steering wheel rim. Additionally, during impact with the ground, the left A-pillar buckled and deformed inboard. The deformed roof and pillar impacted and fractured the left aspect of the instrument panel. The windshield was fractured and completely displaced from its mounting. The backlight and all side glazings disintegrated in the event and the sunroof separated. The left front, left rear, and right rear doors were jammed shut due to deformation. The right front door remained closed during the crash and was operational. The Collision Deformation Classification (CDC) of the damage was 00-TDDO-4. The left A-pillar and the right A- through D-pillars were cut during the extrication of the occupants.



Figure 9: Front view of the deformed greenhouse.



Figure 10: Left side view of the Toyota 4 Runner.



Figure 11: Right side view.

The vehicle's front and back planes sustained minor damage, indicative that the roll was primarily lateral in nature. The wheelbase dimensions of the vehicle were unchanged. The roof, hood, and side planes of the vehicle exhibited scratches and abrasions oriented in at least two different directions. The heaviest scratches were primarily lateral in direction. The secondary angular scratches were biased front to rear. The different orientation of the scratches indicated that the respective planes contacted the ground at least twice. The nature of the body damage was consistent with the rollover sequence.

Interior Damage

The interior damage to the Toyota consisted of intrusion into the front occupant space due to the exterior forces of the rollover event. Inspection of the interior indicated that there was direct contact between the forward left aspect of the intruding roof and the left instrument panel, and steering wheel during inverted ground contact. This dynamic roof intrusion fractured the left aspect of the instrument panel which intruded downward into the driver's foot well 14.0 cm (5.5 in). The lateral intrusion of the left kick panel measured 8 cm (3 in). There was no intrusion into the front right passenger foot well. The residual vertical intrusion of the roof at the time of inspection is identified in the table below:

Position	Component	Left Side	Right Side
Front Row	Roof/A-pillar junction	23 cm (9 in)	18 cm (7 in)
Front Row	Roof/B-pillar junction	15 cm (6 in)	25 cm (10 in)
Second Row	Roof/C-pillar junction	15 cm (6 in)	23 cm (9 in)

The driver seat was located in the full rear track position and the driver's head restraint was missing. The posts supporting the head restraint were cut during the driver extrication for unknown reasons. The seat back was reclined to a 45 degree angle. Examination of the recline mechanism indicated it was damaged; the seat back could not be moved. The seat back was forced rearward during the rollover event as a result of the intruding roof. A bloody transfer

measuring 53 cm x 30 cm (21 in x 12 in) was located 38.1 cm (15.0 in) rearward of the header. This contact resulted in the driver's left scapula and left rib fractures. **Figure 12** is a view of the contact area above the driver's position.

The front right seat was in the full forward position and the seat back was folded forward. Reportedly, the seat had been moved prior to the SCI inspection. The seat back recline mechanism was damaged and would not engage; the seat back return spring would cause the seat to fold completely forward. The recline mechanism was probably damaged in the rollover due to the loading of the front right occupant during inverted ground contact. A 15.0 cm x 14.0 cm (6.0 in x 5.5 in) contact, **Figure 13**, to the right side rail/headliner junction was identified above the right front position. The contact was located 66 cm (26 in) rearward of the header and attributed to the right shoulder of the occupant. This contact resulted in her right clavicle fracture.



Figure 12: Driver's contact.



Figure 13: Front right passenger contact.

Manual Restraint System

The manual restraint system in the 1990 Toyota 4 Runner consisted of 3-point lap and shoulder belts with continuous loop webbings, sliding latch plates and Emergency Locking Retractors (ELR) for the front seat positions. The D-rings for the front restraints were fixed. The second row was equipped with 3-point restraints, lightweight locking latch plates, ELR's and fixed D-rings for the outboard seat positions. The center position was lap belt equipped.

Inspection of the driver's safety belt indicated the first responders had cut the driver's safety belt during the extrication. The left front retractor was inoperative and locked. The latch plate was still inserted into inboard buckle. Examination of the latch plate revealed evidence of historical use. A 105.4 cm (41.5 in) cut webbing section was attached to the outboard floor anchor. This lap section of webbing exhibited 46 cm (18 in) of loading evidence that began 46 cm (18 in) above the anchor. An 82.6 cm (32.5 in) section of webbing was threaded through the D-ring. A 5 cm (2 in) webbing abrasion was identified at the D-ring.

Inspection of the front right restraint found that it was also cut by the first responders. The latch plate was still engaged with the buckle. The length of the cut section measured 145 cm (57 in). The webbing was cut 43 cm (17 in) above the outboard floor anchor and immediately below the right D-ring. The right B-pillar and the restraint were cut simultaneously during the extrication. A 2 cm (1 in) section of the shoulder belt webbing remained captured in the D-ring. A 9.7 cm (3.8 in) partial tear caused by the webbing's engagement with the latch plate was identified in the cut webbing section. The tear began 29.7 cm (11.7 in) from the end of the webbing [72.9 cm (28.7 in) above the floor anchor]. This partial tear was caused by the webbing's interaction with the latch plate. The balance of the webbing had spooled back into the retractor.

The rear right restraint was cut in order to extricate the child while he was still restrained within the child safety seat. A 102 cm (40 in) section of webbing was found in the rear right position. This webbing section was threaded through the lightweight locking latch plate that was still inserted into the inboard buckle at the time of the inspection. The restraint's outboard floor anchor was located under the rear seat cushion. The webbing was attached to the anchor and then passed through the seat bight forming the continuous loop. The webbing was cut 16.5 cm (6.5 in) above the seat bight during the extrication. **Figure 14** is a view of the cut webbing section. A crease in the webbing identified the at crash location of the latch plate. The latch plate was located 38 cm (15 in) from the end of the webbing section. This section of webbing was used to restrain the child seat during the crash. Load evidence was located 19.1 cm (7.5 in) and 49.5 cm (19.5 in) from the end of the section. This evidence was consistent with an interaction with the forward facing belt path of the CSS. The width of the tunnel forming the belt path measured 33 cm (13 in) consistent with the separation of the loading marks on the belt, **Figure 15**.

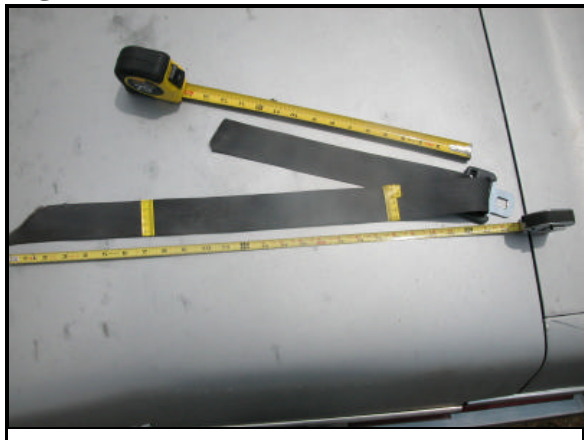


Figure 14: View of the webbing section/belt path interaction.



Figure 15: View of the rear right cut webbing section.

CHILD SAFETY SEAT DATA

The 2 year old male was secured in a Century Smart Move SE convertible seat, **Figure 16**. This seat had a manufacture date of April 15, 1999. The model number was 4709FOX. Portions of the manufacturer's label were torn and missing. The seat was designed for rear-facing use by infants up to 14 kg (30 lb) and for forward facing use by toddlers 9 – 18 kg (20 – 40 lb). The label further detailed that infants to 9 kg (20 lb) *must* be rear facing and that toddlers 9 – 14 kg (20 to 30 lb) *could* remain rear facing so long as their feet did not touch the vehicle's seat back. The seat cradle rotated relative to the base to change from the rear facing to forward facing mode and had four adjustments positions. Two adjustment positions were for each mode. The seat was adjusted to the fourth position. This was the most upright forward facing position.



Figure 4: View of the Century Smart Move SE.

The seat was equipped with a 5-point harness and a two-piece harness retainer clip. The harness straps were routed through the top slots of the seat back. It was not equipped with a tether strap. Inspection of the harness straps did not reveal any crash related evidence. The length of the right strap measured 48.9 cm (19.3 in) from the top slot to the base. The length of the left strap measured 42.5 cm (16.8in). The chest clip was adjusted 21.6 cm (8.5 in) below the top slot on each strap. The retainer clip opened and closed properly. The straps were slightly roped at the crotch clips. The crotch clips properly fastened and released from the buckle.

Examination of the child seat involved removing the cloth seat cover and inspecting the shell. Removing the seat cover revealed fracture damage to the Styrofoam absorber overlying the upper right aspect of the shell. **Figure 17** is a view of the fractured Styrofoam. **Figure 18** is a view of the shell with the Styrofoam removed. Inspection revealed three areas of stress marks to the plastic shell denoted by the arrows in the figure. During the crash sequence the deformed roof impacted the upper right wing of the shell. This contact fractured the Styrofoam absorber and caused the stress marks within the CSS shell. The shell was not fractured. Although the shell of the CSS was contacted by the intruding roof, the child remained protected during the rollover crash through the use of the 5-point harness.



Figure 17: View of the Styrofoam fracture.

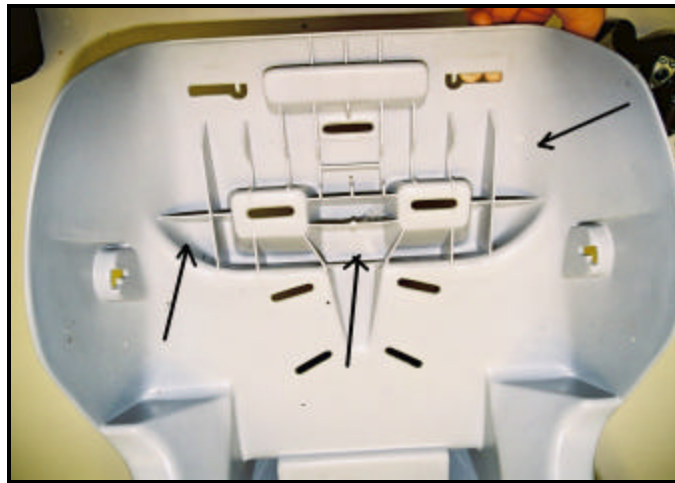


Figure 18: View of the upper aspect of the CSS shell and the stress marks.

REAR RIGHT CHILD PASSENGER DEMOGRAPHICS

Age/Sex: 2 year old/Male
 Height: 69 cm (27 in)
 Weight: Not reported
 Seat Position: Fixed Bench – right rear position
 Restraint Use: Convertible Child Safety Seat – forward facing mode
 Usage Source: SCI inspection
 Medical Treatment: Examined and released from Emergency Room

REAR RIGHT CHILD PASSENGER INJURY

<i>Injury</i>	<i>Injury Severity (AIS 98 update)</i>	<i>Injury Mechanism</i>	<i>Confidence Level</i>
Minor abrasions to face, NFS	Minor (290202.1,9)	Flying glass	Possible
Right wrist contusion, NFS	Minor (751410.1,1)	Right interior door panel	Probable

Note: The above injuries were identified from the occupant’s Emergency Room records.

REAR RIGHT CHILD PASSENGER KINEMATICS

The 2 year old male was restrained by the 5-point harness of a convertible child safety seat buckled in the rear right position of the 4 Runner. **Figure 19** is a view of the reconstructed seat position. As the vehicle went through the dynamics of the rollover, the child loaded the harness straps of the safety seat with his shoulders. The harness straps of the CSS and design of the shell protected the child as he rode down the forces of the crash. During the event, the vehicle’s roof crushed down and impacted the right upper aspect of the shell. This contact was evidenced by the fractured Styrofoam absorber overlying the shell. During the event, the right rear window glazing disintegrated and the flying glass was a possible source of the child’s facial abrasions.

The unknown aspect of the a facial abrasions made it difficult to establish an improved confidence level of the injury mechanism The child’s arm flailed about the interior and probably contacted the interior panel of the right rear door resulting in a contusion.

The child came to rest within the confines of the CSS. The use of the CSS prevented the child from further injury and probable ejection. He was removed from the vehicle still harnessed within the safety seat. He was transported to a trauma center in the CSS as a precaution, examined and released three hours after arrival in the Emergency Room.



Figure 19: View of the CSS in the rear right position.

DRIVER DEMOGRAPHICS

Age/Sex: 22 year old/Male
 Height: Not Reported
 Weight: Not Reported
 Seat Position: Full rear position
 Restraint Use: 3-point lap and shoulder belt
 Usage Source: SCI inspection
 Medical Treatment: Transported by air ambulance to a local Level I trauma center and admitted for treatment. Hospitalized for 11 days

DRIVER INJURY

<i>Injury</i>	<i>Injury Severity (AIS 98 update)</i>	<i>Injury Mechanism</i>	<i>Confidence Level</i>
Left pulmonary contusion and right apical pulmonary contusion	Severe (441410.4,3)	Intruding roof	Certain
Left posterior rib fractures with pneumothorax, NFS	Serious (450211.3,2)	Intruding roof	Certain
Left scapular and corticoid fracture	Moderate (753000.2,2)	Intruding roof	Certain
Comminuted fracture of the left femoral shaft	Serious (851814.3,2)	Intruding left lower instrument panel	Certain
Facial lacerations, bridge of nose and near left eye	Minor (290600.1,4)	Steering wheel rim	Certain
Multiple chest abrasions, NFS	Minor (490202.1,9)	Seat belt	Probable
Left second metacarpal fracture	Minor (752404.1,2)	Left instrument panel	Probable

Note: the above injuries were identified from the occupant’s Emergency Room records, Discharge Summary and Radiology reports.

DRIVER KINEMATICS

At the time of the crash, the 22 year old driver was restrained by the 3-point lap and shoulder belt. He was seated in the full rear track position. The driver lost control of the vehicle as a result of the left rear tread separation and was probably struggling to maintain control of the vehicle at the onset of the rollover. As the vehicle initiated the right side leading roll, the driver would have initiated a leftward and vertical trajectory. The driver contacted and loaded the manual restraint system. As the vehicle rolled inverted and impacted the ground, the roof crushed down and struck the driver's left shoulder and back. The roof contact was evidenced by a blood transfer identified during the inspection and resulted in the left scapula and corticoid fracture, left posterior rib fracture with pneumothorax, and bilateral pulmonary contusions. The intrusion of the roof caused the driver's head to contact the steering wheel rim resulting in his facial lacerations. The inverted ground contact also caused the vertical intrusion of the left instrument panel. The intruding instrument panel contacted the driver's left lower extremity resulting in the comminuted femur fracture. The driver's loading of the seat belt system during the rollover event was the probable source of his unspecified chest abrasions. The safety belt system restrained the driver within his occupant space and prevented probable ejection. The left metacarpal fracture probably resulted due to contact with the left instrument panel. As the vehicle came to final rest, the driver came to rest within his seat and in contact with the left door panel.

FRONT RIGHT PASSENGER DEMOGRAPHICS

Age/Sex: 22 year old/Female
Height: Not reported
Weight: Not reported
Seat Position: Unknown (moved prior to inspection)
Restraint Use: 3-point lap and shoulder belt
Usage Source: SCI inspection
Medical Treatment: Transported by ground ambulance to a local Level I trauma center and admitted for treatment. Hospitalized for 7 days

FRONT RIGHT PASSENGER INJURY

<i>Injury</i>	<i>Injury Severity (AIS 98 update)</i>	<i>Injury Mechanism</i>	<i>Confidence Level</i>
Right clavicle fracture	Moderate (752200.2,1)	Right roof side rail	Certain
Forehead laceration	Minor (290600.1,7)	Disintegrated right window glazing	Probable
Left hand laceration	Minor (790600.1,2)	Ground contact	Certain
Multiple abrasions of the arms bilaterally, NFS	Minor (790202.1,3)	Ground contact	Certain

Note: the above injuries were identified from the occupant's Emergency Room records, Discharge Summary and Radiology reports.

FRONT RIGHT PASSENGER KINEMATICS

The 22 year old female passenger was seated in an unknown track position and restrained by the manual belt system. During the rollover sequence, the passenger loaded the manual restraint as evidenced by the partially torn webbing at the latch plate. The disintegrated glazing of the right window resulted in her forehead laceration. Her upper extremities probably flailed due to the rotation. Upon inverted ground contact, the passenger's right shoulder impacted the right roof rail resulting in the clavicle fracture. During the rollover sequence, her upper extremities became exposed to ground contact resulting in the identified laceration and abrasions. She came to rest within the front right seating area. The use of the manual restraint maintained her position within the front right occupant compartment and minimized her exposure to further injury and probable ejection.

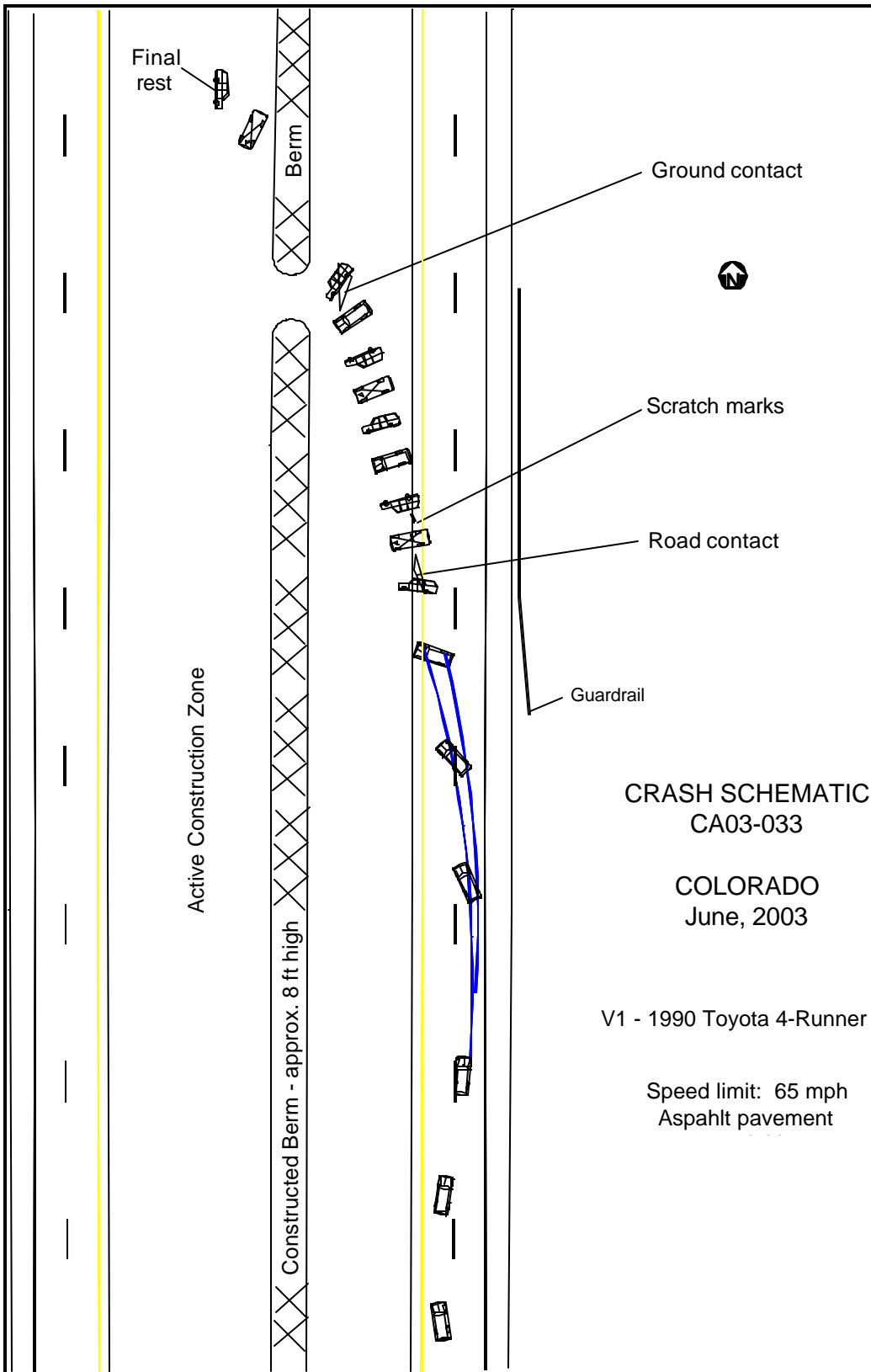


Figure 20: Crash Schematic.