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CALSPAN ON-SITE CHILD SAFETY SEAT CRASH INVESTIGATION
CENTURY CONVERTIBLE CHILD SAFETY SEAT
SCI CASE NO: CA07-006

VEHICLE: 1991 PLYMOUTH VOYAGER
LOCATION: TENNESSEE
CRASH DATE: JANUARY, 2007

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

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

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16. Abstract

This investigation focused on the crash dynamics and injury sources of an 11 month old male restrained in a forward facing mode in a Century Ovation Convertible Child Safety Seat (CSS). The CSS was positioned in the row 2 left position of a 1991 Plymouth Voyager and was restrained in the vehicle by the 3-point manual lap and shoulder safety belt. The 18 year old female driver of the Plymouth disregarded a red traffic signal and struck the left side of a 1996 Ford Contour in a 12/9 o'clock impact configuration. The unrestrained female driver and the 20 year old unrestrained male passenger of the Voyager sustained non life-threatening injuries and were hospitalized. The unrestrained 18 year old female passenger in the row 2 right position of the Plymouth sustained fatal blunt force injuries and died three days post-crash. The 11 month old male restrained within the CSS sustained minor injuries and was transported to a local hospital. He was hospitalized for four days as a precaution to a possible closed head injury and was released. The 22 year old female driver and 42 year old female passenger of the Ford were fatally injured in the crash and died at the scene.

This crash was identified by the Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) through an Internet news article posted on January 31, 2007. The article was forward to the Calspan Special Crash Investigations team (SCI) for follow-up investigation due to the agency's interest in child passenger safety. Cooperation was established with the investigating police agency and an on-site crash investigation was assigned on February 2, 2007. The vehicles and child seat were being held in the police impound pending the conclusion of the police investigation and were available for inspection. The on-site portion of the SCI investigation took place February 13 and 14, 2007.

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BACKGROUND

This investigation focused on the crash dynamics and injury sources of an 11 month old male restrained in a forward facing mode in a Century Ovation Convertible Child Safety Seat (CSS). The CSS was positioned in the row 2 left position of a 1991 Plymouth Voyager (**Figure 1**) and was restrained in the vehicle by the 3-point manual lap and shoulder safety belt. The 18 year old female driver of the Plymouth disregarded a red traffic signal and struck the left side of a 1996 Ford Contour in a 12/9 o'clock impact configuration. The unrestrained female driver and the 20 year old unrestrained male passenger of the Voyager sustained non life-threatening injuries and were hospitalized. The unrestrained 18 year old female passenger in the row 2 right position of the Plymouth sustained fatal blunt force injuries and died three days post-crash. The 11 month old male restrained within the CSS sustained minor injuries and was transported to a local hospital. He was hospitalized for four days as a precaution to a possible closed head injury and was released. The 22 year old female driver and 42 year old female passenger of the Ford were fatally injured in the crash and died at the scene.

Figure 1: Front right view of the Plymouth.

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SUMMARY

VEHICLE DATA

1991 Plymouth Voyager

The 1991 Plymouth Voyager was identified by the Vehicle Identification Number (VIN): 2P4GH2534MR (production sequence deleted). The three-door, seven passenger minivan was configured on the 285 cm (112.3 in) wheelbase and was equipped with base model trim. The power train consisted of a 3.0 liter/V6 engine linked to a four-speed automatic transmission. The

service brakes were a front disc/rear drum system. The seating configuration consisted of two manual bucket seats in the front row, a two-passenger second row bench seat, and a third row three-passenger bench seat. The manual restraint system consisted of three-point lap and shoulder belts in the six outboard positions and a third row center lap belt. The Plymouth was equipped with a driver air bag that deployed as a result of the crash. The date of manufacture was unknown. The odometer read 283,324 km (176,000 miles). The Voyager was equipped with Firestone FR380 P205/70R14 tires on OEM alloy wheels. The recommended tire pressure was 241 kPa (35 PSI). The specific measured tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0 kPa	4 mm (5/32 in)	No	Tire debeaded, localized rim fracture
LR	0 kPa	4 mm (5/32 in)	No	Tire debeaded, 2 cm sidewall puncture
RF	104 kPa (15 PSI)	5 mm (6/32 in)	No	Rim abraded
RR	0 kPa	4 mm (5/32 in)	No	Tire debeaded, localized rim fractures

1996 Ford Contour

The 1996 Ford Contour GL was identified by the Vehicle Identification Number (VIN): 1FALP6537TK (production sequence deleted). The four-door sedan was equipped with a power train that consisted of a 2.0 liter/I4 engine linked to a four-speed automatic transmission. The front disc/rear drum service brakes were equipped with four-wheel ABS. The manual restraint system consisted of 3-point lap and shoulder belts for the five seat positions. The Ford Contour was equipped with driver and front right passenger air bags that deployed as a result of the crash. The odometer reading was unknown. The Contour's date of manufacture was November 1995. The vehicle's left front and right tires were a Guardsman 40 T/E and a Cooper Trendsetter S/E, respectively. The rear tires were Hercules MR IV. All four tires were size P195/70R14 mounted on OEM steel wheels. The recommended tire pressure was 233 kPa (34 PSI). The specific measured tire data at the time of the SCI inspection is identified in the following table:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	0 kPa	5 mm (6/32 in)	No	None
LR	0 kPa	5 mm (6/32 in)	No	None
RF	90 kPa (13 PSI)	4 mm (5/32 in)	No	Rim bent, debris in bead
RR	0 kPa	4 mm (5/32 in)	No	Rim bent, debris in bead and packed onto wheel

CRASH SITE

This two-vehicle crash occurred during the afternoon hours in January 2007. At the time of the crash, it was daylight and the weather was not a factor. The crash occurred at the four leg intersection of a two-lane north/south road and a one-way (eastbound) two-lane road in an urban setting. The north/south road measured 8.1 (26.5 ft) in total width. The traffic lanes were separated by a double yellow centerline. The total width of the eastbound one-way road measured 11.9 m (39 ft). The traffic lanes were separated by broken white lines. The travel lanes were bordered by 15 cm (6 in) concrete curbs, grass, and sidewalks. A 15 cm (6 in) diameter hardwood tree and a wooden utility pole were located on the north side of the one-way road within the post-crash trajectory of the Plymouth. The pole was stabilized by a guy wire that was also impacted during the crash sequence. A private school was located in the northeast quadrant of the intersection. The property of the school was elevated approximately 1 m (3 ft) with respect to the bordering streets. This elevation change was landscaped by an embankment located 5.8 m (19 ft) north of the eastbound road edge. The slope of the embankment measured 18 degrees. A 2.4 m (8 ft) high aluminum fence set between 0.6 m (2 ft) square brick columns was located at the top of the embankment. The brick columns were spaced 12 m (40 ft) apart. A commercial business was located in the southwest corner of the intersection. The building was located 15 m (50 ft) south of the eastbound roadway and would not have obscured the vision of the respective drivers. The intersection was controlled by overhead (green/amber/red) traffic signals. The traffic light was green for the north/south traffic at the time of the crash. The posted speed limit was 48 km/h (30 mph). **Figure 2** is the northbound trajectory view of the Ford. **Figure 3** is an eastbound trajectory view of the Plymouth. **Figure 4** is an on-scene police photograph of the vehicles at final rest.

Figure 2: Northbound trajectory view of the Ford.

Figure 4: Eastbound trajectory view of the Plymouth.

Figure 3: On-scene view of the vehicles at final rest.

CRASH SEQUENCE

Pre-Crash

The 1996 Ford Contour was northbound driven by a 22 year old female and occupied by a 42 year old female front right passenger. Both occupants were restrained at the time of the crash by the vehicle's manual 3-point lap and shoulder belt system. These two individuals had just left their place of employment located several blocks from the crash site and were in the process of their evening commute. The Ford entered the intersection under a green traffic signal.

The 1991 Plymouth Voyager was driven by an unrestrained 18 year old female and was traveling eastbound in the right lane. The Voyager was occupied by an unrestrained 20 year old male front right passenger, an unrestrained 18 year old female seated on the right side of row 2 and an 11 month old male seated in a Century Ovation Convertible Child Safety Seat (CSS) located on the left side of row 2. The Plymouth was being followed by a non-contact vehicle due to a reported domestic dispute. The Plymouth and the non-contact vehicle were traveling at speeds approaching 113 km/h (70 mph) immediately prior to the crash. The Plymouth failed to yield the right of way and entered the intersection against red traffic signal. The driver of the Plymouth became aware of the impending crash late in the pre-crash envelope and steered left immediately prior to the impact in an avoidance maneuver.

Crash

The front plane of the Plymouth impacted the left side plane of the Ford in a 12/9 o'clock impact configuration. The Plymouth's impact with the Ford was centered on the left front door of the Contour. The force of the impact caused the air bag systems in both vehicles to deploy. The severity of the impact was calculated using the Damage Algorithm of the WINSMASH model. The total delta V of the Plymouth was 70 km/h (43.5 mph). The longitudinal and lateral delta V components were -66 km/h (-40.9 mph) and -24 km/h (-14.9 mph). The total delta V of the Ford was 76 km/h (47.2 mph). The longitudinal and lateral delta V components were -13 km/h (-8.2 mph) and 75 km/h (46.6 mph).

Figure 5: Point of impact and post-crash vehicle trajectories.

Both vehicles departed the impact with the northeast trajectory and a counterclockwise rotation. The highly dynamic impact event was evidenced by numerous tire marks that documented the post-impact trajectories of the vehicles and by multiple minor secondary events to each vehicle. **Figure 5** is a northeastward view at the point of impact along the post-crash trajectories of the vehicles.

The Ford slid approximately 10 m (33 ft) to the northeast and rotated approximately 72 degrees CCW at which time the right front wheel rim and then the right rear wheel rim impacted the north curb (Events 2 and 3). The vehicle mounted the curb and slid an additional 15 m (50 ft) across the grass and sidewalk. At this time the vehicle had rotated approximately 125 degrees and was traveling backwards. The Ford encountered and traveled up the embankment and impacted the aluminum fence bordering the school's property with its back plane (Event 4). The

fence deformed and redirected the vehicle's trajectory to the east. The length of the direct contact to the fence measured 4.9 m (16 ft). The left side of the Ford aft of the rear axle impacted and uprooted the brick column (Event 5). The Ford separated from the column and came to rest facing southeastward 29.9 (98 ft) from the point of impact.

The Plymouth separated from the Ford and slid 18.9 m (62 ft) along an east-northeast trajectory through the left eastbound lane and rotated approximately 190 degrees CCW. The right rear tire debeaded and the wheel rim contacted the road pavement evidenced by a 1 m (3 ft) long scratch mark leading to an impact with the north curb (Event 6). The Plymouth mounted the curb and traveled an additional 5.5 m (18 ft) through the grass. At this time, the Plymouth had rotated approximately 260 degrees CCW and was facing southward. The aft aspect of the vehicle's left side impacted a 15 cm (6 in) diameter tree (Event 7). The impact was located at the left rear axle location. The force of this impact caused the Plymouth to rotate counterclockwise rapidly about the tree. During this rotation, the left side of the Plymouth contacted and unearthed a guy wire stabilizing a wooden utility pole located 3.2 m (10.5 ft) from the tree (Event 8). The Plymouth separated from the tree and impacted this pole with the front aspect of the left plane (Event 9). The vehicle's impact with the pole sheared the fixed object at ground level. The Plymouth came to rest facing northeast 29 m (95 ft) from the intersection impact. A schematic of the crash is attached to the end of this report as **Figure 20**.

Post-Crash

The police, fire, and ambulance personnel responded to the crash. The doors of the Voyager were jammed shut and required extrication. The two adult front seat passengers in the Plymouth sustained non-life threatening injuries and were transported to a local hospital for treatment. The adult passenger in row 2 sustained multiple blunt force injuries. She was hospitalized and died three days post-crash upon removal of life support. The 11 month old child was removed from the Plymouth while still restrained with the child safety seat and transported to a local hospital with police reported minor injuries. He was hospitalized as a precaution to a closed head injury for four days and released. The two adult occupants of the Ford were pronounced dead at the scene of the crash due to blunt force trauma. Both vehicles sustained disabling damage, were towed and impounded by the investigating police department.

1991 PLYMOUTH VOYAGER

Exterior Damage

Figure 6 is the front view of the Plymouth. The front plane of the Plymouth sustained 152 cm (60 in) of direct contact damage that extended across its entire front end width. The front bumper fascia was separated during the impact. The residual crush profile was documented across the front bumper reinforcement and was as follows: C1 = 41 cm (16.1 in), C2 = 30 cm (11.8 in), C3 = 29 cm (11.4 in), C4 = 22 cm (8.7 in), C5 = 15 cm (5.9 in), C6 = 12 cm (4.7 in). The maximum crush was located at C1, the front left bumper corner. The left front fender was buckled and deformed outboard. The

Figure 6: Front view of the Plymouth.

residual damage profile was biased to the left consistent with the lateral momentum of the Contour during the impact. White paint transfer was observed on the right front fender and extended rearward to the mid aspect of the right front door. The paint transfer to the right front door occurred as the vehicles rotated during separation. The right front door was opened by rescue personnel evidenced by extrication damage. The right rear door was removed during the rescue operations. The left front door was jammed shut. The left wheelbase dimension was unchanged. The right front suspension was damaged during the crash and the right drive axle dislodged from the transmission. The right wheelbase measured 255 cm (100.5 in) at inspection; a 30 cm (11.8 in) reduction. This reduction was not consistent with the impact damage and a portion of this reduction was related to the post-crash towing of the vehicle based on a review of the on-scene photographs. The roof of the Plymouth was buckled above the driver's portion. The lower aspect of the windshield was fractured from the exterior crash force and the right and center aspects were fractured by occupant contact. The Collision Deformation Classification (CDC) of the frontal impact (Event 1) was 01-FDEW2.

The left side of the Plymouth sustained three localized regions of damage as a result of the impacts to the tree, guy wire and utility pole (Events 7 - 9). The rear aspect of the Plymouth's left side sustained 56 cm (22 in) of direct and induced damage as a result of contact to the tree (**Figure 7**). The damaged region began 28 cm (11 in) forward of the rear axle was centered on the axle. The maximum deformation measured 6 cm (2.3 in). The damage extended vertically to the 145 cm (57 in) height of the roof. The damage was consistent with the damage observed to the tree during the scene inspection. The CDC of this impact was 09-LBAW-3.

Figure 7: Left rear tree impact damage.

Evidence of contact to the guy wire (Event 8) was noted to the aft lower aspect of the left front door 152 cm (60 in) forward of the rear axle. This damage consisted of paint removal. Refer to **Figure 8**. Its location on the vehicle was consistent with the physical dimension between the tree and the guy wire determined during the scene inspection. The CDC of the impact was 09-LPEN1. The forward aspect of the left plane impacted and sheared the wooden utility pole as the vehicle rotated away from the tree (Event 9). The damage was evidenced by a creosote transfer to the left front wheel rim and pocketing damage to the left side of the deformed hood. **Figure 8** is a left view of the Plymouth depicting the guy wire and utility pole damages. The pole CDC was 09-LFEW1.

Figure 8: Forward left side damage.

1996 FORD CONTOUR

Exterior Damage

The Ford sustained severe left side damage as a result of the intersection impact with the Plymouth. **Figure 9** is a left front oblique view of the Ford Contour. The direct contact damage began 20 cm (8 in) rearward of the left front axle and extended rearward 180 cm (71 in). The force of the crash resulted in severe bowing of the vehicle. Due to the bowing, the front right corner of the Contour was displaced (shifted) laterally leftward approximately 38 cm (15 in). The length of the left side of the vehicle (corner to corner) measured 378 cm (149 in). The deformation and bowing reduced the length of the left side approximately 58 cm (23 in). The left wheelbase was reduced 35 cm (13.8 in). The right wheelbase lengthened 16 cm (6.2 in). The left side crush was measured by establishing a string line from left corner to the undeformed left rear quarterpanel which was broken into six equal zones to locate the crush measurements. A secondary string line was then established from deflection point to deflection point of the direct damaged region. The average lateral offset of the two string lines was then used to develop a bow constant, K, which was then added to the measured crush to account for the energy absorbed by bowing. The average bowing constant K measured 36 cm (14 in). The left side crush profile (inclusive of the K constant) was as follows: C1 = 33 cm (13.0 in), C2 = 61 cm (24.0 in), C3 = 130 cm (51.2 in), C4 = 112 cm (44.1 in), C5 = 65 cm (25.6 in), C6 = 32 cm (12.6 in). The maximum crush was located at the left B-pillar location (C3). The static residual crush measured 94 cm (37 in). This measurement does not include the bowing constant. The left side seating positions were nearly eliminated by the impact. The left front and rear doors were jammed shut by deformation. The right side doors remained closed during the impact and were jammed shut by body distortion. The right doors were removed during the rescue operations. The windshield was fractured. The backlight and all the side glazing had disintegrated. The CDC of the damage was 90-LYEW7. Note, the 10 o'clock direction of force was incremented by 80 to denote the left end bowing.

Figure 9: Left front oblique view of the Ford.

The entire end width of the back plane impacted and deformed the aluminum fence during the later stages of the crash sequence (Event 4). This impact did not result in any residual deformation. The CDC of this contact was 06-BDEW1. The left rear quarterpanel of the Ford sustained 61 cm (24 in) of direct and induced damage as a result of its impact with the brick column (Event 5). The damage began at the left rear corner and extended forward. The direct contact damage measured 38 cm (15 in). The maximum lateral crush measured 15 cm (6 in) and was located at the left rear corner. The CDC of this contact was 09-LBEN2. **Figure 10** is a view of the damaged left rear quarterpanel.

Figure 10: Left rear quarterpanel damage.

1991 PLYMOUTH VOYAGER

Interior Damage

The interior damage to the Voyager consisted of minor left toe pan intrusion, and numerous occupant contacts. The only restrained occupant in the vehicle was the 11 month old male in the child safety seat. **Figure 11** is an overall view of the front interior contacts within the Plymouth.

Figure 11: Forward interior view.

The driver seat was located in a full rear track position. The seat back angle measured 15 degrees aft of vertical. The horizontal distance from the seat back to the center hub of the steering wheel measured 53 cm (21 in).

The top half of the two-spoke steering wheel rim was deformed forward. The deformation measured 9 cm (3.5 in). The driver loaded the deployed driver air bag, deformed the rim, and completely separated the steering column from the shear capsules. The steering column had dropped and was resting on the top aspect of the lower instrument panel. Evidence of lower extremity contact was evidenced on the knee bolster. The bolster was cracked and scuffed 13 cm (5 in) right of the steering column centerline. The outboard aspect of the driver's toe pan had intruded an estimated 15 cm (6 in).

The front right seat was in a mid-to-rear track position and measured 6 cm (2.5 in) forward of full rear. The seat track position was measured with reference to the driver seat. The seat was jammed and could not be moved. The seat back was deformed forward by the adult rear passenger. The seat back angle measured 20 degrees forward of vertical.

The right aspect of the windshield was fractured by the front right occupant. The fracture site was located 5 cm (2 in) left of the A-pillar and 8 cm (3 in) below the header. Hair was observed within the fracture. The adjacent A-pillar trim was scuffed over an 8 cm x 29 cm (3 in x 11.5 in) area. Refer to **Figure 12**. The top forward aspect of the right front door panel was scuffed over an 8 cm x 46 cm (3 in x 18 in) area. The grab handle located within this region was deformed forward. The outboard corner of the instrument panel at the air conditioner vent was scuffed over an 8 cm x 10 cm (3 in x 4 in) area. Hair and blood were observed within this contact. The outboard aspect of the lower bolster was cracked.

Figure 12: Right windshield fracture and A-pillar contact.

Contacts to the center instrument panel were attributed to the female passenger seated in the right side of row 2 displaced forward by the crash. The center instrument panel was deformed forward and upward. The top edge of the instrument panel was scuffed over a 25 cm (10 in) length. The scuff began 38 cm (15 in) left of the right A-pillar and left to the approximate

centerline of the vehicle. Hair and blood were noted within this contact. Immediately above this region was a focused windshield fracture. This contact measured 7 cm (2.8 in) in diameter and caused the windshield to bulge outward approximately 1 cm (0.5 in). The fracture site was located 57 cm (22.5 in) left of the right A-pillar and 8 cm (3 in) above the deformed instrument panel. The trim surrounding the center instrument panel was fractured and separated. The glove box door was scuffed over a 32 cm x 13 cm (12.5 in x 5 in) area. Vertical oriented scuff marks were observed throughout the area. The center ash tray was scuffed over an 18 cm (7 in) wide region and the tray's latch was broken. Directly above these contacts, a 15 cm (6 in) long longitudinally oriented scuff was observed to the headliner. **Figure 13** is a view of the center instrument panel contacts.

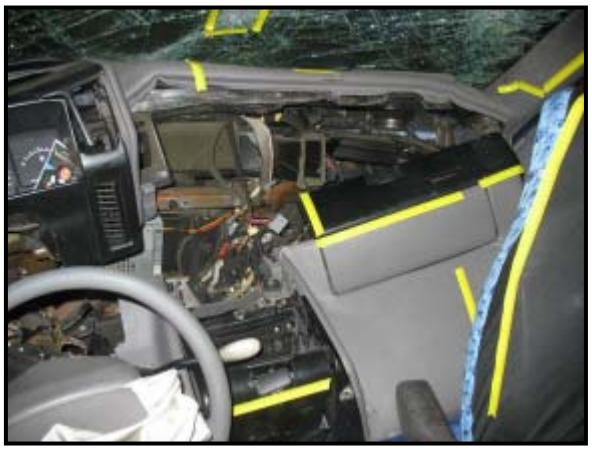

Figure 13: Center instrument panel contacts.

Manual Restraint Systems

The manual restraint systems in the Plymouth Voyager consisted of three-point lap and shoulder belts in the six outboard positions. Each outboard restraint consisted of continuous loop webbing, a sliding latch plate and an Emergency Locking Retractor (ELR). Upon initial inspection, the driver's belt webbing was partially extended from the retractor and the belt webbing was captured between the door frame and the jammed front left door. The driver could not have been using the restraint based on the physical evidence of the inspection.

The front right passenger restraint was in the stowed position upon inspection. The overall condition of the belt was worn, consistent with the vehicle's age. However, the restraint was not in use at the time of the crash. The safety belt buckle attached to the inboard aspect of the front right seat was covered with blood evidence. If the restraint had been in use, blood evidence would also have been present on the sliding latch plate. Examination of the latch revealed that it was clean and free from any blood evidence. In addition, there was no crash related loading to the webbing.

The row 2 right restraint was stowed. The outboard lower anchor at this position consisted of a metal tab fastened to the lower aspect of the right C-pillar. A clasped J-hook affixed to the end of the restraint webbing attached to the tab to comprise the lower anchor. This J-hook was not attached to the tab at inspection; the restraint at this position was not anchored. The restraint was not in use at the time of the crash. The unrestrained adult female seated at this position responded to the frontal impact by initiating a forward trajectory, loading the front right seat back and center instrument panel. This kinematic pattern would not have occurred had the occupant been restrained.

The row 2 left restraint was used to restraint the child safety seat at the time of the crash. The restraint was stowed upon initial inspection and revealed two regions of loading evidence in the form of stretched and abraded webbing. The first webbing section measured 11 cm (4.5 in) in length and was began 23 cm (9 in) above the webbing's exit from the seat bight. The second area of loading measured 18 cm (7 in) in length and began 48 cm (19 in) above the seat bight.

These areas of loading were consistent with the forward-facing belt path of the child safety seat. Further details regarding the restraint of the child seat can be found by referring to the *Child Safety Seat Section* of this report.

Air Bag System

The Plymouth Voyager was equipped with a driver (only) airbag system. The air bag deployed as a result of the crash from an H-configuration module located within the center hub of the steering wheel. The symmetrical cover flaps measured 17 cm x 6 cm (6.5 in x 2.5 in), width by height, and were not damaged. The deployed air bag measured 61 cm (24 in) in its deflated state. The bag was vented by two 3 cm (1 in) diameter ports located on the back side of the bag in the 11/1 o'clock sectors. There was no identified evidence of occupant contact to the air bag.

CHILD SAFETY SEAT DATA

Figure 14 is a front view of the Child Safety Seat (CSS) in use at the time of the crash. The CSS was restrained in the Plymouth's row 2 left position by the vehicle's 3-point lap and shoulder in a forward-facing mode. The CSS was a Century Ovation convertible seat Model No: 4265TRF110193. The last six digits of the model number are believed to be the date of manufacture (November 1, 1993). Due to the age of the seat, many of the seat's labels had been partially removed. The seat was labeled for rear facing use by infants 0 kg to 9 kg (0 lb to 20 lb) and for forward facing use by toddlers 9 kg to 18 kg (20 to 40 lb). The forward-facing labeled height requirement was 69 cm to 102 cm (27 in to 40 in). The seat design incorporated a tubular metal bar to adjust seat from rear-facing to forward-facing use. The metal bar adjusted to the forward facing position. The instruction manual was not present and there was no locking clip.

Figure 14: Century CSS front view.

The CSS was configured with a two harness straps connected to a T-shield. The harness straps were routed through the top slots. The right harness strap was folded over, roped, and creased. The padded T-shield was triangular in shape and measured 23 cm (9 in) wide and 17 cm (6.8 in) in height. A 5 cm (2 in) long metal latch plate extended from the base of the shield. The latch plate buckled into the base of the shell forming a 3-point restraint system. The latch plate inserted into the buckle to a depth of 3 cm (1 in). The chest retainer clip was located 8 cm (3 in) above the T-shield. The right harness strap was blood stained over a 10 cm (4 in) length.

Examination of the T-shield revealed that the shield was deformed forward due to occupant loading. Refer to **Figure 15**. The T-shield was in a vertical position at inspection. The latch plate was bent at its exit from the buckle (**Figure 16**). The top of the T-shield measured 25 cm (10 in) forward of the shell. It was estimated that the distance between the top of the undeformed T-shield and shell would have been 17 cm (6.5 in). These measurements indicated

the shield deformation allowed 8 cm (3.5 in) of ride down during the crash. This deformation allowed the child to effectively ride down the crash by reducing peak deceleration. Examination of the harness straps revealed 8 cm (3.5 in) of loading evidence along the straps at their respective contact to the back of the shell. **Figure 17** is a close-up view of the loaded right strap. The creased edge of the strap was frayed.

Figure 15: View of the buckled and deformed T-shield.

Figure 16: Close-up view of the deformed latch plate.

Figure 17: Close-up view of the loaded right harness

The CSS was installed in a forward-facing mode as depicted in **Figure 18**. With the seat in this position, the horizontal distance between the CSS back to the driver seat back measured 56 cm (22 in). There was no contact evidence identified to the driver seat back. Given the survival space between the CSS seat back and driver seat back, it was unlikely that the child contacted the front seat back. The loading evidence of the vehicle's manual restraint was consistent with the forward facing belt path of the CSS. Examination of the seat cushion of row 2 revealed four linear abrasions consistent with the base of the CSS shell. The seat was abraded by the bottom of the CSS as the CSS and occupant rode down the force of the crash. Refer to **Figure 19**. There was no crash related damage to the CSS shell.

Figure 18: Installed CSS.

Figure 19: Abrasions to the seat cushion of row 2.

OCCUPANT DEMOGRAPHICS

1991 Plymouth Voyager

	Driver	***Front Right Passenger***
Age/Sex:	18 year old / Female	20 year old / Male
Height:	173 cm (68 in)	149 cm (55 in)
Weight:	122 kg (270 lb)	61 kg (135 lb)
Seat Track Position:	Full rear track	Mid-to-rear
Restraint Use:	None	None
Usage Source:	SCI inspection	SCI inspection
Medical Treatment:	Transported via ground ambulance, hospitalized 2 days	Transported via ground ambulance, hospitalized 6 days
	Row 2 Left	***Row 2 Right***
Age/Sex:	11 month old / Male	18 year old / Female
Height:	79 cm (31 in)	Not reported
Weight:	11 kg (24 lb)	Not reported
Seat Track Position:	Fixed bench	Fixed Bench
Restraint Use:	Restrained within a CSS	None
Usage Source:	SCI inspection	SCI inspection
Medical Treatment:	Transported via ground ambulance, hospitalized 4 days	Hospitalized and died 3 days post-crash after removal from life support

DRIVER INJURY

1991 Plymouth Voyager

Injury	***Injury Severity (AIS 98 Update)***	***Injury Mechanism***
Comminuted fracture dislocation of the distal left radius	Serious (752804.3,2)	Possible fling injury into left interior structure
Loss of consciousness at scene, Unknown length of time, awake on admission, GCS=15, NFS	Moderate (160406.2,0)	Acceleration/deceleration
Left lower extremity abrasion, NFS	Minor (890202.1,2)	Knee bolster
Left lower extremity contusion, NFS	Minor (890402.1,2)	Knee bolster
8 cm superficial laceration of the left lower extremity	Minor (890602.1,2)	Knee bolster
6 cm superficial right knee laceration	Minor (890602.1,1)	Knee bolster
Right hand abrasion, NFS	Minor (790202.1,1)	Instrument panel
Right abdominal abrasion, NFS	Minor (590202.1,1)	Steering wheel rim

Injury	*Injury Severity (AIS 98 Update)*	*Injury Mechanism*
Central chest contusion, NFS	Minor (490402.1,4)	Steering column

Note: the above injuries were identified in the driver's hospitalization records.

DRIVER KINEMATICS

1991 Plymouth Voyager

The driver of the Plymouth was seated in a full rear track position at the time of the crash in an upright posture. She was not restrained by the manual safety belt. The police reported that the Plymouth was being chased by a non-contact vehicle and as a result, the driver was operating the Voyager at a high rate of speed. Immediately prior to the impact, she steered left in an avoidance maneuver.

Upon impact, the driver air bag in the vehicle deployed. The expansion of the air bag displaced the driver's left arm from steering wheel rim and into contact with an unidentified interior structure. This fling contact resulted in the radius fracture. The driver initiated a forward trajectory in response to the 1 o'clock direction of the impact force. The driver contacted and loaded through the expanded air bag during the ride down of the frontal crash. Her loading of the air bag and steering wheel rim resulted in deformation of the top sector of the steering wheel rim and a complete separation of the steering column from the shear capsules. The driver's sustained a chest contusion as a result of the contact and an abrasion of the abdomen. The driver's forward trajectory displaced her lower extremities into contact with the knee bolster resulting in the identified lower extremity injuries.

The counterclockwise rotation of the vehicle likely displaced the driver toward the left door panel. During the subsequent vehicle dynamics and (relatively) minor secondary impacts, the driver remained in contact with and loaded the door panel as she rode out the crash sequence. The driver came to rest in the driver seat. She was assisted from the vehicle by the first responders. The driver was transported by ground ambulance and hospitalized for two days.

FRONT RIGHT PASSENGER INJURY

1991 Plymouth Voyager

Injury	*Injury Severity (AIS 98 Update)*	*Injury Mechanism*
Comminuted, displaced fracture of the proximal and mid-shaft of the right femur	Serious (851814.3,1)	Right lower instrument panel
Small right frontal lobe edema	Serious (140606.3,1)	Right A-pillar
Right temporal skull fracture extending to the lateral orbital wall and orbital roof	Moderate (150402.2,1)	Right A-pillar
Comminuted fracture of right maxillary sinus	Moderate (250800.2,1)	Right A-pillar

Injury	*Injury Severity (AIS 98 Update)*	*Injury Mechanism*
Comminuted right mandible fracture	Moderate (250610.2,1)	Right A-pillar
Multiple right facial lacerations	Minor (290600.1,1)	Windshield
Central chest laceration, NFS	Minor (490600.1,4)	Right instrument panel
Central chest abrasion, NFS	Minor (490202.1,4)	Right instrument panel

Note: the above injuries were identified in the passenger's hospitalization records.

FRONT RIGHT PASSENGER KINEMATICS

1991 Plymouth Voyager

The front right passenger was seated in a mid-to-rear track position and was unrestrained. Immediately prior to the impact, the Plymouth was steered left in an attempt to avoid the crash. The passenger was displaced to the right by this maneuver and contacted the right door panel. Upon impact, the passenger initiated a forward and right trajectory in response to the 1 o'clock direction of the impact force.

The passenger loaded the door panel evidenced by the displaced door handle and scuffing to the panel's surface. The passenger's head contacted the right A-pillar resulting in edema to the right frontal lobe and fractured to the right temporal skull, maxillary sinus and mandible. The right face contacted and fractured the right aspect of the windshield. This contact resulted in multiple lacerations. The passenger responded forward and loaded the right outboard aspect of the instrument panel with his lower extremities. This contact resulted in a shaft fracture of the right femur. As the passenger was in the process of these kinematic movements, the right rear adult passenger was loading the front right seat from behind. The front right passenger was contacted and loaded by the seat back accentuating his loading of the instrument panel. The seat back loading also displaced the occupant downward. During the vehicle's rotation and subsequent minor impacts, the front right passenger maintained this position due to the loading and the seat back deformation. The passenger came to rest within the front right occupant space and was assisted from the vehicle. He was transported by ground and hospitalized for six days.

ROW 2 RIGHT PASSENGER INJURY

1991 Plymouth Voyager

Injury	*Injury Severity (AIS 98 Update)*	*Injury Mechanism*
Subdural hemorrhage of the left cerebellar tentorium	Severe (140442.4,6)	Center instrument panel
Subarachnoid hemorrhage along the tentorium and left temporal and posterior parietal region	Serious (140684.3,2)	Center instrument panel

Injury	*Injury Severity (AIS 98 Update)*	*Injury Mechanism*
Compression fracture of the C7 body w/ posterior displacement of the segment into the spinal canal, 30% stenosis	Serious (650234.3,6)	Indirect loading of the center instrument panel
C7 left lamina non-displaced fracture	Serious (650224.3,6)	Indirect loading of the center instrument panel
Grade I distal right femur fracture	Serious (851801.3,1)	Front right seat back
Comminuted, slightly displaced fracture of the distal right radius	Serious (752804.3,1)	Windshield
Small left pneumothorax	Serious (442202.3,2)	Center instrument panel
Left scapular fracture, NFS	Moderate (753000.2,2)	Center instrument panel
Moderately displaced fracture of the left anterior mandible	Moderate (250610.2,2)	Center instrument panel
Right 4th metacarpal fracture	Moderate (752002.2,1)	Windshield
Right fronto-parietal laceration, NFS	Minor (190600.1,5)	Center instrument panel
Multiple right facial lacerations	Minor (290600.1,1)	Center instrument panel
2 cm open right hand laceration, NFS	Minor (790600.1,1)	Windshield
1 cm laceration right thigh	Minor (890602.1,1)	Front right seat back

Note: the above injuries were identified in the passenger's hospitalization records.

ROW 2 RIGHT PASSENGER KINEMATICS

1991 Plymouth Voyager

This adult passenger was seated on the right side of the vehicle's second row. This seat was a narrow bench seat and as such this passenger was seated immediately to the right of the vehicle's center line. Upon impact, the passenger responded forward to the force of the frontal impact. The passenger contacted and loaded the inboard aspect of the front right seat back with her right lower extremity and torso. The seat back contact resulted in a fracture of the distal right femur. The passenger's loading of the seat back deflected the seat forward. As the seat rotated forward, the passenger ramped up the seat back and was redirected off the seat's inboard aspect. The passenger continued forward into contact with the instrument panel and windshield evidenced by the multiple interior contacts. Her unrestrained contact to these structures resulted in multiple blunt force traumatic injuries. She was found unresponsive by the first responders with a Glasgow Coma Score of 3. She was transported to a local hospital and not pronounced deceased three days post-crash upon removal of life support.

ROW 2 LEFT CHILDPASSENGER INJURY
1991 Plymouth Voyager

Injury	*Injury Severity (AIS 98 Update)*	*Injury Mechanism*
Closed head injury, lethargic in car seat on initial assessment, crying, GCS=14	Moderate (160602.2,0)	Acceleration/deceleration
Forehead contusion, NFS	Minor (290402.1,7)	Head to knee contact during ride down of the crash
Tongue laceration	Minor (243400.1,8)	Self-inflicted
Abrasion, NFS	Unknown (990200.1,9)	Unknown

The above injuries were identified in the Discharge Summary and hospitalization records of the child.

ROW 2 LEFT CHILD PASSENGER KINEMATICS

The child passenger was seated in a Century Ovation convertible Child Safety Seat (CSS) in a forward facing manner and was restrained by the internal harness straps and T-shield. The CSS was restrained by the vehicle's three-point lap and shoulder belt system.

Upon impact, the ELR retractor locked and the combined mass of the child and CSS initiated a forward trajectory. The CSS loaded the manual safety belt and decelerated. The child continued forward and loaded the harness straps with his shoulders and the T-shield with his chest. Due to the magnitude of the crash force, the child continued to load and ride down the T-shield. The T-shield rotated forward 9 cm (3.5 in) and deformed the latch plate at the T-shield's base. The child's neck flexed over the top of the T-shield and his head contacted his knees evidenced by the forehead contusion. The acceleration/deceleration of the head resulted in the reported closed head injury. The child bit and lacerated his tongue during the crash sequence.

The child was transported in the child safety seat to a local hospital for treatment. Upon admission to the emergency room, he was noted to by crying and lethargic. His Glasgow Coma Score was 14. He was admitted into the intensive care unit for observation as a precaution to a closed head injury. He was monitored and treated for his tongue laceration. He was released after a three day hospitalization without complications.

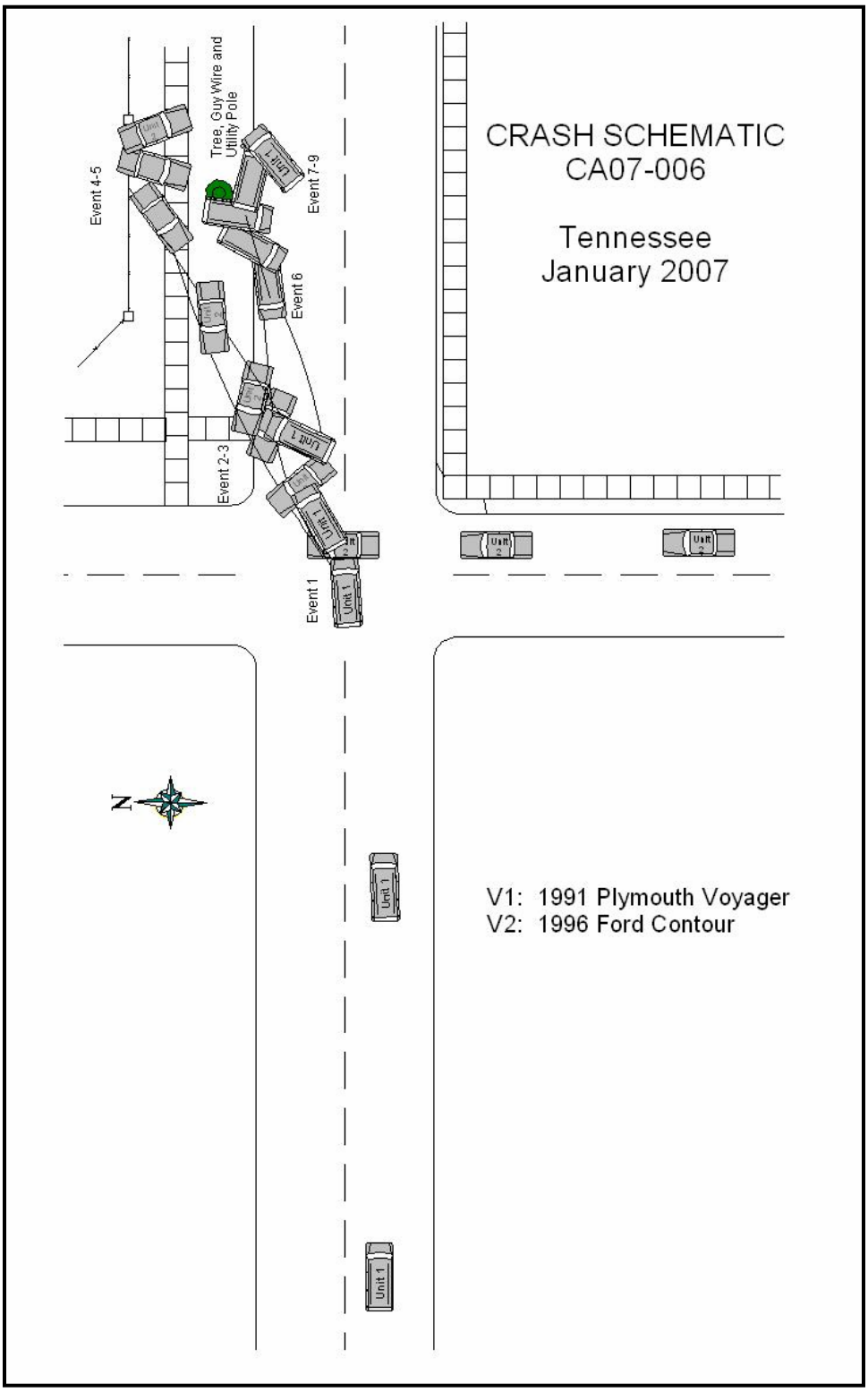

Figure 20: Crash Schematic.