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TRANSPORTATION RESEARCH GROUP
CRASH RESEARCH SECTION

VERIDIAN ENGINEERING
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VERIDIAN ENGINEERING CASE NO. CA98-036

ON-SITE FATAL AIR BAG DEPLOYMENT INVESTIGATION 1997 PLYMOUTH VOYAGER MINIVAN

REDESIGNED AIR BAG DEPLOYMENT 1998 DODGE NEON

LOCATION - STATE OF CONNECTICUT

CRASH DATE - JUNE, 1998

Contract No. DTNH22-94-D-07058

Prepared for:

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

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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 crash involved a 1997 Plymouth Voyager minivan which was equipped with dual front air bags and a 1998 Dodge Neon which was equipped with dual front redesigned air bags. The crash occurred during the early evening hours in the month of June, 1998. The 75 year old male driver of the Plymouth was en route to a social event with his 90 year old wife who was seated in the front right seat. The Plymouth turned left at a three leg signalized intersection and was struck on the right front door by the front of the Dodge which was traveling in the opposite direction. The Plymouth rotated counterclockwise, traveled 16.0 m (52.5'), and subsequently struck a guardrail. The SMASH algorithm computed the total delta V of 24.9 km/h (15.5 mph) for the Plymouth and 33.9 km/h (21.0 mph) for the Dodge. These delta V values were sufficient to actuate the Supplemental Restraint System (SRS) in both vehicles. Both vehicles were towed from the scene due to damage.

The front right occupant in the Plymouth was not restrained by the manual lap and torso belt and found by rescue partially on the floor and front right seat cushion. She suffered a fracture of C3/C4 with transection of the spinal cord (AIS-6) and soft tissue lesions of the face and hand from contact with the intruding right door panel. She was transported to a medical facility where she was pronounced deceased. The driver was not reportedly injured.

The restrained driver of the Dodge, a 21 year old male, suffered minor injuries of the right arm/shoulder and chest from contact with the front right occupant and the torso belt. The front right occupant was unrestrained and contacted the deployed redesigned front right air bag with no related injuries. He subsequently moved rearward and contacted the driver's right shoulder resulting in a fracture of the left arm (AIS-2). Both were transported to the medical treatment facility where they were treated and released.

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REDESIGNED AIR BAG DEPLOYMENT
STATE OF CONNECTICUT
JUNE, 1998

BACKGROUND

The Crash Investigation Division (CID) of the National Highway Traffic Safety Administration (NHTSA) was notified by a medical treatment facility of a two vehicle crash in which the front right passenger in one of the air bag equipped vehicles sustained fatal injuries. The Veridian Engineering team was subsequently notified by the CID to conduct an on-site investigation. The investigation began the same day of notification with a team member on-site within four calender days of notification.

The objective of this investigation was to determine the role (if any) of the front right air bag with respect to the fatal injuries sustained by the front right occupant in a 1997 Plymouth Voyager minivan. A secondary objective was to focus on the relationship between the redesigned air bag system in the 1998 Dodge Neon and the injuries suffered (if any) by the driver and front right occupant.

SUMMARY

This crash involved a 1997 Plymouth Voyager minivan which was equipped with dual front air bags and a 1998 Dodge Neon which was equipped with dual front redesigned air bags. The crash occurred during the early evening hours in the month of June, 1998. The 75 year old male driver of the Plymouth was en route to a social event with his 90 year old wife who was seated in the front right seat. The Plymouth turned left at a three leg signalized intersection and was struck on the right front door by the front of the Dodge which was traveling in the opposite direction. The Plymouth rotated counterclockwise, traveled 16.0 m (52.5'), and subsequently struck a guardrail. The dual front air bags in both vehicles deployed. The front right occupant in the Plymouth sustained fatal injuries in the crash.

Prior to the crash, the Plymouth which was traveling northbound had stopped at a traffic light in the designated left turning lane **(Figure 1)**. The driver of the Dodge, a 21 year old male, traveling southbound in the left through lane of a four lane, divided, 2.6 percent positive slope (southbound), dry asphalt, straight arterial roadway with a posted speed limit of 89 km/h (55 mph) reportedly observed the Plymouth stopped at the intersection **(Figure 2)**. As he approached the intersection, the driver indicated that the Plymouth suddenly

proceeded into the intersection. From scene physical evidence, the driver of the Dodge steered to the right and applied full brakes skidding 15.3 m (50.2') prior to the point of impact (POI).

The front of the Dodge struck the right side of the Plymouth which resulted in the deployment of the frontal air bag systems in both vehicles. The Dodge then rotated 45 degrees clockwise and came to the final rest position (FRP) within the intersection boundary in the right through lane. The Plymouth rotated counterclockwise and traveled 16.0 m (52.5') in a southeasterly direction and struck a W-beam strong post guardrail system located adjacent to the intersection roadway edge with the front right bumper of the vehicle **(Figure 5 - Scene Schematic)**. The vehicle remained in contact with the guardrail at the FRP facing south.

Figure 1-Trajectory of the Plymouth

Figure 2-Trajectory of the Dodge

The impact to the side plane of the Plymouth resulted in a Collision Deformation Classification (CDC) code of 02-RYEW-3 while the related damage to the Dodge was classified 11-FDEW-2 **(Figures 3 & 4)**. The impact with the guardrail resulted in a CDC of 12-FREW-1.

Figure 3
View of the right side impact damage and the right front bumper corner damage to the 1997 Plymouth Voyager

Figure 4
View showing contact damage to the frontal plane of the 1998 Dodge Neon

The SMASH algorithm computed the total delta V of 24.9 km/h (15.5 mph) for the Plymouth and 33.9 km/h (21.0 mph) for the Dodge. The longitudinal delta V component for the Plymouth was 12.5 km/h (7.7

mph) and 31.8 km/h (19.8 mph) for the Dodge. These delta V values were sufficient to actuate the Supplemental Restraint System (SRS) in both vehicles.

The front right occupant in the Plymouth was found by rescue on the floor adjacent to the right side panel forward of the right front door. A bodily fluid deposit on the front right seat cushion indicated that the occupant's head was laying on the front right seat cushion along the outboard side at final rest.

Given the final rest position of the front right occupant in the Plymouth, the initial indication from rescue and police was that the occupant was not restrained by the manual restraint belt system at the time of the crash. The driver, however, indicated to medical personnel that his wife was using the restraint belt prior to the crash.

Inspection of the belt system indicated there were score marks on the latching plate of the front right restraint belt which indicated frequent belt usage. Additionally there were white transfer marks on the restraint belt that resembled the same type of white transfer marks noted to the surface of the right door surface. These marks appeared to be cosmetic type marks which were attributed to contact by the occupant's face, head, and neck area. However, the final rest position of the occupant appeared typical for someone that was not using the restraint belt. It was theorized that the occupant contacted the door panel and glazing during the first impact sequence and was subsequently contacted by the expanding air bag. This interaction propelled her rearward where her head area contacted the fully retracted restraint belt resulting in a white transfer on the belt.

The occupant then moved forward in response to the longitudinal deceleration resulting from the frontal impact with the guardrail where her facial area contacted the still inflated front right air bag. This contact was noted by the presence of a circular cosmetic transfer on the vertical surface of the air bag. The contact with the air bag restricted the forward motion of her upper body while her lower torso and legs continued forward. Her head area then came to rest on the seat cushion while feet came to rest against the right kick panel.

It was reasoned that the driver of the Plymouth was using the continuous lap and torso belt at the time of the crash as determined from fabric transfers noted along the inside surface of the torso belt and the limited amount of driver related contact evidence to interior components. The police listed restraint usage for the driver as unknown and injury as not injured.

The driver of the Dodge was reportedly wearing the manual lap and torso belt at the time of the crash. There was loading on the knee bolster which was attributed to contact by the driver's right knee during the crash sequence. There was no evidence of belt loading or artifacts on the restraint belt which could have been attributed to usage during the crash.

The driver of the Dodge moved forward during the impact sequence and was restrained by the restraint belt and front left air bag which resulted in an unspecified chest injury. His right knee moved forward and contacted the knee bolster and the right side of the steering column. He rebounded into the seat and was struck on the right shoulder by the front right occupant. He reportedly suffered pain of the right shoulder and was transported to a local medical facility where he was treated and released.

The 20 year old male front right occupant in the Dodge (the driver's brother) reportedly had removed his restraint belt prior to the crash while trying on a pair of sneakers which he had just purchased at a nearby shopping center. During the crash sequence, he moved forward and loaded the fully expanded redesigned front right air bag. As his upper torso compressed the air bag, his left hand contacted the center instrument panel. He subsequently rebounded to the left and struck the right shoulder of the driver with his left upper arm resulting in a fracture of the left humerus. He was transported from the scene to a medical facility where he was treated and released.

Upon arrival of rescue, the EMTs checked the vital signs of the front right occupant in the Plymouth and detected an erratic pulse. The occupant was subsequently transported to a local medical treatment facility where she was pronounced deceased. She reportedly sustained a fracture of the neck at C3, C4 with transection of the spinal cord. The neck was described by hospital personnel as being displaced 90 degrees posteriorly. The driver (husband) indicated that his wife had arthritis of the neck.

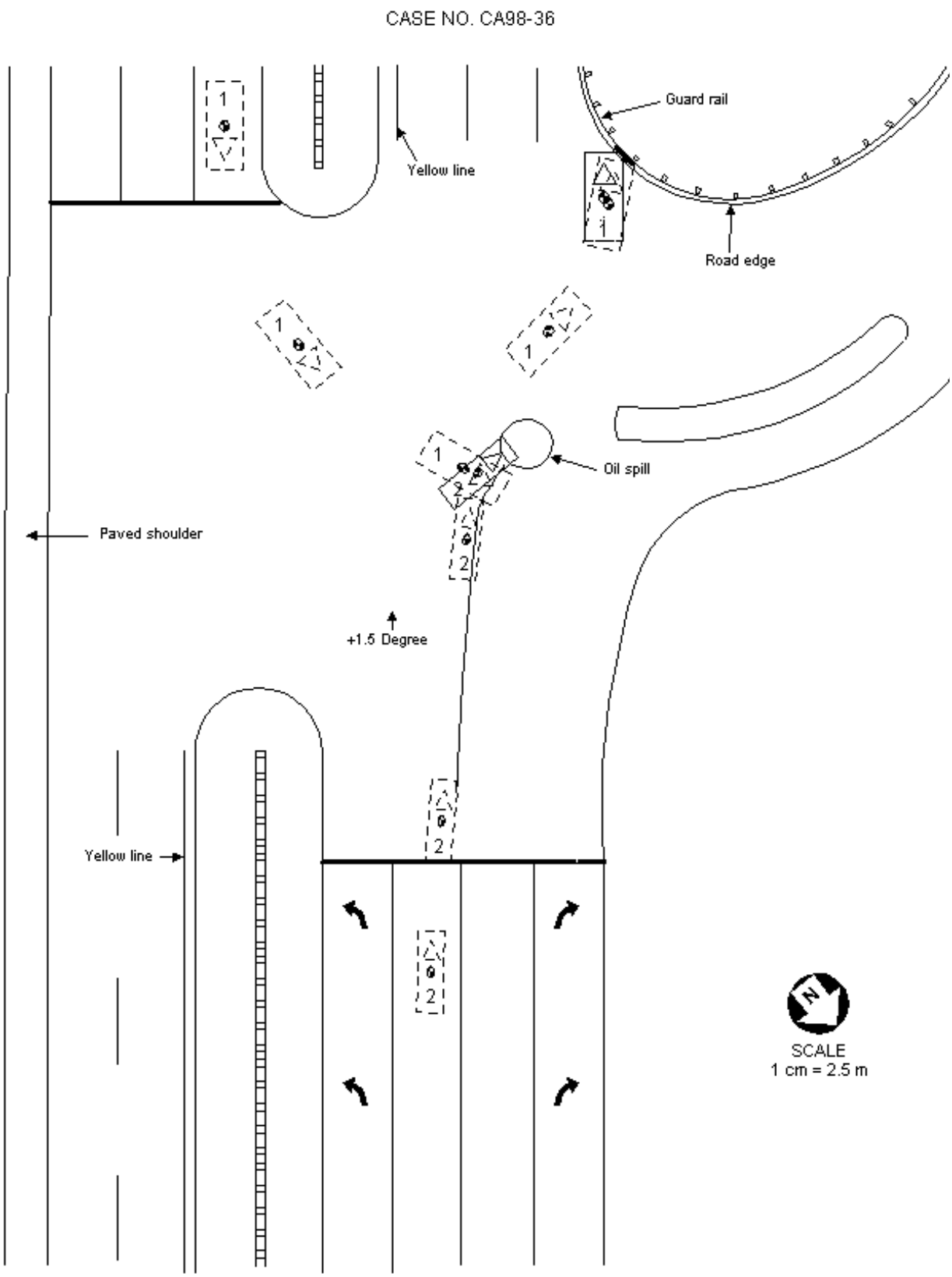

Figure 5 - Scene Schematic

VEHICLE DATA

Exterior Vehicle Damage - 1997 Plymouth Voyager minivan

The 1997 Plymouth Voyager minivan was equipped with a dual front Supplemental Restraint System (SRS) which deployed as the result of the impact with the Dodge. Exterior damage to the Plymouth involved the right front tire and wheel, right front fender, right front door, right rear sliding door, the right sill, the roof, the A-pillar, B-pillar, the front bumper, the hood, and the windshield. The right front wheel was displaced rearward 13.5 cm (5.3"). The maximum crush of 34.3 cm (13.5") was located 178.4 cm (70.25") forward of the right rear axle and 12.7 cm (5.0") below the door rub strip. Crush values are listed in the following table:

1997 Plymouth Voyager minivan - Crush			
Crash Impact Sequence #1- Impact with the Dodge *(Right Side Crush)*	C_1 = 0	C_2 = 15.2 cm (6.0")	C_3 = 30.5 cm (12.0")
	C_4 = 34.3 cm (13.5")	C_5 = 30.5 cm (12.0")	C_6 = 15.2 cm (6.0")
Crash Impact Sequence #2- Impact with the guardrail *(Frontal Crush)*	C_1 = 0	C_2 = 0	C_3 = 0
	C_4 = 0.6 cm (0.25")	C_5 = 0.6 cm (0.25")	C_6 = 8.3 cm (3.25")

Collision Deformation Classification (CDC)

The following table identifies the Collision Deformation Classification (CDC) for the Plymouth:

Plymouth Voyager - CDC	
Crash Impact Sequence #1- Impact with the Dodge	02-RYEW-3
Crash Impact Sequence #2- Impact with the guardrail	12-FREW-1

The vehicle was purchased new in July, 1997. Electronic odometer information was not obtainable due to the lack of electrical power.

Interior Vehicle Damage - 1997 Plymouth Voyager minivan

Interior vehicle damage to the 1997 Plymouth Voyager minivan was attributed to intrusion, occupant contacts, and the deployment of the Supplemental Restraint System (SRS). The right side of the vehicle sustained the highest magnitude of intrusion from the impact with the Dodge. The right front door surface and

right B-pillar intruded into the front right occupant space 27.9 cm (11.0") laterally. The sill below the right door was displaced inward 33.0 cm (13.0") while the right side front kick panel (panel forward of the lower A-pillar) was displaced 25.4 cm (10.0") laterally. The right roof side rail was displaced laterally 14.0 cm (5.5"). The floor pan in front of the front right seat was buckled upward 7.6 cm (3.0") which resulted in the restriction of the front right seat adjustment system.

There were a series of white transfer marks noted on the interior surface of the right front door which were attribute to contact by the front right occupant during the first impact sequence with the Dodge **(Figure 6)**. The highest mark was located on the right front side glazing which measured 1.3 cm (0.5") in diameter and located 55.9 cm (22.0") rearward from the base of the upper A-pillar and 17.8 cm (7.0") above the belt line. The next highest mark was located 44.5 cm (17.5") rearward from the instrument panel along the belt line and measured 17.1 cm (6.75") in length and 5.1 cm (2.0") in height. This was attributed to contact by the occupant's upper torso.

Figure 6
View of occupant contacts to the right front door surface of the Plymouth

Figure 7
Lateral view of the front right seat in the Plymouth

The next white transfer mark which was 8.9 cm (3.5") long was located on the rear most portion of the door armrest. This was attributed to contact by the occupant's hip area. The lowest white transfer mark on the door surface was located at the bottom portion of the armrest in-line with the seat cushion surface. This mark measured 16.5 cm (6.5") in length and 9.5 cm (3.75") in height and was located 49.5 cm (19.5") rearward from the instrument panel.

The front right continuous loop lap and torso restraint belt was observed in the fully retracted position and taut against the B-pillar at the time of inspection. The belt was restricted by the intruding B-pillar against the outboard surface of the seat back support where initial efforts using normal pull force to spool out the belt were unsuccessful. After more force was subsequently applied, the restriction was overcome and the belt spooled out normally.

While the front right restraint belt was in the fully retracted taut position, white transfer marks were noted along the underside of the lap belt adjacent to the stop button in the belt webbing. The stop button was located at the D-ring. The underside of the lap belt was facing inboard to the vehicle interior. The white transfer marks measured 2.5 cm (1.0") and 1.9 cm (0.75") over a 7.6 cm (3.0") area. The coloration of the

transfer marks was consistent with the transfer marks noted on the right front door panel. The adjustable D-ring was in the lowest vertical position over an adjustable range of 9.8 cm (3.875"). There was no evidence of belt loading on the D-ring

The front right occupant seat was locked by damage, but appeared to be in the full rear adjusted position **(Figure 7)**. It was displaced laterally with the in-board armrest in contact with the inboard armrest of the driver's seat. The leading edge of the seat cushion was located 29.2 cm (11.5") rearward from vertical plane of the instrument panel, 76.2 cm (30.0") from the toe pan, and 34.3 cm (13.5") above the floor pan. The seat cushion was inclined 13 degrees and measured 45.7 cm (18.0") longitudinally and 55.9 cm (22.0") laterally. There was a bodily fluid deposit on the outboard mid aspect of the seat cushion which was attribute to the position of the front right occupant's head at final rest.

The front right seat back support was reclined 25 degrees from vertical and was located 83.8 cm (33.0") rearward from the mid mount air bag module cover at a height of 39.4 cm (15.5") above the junction with the seat cushion. The height of the seat back support measured 78.7 cm (31.0"), inclusive of the integral head restraint.

The mid mount front right air bag module cover flaps opened in an "H" pattern. There was no contact evidence noted to surface of the flaps. The untethered front right air bag exhibited a circular peach color cosmetic transfer mark on the front surface of the air bag which measured 12.7 cm (5.0") in diameter. This transfer was attributed to contact with the occupant's facial area. The air bag was cut by rescue to facilitate the extrication of the front right occupant.

The windshield was cracked along the top right portion which was attributed to impact forces. The glove compartment door was open at the time of inspection and could not be closed. It was presumed it opened during the first impact sequence as the result of the lateral impact deformation of the instrument panel.

The vinyl surface of the steering column shroud was abraded in the area which measured 6.4 cm x 2.5 cm (2.5" x 1.0"). This abraded area was located 31.8 cm (12.5") left of the vehicle centerline and 27.9 cm (11.0") below the instrument panel (adjacent to the bottom of the ignition key). This was attributed to contact by the driver's right knee during the first impact sequence.

A 2.5 cm (1.0") black transfer mark was noted on the left side of the ash tray cover which was located 6.4 cm (2.5") right of the vehicle centerline and 36.8 cm (14.5") above the floor. This mark was attributed to a possible contact by the driver's right hand/forearm.

There was a 1.3 cm (0.5") abraded area on the vinyl surface of the driver door which was attributed to contact by the driver's left hip. This mark was located 43.2 cm (17.0") rearward from the A-pillar and 39.4 cm (15.5") below the belt line.

The driver appeared to be wearing the continuous loop lap and torso belt at the time of the crash. There were fabric transfers noted in the belt webbing of the torso portion of the belt which were consistent with restraint usage during the crash.

The steering wheel angle measured 31 degrees above horizontal and was adjusted in the center position. There was no forward displacement of the steering column noted at the shear capsules. The steering wheel rim was not deformed.

The front left air bag module cover was a single flap design which opened along the designated tear point. The surface of the module flap did not reveal any occupant contact evidence related to the deployment sequence. The tethered air bag, however, exhibited black transfers in the lower quadrants on the back surface. Typically, the location and pattern of the transfers is the result of a deploying air bag interacting with the underside of the module cover. However, the underside of the module cover was a blue color. The source of the transfers was not known.

The left front seat was 9.5 mm (0.375") forward of the full back position over an adjustment range of 21.3 cm (8.375"). The seat back support was reclined to the full rearward position due to rescue efforts.

Exterior Vehicle Damage - 1998 Dodge Neon

The 1998 Dodge Neon was equipped with a redesigned dual front Supplemental Restraint System (SRS) which deployed as the result of the impact with the Dodge. Exterior damage to the Dodge involved the front bumper, grille, both front fenders, right headlight, and the windshield. The right front wheel was displaced rearward 6.4 cm (2.5"). Maximum crush of 41.3 cm (16.25") was located 17.8 cm (7.0") right of the vehicle centerline. Crush values are listed in the following table:

Dodge Neon - Crush			
Crash Impact Sequence #1- Impact with the Plymouth	C_1 = 18.7 cm (7.375")	C_2 = 22.2 cm (8.75")	C_3 = 27.3 cm (10.75")
	C_4 = 34.9 cm (13.75")	C_5 = 31.1 cm (12.25")	C_6 = 27.9 cm (11.0")

Collision Deformation Classification (CDC)

The Collision Deformation Classification (CDC) for the Dodge was: 11-FDEW-2.

Interior Vehicle Damage - 1998 Dodge Neon

Interior vehicle damage to the 1998 Dodge Neon was attributed to occupant contacts, intrusion, and the deployment of the Supplemental Restraint System (SRS). The toe pan in front of the front right seat was intruded longitudinally 3.8 cm (1.5").

The front right occupant seat was locked by damage, but appeared to be in the full rear adjusted position **(Figure 8)**. The leading edge of the seat cushion was located 17.8 cm (7.0") rearward from vertical plane of the instrument panel, 63.5 cm (25.0") from the toe pan, and 24.1 cm (9.5") above the floor pan. The

seat cushion was inclined 10 degrees and measured 50.8 cm (20.0") longitudinally. The front right seat back support was reclined 20 degrees from vertical and was located 88.9 cm (35.0") rearward from the leading edge of the top mount air bag module cover at a height of 52.1 cm (20.5") above the junction with the seat cushion. The height of the seat back support measured 57.2 cm (22.5") with the head restraint extending 15.2 cm (6.0") above the top of the seat back support.

The front right air bag module cover flap opened upward and contacted the top surface of the instrument panel as noted by the outline transfer pattern on the vinyl surface. There was no contact evidence noted on the surface of the flap **(Figure 9)**.

The tethered front right air bag exhibited a small bodily fluid deposit which measured 3.2 mm (0.125") in diameter. This was attributed to post crash contact by the front right occupant.

The windshield was cracked along the right side from impact forces. The left bottom area of the windshield was cracked and penetrated by the hood edge. A 17.8 cm (7.0") long swipe mark was noted at mid level on the windshield which was located 21.6 cm (8.5") left of center. This was attributed to contact by the driver's right hand during the impact sequence.

Figure 8
Lateral view of the front seat area in the Dodge

Figure 9
View of the instrument panel of the Dodge

There was a swipe transfer mark on the center instrument panel which began at the vehicle centerline and extended 14.0 cm (5.5") to the left. This was attributed to contact by the front right occupant's left hand during the impact sequence. An adjacent mark to the right of the swipe mark exhibited a 6.4 cm (2.5") striated pattern which began 5.1 cm (2.0") right of the vehicle centerline and extended to the right along the top surface of the instrument panel. This artifact was attributed to contact by the front right air bag as it was compressed by the front right occupant.

The glove compartment door was exhibited two transfer areas on the left side surface which were attributed to the front right occupant's left knee and lower leg. The highest contact measured 8.9 cm (3.5") wide and was located 21.6 cm (8.5") right of the vehicle centerline. The lower of the two transfers measured 3.8 cm (1.5") wide and was located 24.1 cm (9.5") right of the vehicle centerline. There was a transfer on the

glove compartment latch release handle which was attributed to contact by the front right occupant's right knee.

The rearview mirror was rotated in a clockwise upward direction and exhibited a heavy abrasion of the black vinyl surface along the right lower corner. This was attributed to contact by the deploying front right air bag.

The front right continuous loop lap and torso restraint belt did not exhibit any evidence of occupant loading or usage during the crash. The adjustable D-ring was positioned 1.9 cm (0.75") below full up position over an adjustable range of 9.5 cm (3.75"). There was no evidence of belt loading on the D-ring.

There was a 5.1 cm (2.0") fabric transfer mark along the upper instrument panel which was located 22.9 cm (9.0") left of the vehicle centerline. This was attributed to contact by the driver's right forearm during the crash. The defroster module unit located left of the fabric transfer was dislodged from the instrument panel mounting bracket.

The knee bolster directly below the steering column shroud exhibited a contact transfer which was attributed to loading by the driver's right knee during the crash. A stress fracture of the knee bolster directly above this contact area was indicative of the knee loading sequence. The driver's knee continued upward along the inboard side of the steering column and contacted the ignition key. The key was bent in an upward and forward direction. The steering wheel rim was not deformed. The non adjustable steering column angle measured 20 degrees above horizontal. The shear capsules could not be assessed for steering column movement.

The continuous loop lap and torso belt for the driver did not exhibit any evidence that would suggest usage at the time of the crash. The adjustable D-ring was in the full up position with no signs of abrasion in the vinyl covering related to belt loading.

The front left air bag module cover was a single flap design which opened along the designated tear point. The surface of the module flap did not reveal any occupant contact evidence related to the deployment sequence. The tethered air bag, however, exhibited black transfers in the upper and lower right quadrants which was attributed to contact with the air bag module flap during the deployment sequence.

The driver's seat was in the full rear adjusted position over a 20.3 cm (8.0") adjustment range. The seat back support was reclined 11 degrees rearward from vertical and measured 55.9 cm (22.0") rearward from the air bag module cover at a height of 44.5 cm (17.5") above the junction with the seat cushion. The seat cushion incline was 10 degrees.

SPEED RECONSTRUCTION

The output delta V results from the SMASH program appeared to be somewhat lower for the Plymouth than would have visually been anticipated. The barrier equivalent computed delta V of 31.8 km/h

(19.8 mph) appeared more appropriate than the 24.9 km/h (15.5 mph) computed by the damage routine. The following table lists the output results:

WinSMASH 1.2.1 1997 Plymouth Voyager	**Speed Change (Damage)**	**Speed Change (Linear Momentum and Spin out)**	**Impact Speed (Linear Momentum and Spin out)**
Total	24.9 km/h (15.5 mph)	22.3 km/h (13.9 mph)	27.2 km/h (16.9 mph)
Longitudinal	-12.5 km/h (-7.7 mph)	-10.5 km/h (-6.5 mph)	
Lateral	-21.6 km/h (-13.4 mph)	-19.7 km/h (-12.2 mph)	
Energy	70,723 Joules (52,188 ft-lb)		
Barrier Equivalent	31.8 km/h (19.8 mph)		

WinSMASH 1.2.1 1998 Dodge Neon	**Speed Change (Damage)**	**Speed Change (Linear Momentum and Spin out)**	**Impact Speed (Linear Momentum and Spin out)**
Total	33.9 km/h (21.0 mph)	30.3 km/h (18.8 mph)	42.5 km/h (26.4 mph)
Longitudinal	-31.8 km/h (-19.8 mph)	-28.5 km/h (-17.7 mph)	
Lateral	11.6 km/h (7.2 mph)	10.4 km/h (6.4 mph)	
Energy	46,967 Joules (34,659 ft-lb)		
Barrier Equivalent	26.9 km/h (16.7 mph)		

SUPPLEMENTAL RESTRAINT SYSTEM (SRS)

1997 Plymouth Voyager minivan

Front Left Air Bag

The Supplemental Restraint System (SRS) in the 1997 Plymouth Voyager minivan was designed with dual front air bags. The impact with the Dodge was sufficient to actuate the SRS deployment sequence. The front left module cover was comprised of a single flap which opened at the top and rotated downward during the deployment sequence. The cover measured 10.8 cm (4.25") vertically and 17.5 cm (6.875") laterally. There were no apparent occupant contact points on the surface of the module cover.

The front left air bag had two tethers that were located in the 3 o'clock and 9 o'clock positions. There were no visible vent ports in the air bag fabric. The front surface was a fine mesh light green color fabric with a white mesh color fabric back surface. There were black transfer marks in the lower quadrants of the back surface. The origin of these marks could not be determined as the air bag module cover was a blue color. The air bag diameter measured 72.4 cm (28.5") in diameter with a 16.5 cm (6.5") center stitched area. The air bag identification number was:

P120235-02C
TMN1568G3414

The air bag had a fabric tag which read: TEAM 23IS. There was no visible evidence of driver contact on the air bag.

Front Right Air Bag

The mid mount front right air bag module cover opened in an elongated "H" pattern. The top and bottom flaps were the same size with a 6.4 cm (2.5") vertical seam and 29.2 cm (11.5") lateral seam. The flap was composed of a high density foam layer over a metal panel which collectively measured 11.1 mm (7/16") in thickness. The following information was listed on the underside of the upper flap: NS Upper SIR Door 5/15/97-10:02. There was no contact evidence noted on the air bag module flaps.

The front right air bag was non tethered and did not have any visible vent ports. The air bag extended a measured longitudinal distance of 48.3 cm (19.0") from the instrument panel and a vertical distance of 68.6 cm (27.0"). The width of the air bag measured 47.0 cm (18.5").

An oblong circular prominent peach color cosmetic transfer pattern **(Figures 10 & 11)** was present on the vertical face of the air bag which was attributed to contact by the front right occupant's facial area. The pattern measured 10.2 cm (4.0") vertically and 8.9 cm(3.5") laterally. It was located 26.7 cm (10.5") below the top of the vertical face of the air bag and 10.2 cm (4.0") left of the right vertical seam edge line.

Figure 10
View of the cosmetic transfer on the front right air bag in the Plymouth

Figure 11
Close-up view of the cosmetic transfer on the front right air bag surface in the Plymouth

The concentration of the cosmetic transfer indicated that the air bag was fully inflated by the time the occupant made contact. This was an important factor in determining the occupant's position at the time of SRS

actuation. If the occupant had been out of position and close to the air bag module cover at the time of deployment, then it would have been anticipated that the cosmetic transfer would have been extended over a larger area with a less distinctive pattern. Additionally, the occupant would have suffered typical air bag related facial soft tissue related to air bag expansion (e.g. abrasions, contusions, etc.) which were not present. It was hypothesized that the air bag remained inflated after the first impact sequence due to the absence of vent ports in the air bag. The occupant then moved forward during the guardrail impact and contacted the vertical surface of the air bag with her facial area.

1998 Dodge Neon

Front Left Air Bag

The Supplemental Restraint System (SRS) in the 1998 Dodge Neon was designed with redesigned dual front air bags. The impact with the Plymouth was sufficient to actuate the SRS deployment sequence. The front left module cover was comprised of a single flap which opened at the bottom and rotated upward during the deployment sequence. The cover measured 15.2 cm (6.0") vertically with an additional 5.1 cm (2.0") longitudinal dimension to the upper hinge point. The width of the cover measured 21.6 cm (8.5"). The cover was constructed of a pliable vinyl material which had a measured thickness of 1.6 mm (1/16"). There were no apparent occupant contact points noted on the surface of the cover. An identification number on the inboard side of the air bag module read as follows:

TX9DT203780085
P0QG75LAZAC *0QG75TRMAC

The front left air bag had two tethers that were located in the 12 o'clock and 6 o'clock positions. Two vent ports located on the top rear surface of the air bag had a measured diameter of 3.2 cm (1.25") and were 14.0 cm (5.5") apart. The air bag measured 67.3 cm (26.5") in diameter with a 17.8 cm (7.0") diameter center stitched area. There were black transfer marks in the upper and lower right quadrants on the front surface of the air bag which were attributed to contact with the underside of the black module cover flap during deployment. There was no visible evidence of driver contact on the air bag.

Front Right Air Bag

The front right air bag module cover flap opened upward and contacted the top surface of the instrument panel as noted by the outline transfer pattern on the vinyl surface. The air bag module cover measured 34.3 cm (13.5") laterally and 15.2 cm (6.0") longitudinally. The left side of the module was located 16.5 cm (6.5") right of the vehicle centerline. The leading edge of the flap was recessed 19.1 mm forward of the leading vertical plane of the instrument panel. The hinged edge of the module cover was located 39.2 cm (14.254") rearward from the base of the windshield **(Figure 12)**. There was no contact evidence noted on the surface of the flap.

Figure 12
Angular view of the dual front air bags in the Dodge

Figure 13
View showing the excursion of the front right air bag in the Dodge

The tethered front right air bag had a post crash rearward excursion which measured 44.5 cm (17.5") from the inflator unit **(Figure 13)**. The vertical height of the front surface measured 50.8 cm (20.0") and the width measured 48.3 cm (19.0"). There were four tethers attached to the face of the air bag which were 7.6 cm (3.0") wide and 50.8 cm (20.0") in length. The top two tethers were attached by a red double stitch row to the front of the air bag near the respective perimeter sides and located 48.3 cm (19.0") from the inflator unit. The bottom tethers were also attached adjacent to the respective side seams and located 91.4 cm (36.0") from the inflator unit.

The air bag material consisted of a coarse weave nylon fabric which was woven in porous square patterns. There was a single 7.6 cm (3.0") diameter vent port on the top center surface of the air bag which was located just beyond the leading edge of the air bag module cover. An air bag identification number listed on the air bag over wrap is as follows:

ASSEMBLED IN MEXICO
WC46195K10959
P/N 2000707M

A small bodily fluid deposit which measured 3.2 mm (0.125") in diameter was observed on the face of the air bag which was located 12.1 cm (4.75") below the top tether seam line and 17.8 cm (7.0") right of the left vertical seam edge. This was attributed to post crash contact by the front right occupant.

INJURY DATA

The 90 year old front right occupant in the Plymouth was described in the autopsy report as measuring 152.4 cm (60.0") tall and weighing 70.3 kg (155.0 lb). The driver (husband) reportedly indicated to the medical treatment facility that his wife was wearing the restraint belt prior to the crash. However, rescue found her on the front right floor with her lower body against the front right kick panel. Her head was resting on the front right seat cushion as noted by the deposit of bodily fluid. Wear marks on the latch plate indicated frequent belt usage and there was white powder contact evidence on the lower portion of the torso restraint belt. Upon inspection of the vehicle, however, the restraint belt was fully retracted with the torso portion and pinched

between the outboard side surface of the seat back support and the B-pillar. This was indicative of non restraint belt usage during the crash.

The front right occupant in the Plymouth was extricated from the vehicle. An erratic pulse was obtained by rescue which resulted in the transportation of the occupant to a nearby treatment facility. An attempt was made to intubate the occupant, but it was unclear from the information supplied by the medical facility whether rescue was successful in this procedure. She was subsequently pronounced deceased at the hospital. Medical personnel indicated that radiographic images of the occupant's neck revealed that the woman had sustained a 90 degree hyperextension.

Injuries sustained by the driver of the Dodge and the front right occupant were described in general terms by their representing attorney. He was reluctant to allow his clients to participate in this investigation due to legal concerns.

The following tables lists injuries for the occupants of the Plymouth and Dodge. The injury source for the 90 year old occupant in the Plymouth was verbally acquired from the medical treatment facility and from the post mortem external evaluation. Injuries suffered by the occupants in the Dodge were described by the attorney. These tables also include the respective AIS-90 injury code and correlating injury sources.

INJURY **Plymouth Voyager - Front Right Occupant**	**AIS-90**	**INJURY SOURCE**	**Certainty**
1. Fracture of C3/C4 with transection of the spinal cord.	640272.6,6	Right door surface	Certain
2. Multiple abrasions of the face and forehead	290202.1,0	Right door surface	Certain
Supplemental discussion: Soft tissue injuries under chin (per verbal medical information)			
3. Multiple lacerations of the face and forehead	290602.1,0	Probable eye glass frame/right door surface	Certain
4. Abrasion of the posterior aspect of the right hand	790202.1,1	Right door surface	Certain

INJURY Dodge Neon - Driver	AIS-90	INJURY SOURCE	Certainty
1. Right upper arm/shoulder injured	751099.11	Front right occupant	Probable
2. Chest injured	490099.14	Torso Belt	Probable

INJURY Dodge Neon - Front right Occupant	AIS-90	INJURY SOURCE	Certainty
1. Fracture of the head of the left humerus	752600.22	Driver	Probable

OCCUPANT KINEMATICS

Plymouth Voyager

Driver

The 75 year old male driver of the Plymouth was en route to a social gathering with his 90 year old wife who was seated in the front right seat. He was northbound and stopped in the left turn lane of a four lane divided highway when he accelerated into the intersection and was struck on the right side by Dodge Neon which was traveling southbound in the left through lane.

It appeared that driver of the Plymouth was using the three point manual lap and torso belt at the time of the crash due to the limited amount of driver related contact evidence and the fabric transfers noted in the belt webbing of the torso portion of the belt. He moved primarily to the right with some forward motion in response to the 2 o'clock vector force resulting from the right side impact. His left shoulder/chest area loaded the restraint belt as noted by the fabric transfers. It was not discernable whether his upper torso slipped out of the torso belt and resulted in his body coming in contact with the front right occupant. There was insufficient injury data to correlate this potential contact mechanism.

During the second impact sequence, the driver's right knee contacted the inboard surface of the steering wheel shroud as noted by the abraded vinyl surface. He remained in the seat at final rest and exited the vehicle under his own power.

Front Right Occupant

The 90 year old female front right occupant was not wearing the manual lap and torso belt at the time of the crash as determined by the location of belt in the fully retracted position and pinched by the outboard aspect of the seat back support and the B-pillar. During the crash sequence, her body moved toward the right

in response to impact forces. The right side of her body contacted the intruding right door panel, the underside of the chin area contacted the window sill area, and her face contacted the side glazing as noted by the whitish transfer evidence. The photograph of the occupant's face indicated that she suffered abrasions and lacerations around the left eye, bridge of the nose and left cheek which may have resulted from the fracture of eye glass frames. The door surface intruded laterally which resulted in the hyperextension of her neck with resulting spinal cord transection.

During this impact sequence, the front right air bag may have had a late deployment due to the low longitudinal computed delta V of -12.5 km/h (-7.7 mph) . As the occupant was loading the intruding door panel, the SRS began the actuation sequence and the air bag subsequently expanded and contacted her upper body. This contact did not result in any medically documented injury, but may have resulted in propelling her rearward where her head area contacted the restraint belt which was in the fully retracted position.

She then momentarily came to rest on the seat cushion where she was positioned in a forward facing seated position at the time of the frontal impact with the guardrail. She moved forward in response to the longitudinal deceleration with her facial area contacting the still inflated front right air bag as noted by the presence of a circular cosmetic transfer on the vertical surface of the air bag. The facial contact with the air bag restricted the occupant's forward motion while her lower torso and legs continued forward. Her head area then came to rest on the seat cushion while feet came to rest against the right kick panel.

Dodge Neon - Driver

The 21 year old male driver was wearing his three point manual lap and torso restraint belt at the time of the crash. He moved forward against the restraint belt system during the precrash braking avoidance maneuver and loaded the torso belt during the crash sequence. This loading resulted in pain of the chest. Given the driver's seat was in the full rear adjusted position at the time of the crash and the lack of any visible artifacts on the front left air bag, it was unlikely that he contacted the deployed air bag during the crash sequence.

During the crash sequence, the driver's right knee contacted the knee bolster directly below the steering column shroud as noted by a transfer artifact and a stress fracture of the knee bolster. The driver's knee continued upward along the inboard side of the steering column and contacted the ignition key which resulted in a the upward and forward bending direction of the key. The driver rebounded back against the seat back support when he was struck on the right shoulder by the unrestrained front right occupant. He sustained an unspecified injury of the right upper arm/shoulder injured which was attributed to this contact mechanism.

Dodge Neon - Front Right Occupant

The twenty-year old male front right occupant had removed his three point lap and torso belt just prior to the crash and was reportedly attempting to try on a new pair of sneakers which were recently purchased at the shopping mall. During the pre-impact braking maneuver, the front right occupant moved forward and contacted the glove compartment door with his knees. During the crash sequence, he loaded the inboard surface of the glove compartment door with his left knee and lower leg and the glove compartment latch release handle with his right knee which were delineated by corresponding transfer artifacts.

The occupant's upper body moved forward and to the left in response to impact forces as noted by the swipe transfer mark along the top surface of the instrument panel which was oriented in a right to left forward direction. Although there was no contact evidence visible on the front right air bag, it appeared likely that his upper body contacted the deployed air bag and compressed the air bag resulting in a striated abraded mark on the instrument panel. He rebounded rearward and contacted the driver's right shoulder with his left shoulder. This contact sequence resulted in a reported fracture of the head of his left humerus.