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VERIDIAN ON-SITE AIR BAG ASYMMETRICAL DEPLOYMENT INVESTIGATION

VERIDIAN CASE NO. CA00-028

VEHICLE - 1996 DODGE CARAVAN SE

LOCATION - STATE OF NEW YORK

CRASH DATE - JULY, 2000

Contract No. DTNH22-94-D-07058

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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 on-site investigation focused on a single vehicle crash involving a 1996 Dodge Caravan SE and the non-deployment of the driver frontal air bag. The Dodge was equipped with frontal air bags for the driver and front right passenger positions which asymmetrically deployed as a result of a frontal collision with a large diameter tree. The driver of the Dodge was operating the vehicle eastbound on a multi-lane urban roadway when he allowed the vehicle to depart the right (south) pavement edge in a forward tracking mode. As the Dodge exited the right pavement edge, the vehicle struck several small (yielding) objects and continued into a wooded area where the front left area struck a large diameter tree resulting in moderate damage. The tree impact deployed the front right passenger air bag only. At impact with the tree, the restrained 20 year old male driver initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint resulting in abrasions/contusions to the left shoulder, left upper chest and right pelvic areas. Subsequent contact to the air bag module cover/steering wheel rim resulted in a maxillary spine fracture, a contused nose, a laceration under the left eye and a contused forehead. The driver was transported by ambulance to a local hospital for treatment and released.			
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BACKGROUND

This on-site investigation focused on a single vehicle crash involving a 1996 Dodge Caravan SE and the non-deployment of the driver frontal air bag. The Dodge was equipped with frontal air bags for the driver and front right passenger positions which asymmetrically deployed as a result of a frontal collision with a large diameter tree. The driver of the Dodge was operating the vehicle eastbound on a multi-lane urban roadway when he allowed the vehicle to depart the right (south) pavement edge in a forward tracking mode. As the Dodge exited the right pavement edge, the vehicle struck several small (yielding) objects and continued into a wooded area where the front left area struck a large diameter tree resulting in moderate damage. The tree impact deployed the front right passenger air bag only. At impact with the tree, the restrained 20 year old male driver initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint resulting in abrasions/contusions to the left shoulder, left upper chest and right pelvic areas. Subsequent contact to the air bag module cover/steering wheel rim resulted in a maxillary spine fracture, a contused nose, a laceration under the left eye and a contused forehead. The driver was transported by ambulance to a local hospital for treatment and released.

This crash was identified by the Veridian SCI team through established local contacts. Notification was provided to NHTSA on Friday, August 4, 2000 and the case was immediately assigned to the Veridian SCI team as an on-site investigative effort. Delays were incurred establishing cooperation with the vehicle owner and insurance company, therefore, the SCI investigator conducted the local on-site investigation Thursday, August 18, 2000.

SUMMARY

Crash Site

This single vehicle crash occurred during the early evening hours of July, 2000. At the time of the crash, it was daylight with no adverse conditions as the roads were dry. The crash occurred off the south pavement edge of a 5-lane east/west urban roadway which curved left for eastbound traffic **(see Figure 11 - page 8)**. The level/asphalt roadway was bordered by barrier curbs and sidewalks located 0.6 meters (2.0 feet) off the south curbline. Roadside environmental features included mailboxes, driveway marker posts, a regulatory sign (supported by dual U-beam posts affixed to anchor posts just above ground level) and a wooded area located approximately 7.8 meters (25.6 feet) off the south pavement edge. The posted speed limit at the crash site was 64 km/h (40 mph).

Pre-Crash

The 20 year old male driver of the 1996 Dodge Caravan was en route home, operating the vehicle eastbound on the inboard lane of the 5-lane roadway and negotiating a left curve when he maneuvered the

vehicle into the outboard lane **(Figure 1)** in an attempt to pass another eastbound vehicle ahead. As the vehicle reached the apex of the roadway curvature, it continued in a southeasterly direction toward the right (south) pavement edge in a forward tracking mode.

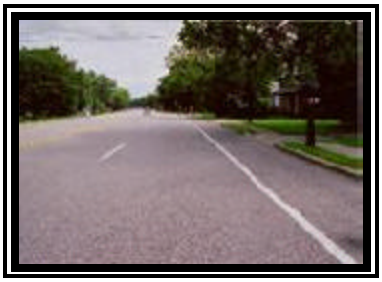

Figure 1. Eastbound approach for the 1996 Dodge Caravan SE.

Crash

As the Dodge Caravan exited the right (south) pavement edge, it traversed a private driveway as the frontal area made initial contact to a small driveway marker post resulting in minor damage. The vehicle continued 19.4 meters (63.7 feet) in a southeasterly direction across a second driveway as the right front (temporary spare) wheel/tire struck two stacked landscaping railroad ties which resulted in moderate rim damage. At this point, the top tie was displaced and came to rest just east of the base tie. The right rear wheel/tire then struck the unstacked ties **(Figure 2)** which produced two large distinctive dents in the rim. The Dodge traveled approximately 19.5 meters (64.0 feet) through some brush as the front left area impacted the right U-beam signpost supporting a regulatory speed limit sign **(Figure 3)**. The signpost separated from its anchor post and sign; and was probably run over, given the dirt noted on the post and final rest position within the soil furrowing perpendicular to the vehicle's path of travel. Contact separation occurred with the object as the sign fell to the ground and sideswiped the vehicle's left side surface resulting in minor damage. The Dodge continued in a southeasterly direction another 17.0 meters (55.8 feet) into a wooded area where the front left area struck a 31.0 cm (12.2 in) diameter tree **(Figure 4)** resulting in moderate damage.

The Dodge Caravan impacted the tree at a WinSMASH computed speed of 54.0 km/h (33.6 mph) with a barrier equivalent velocity change of 50.4 km/h (31.3 mph) and a respective longitudinal component of -50.4 km/h (-31.3 mph). The speed change exceeded the threshold required for deployment, therefore, the front right passenger air bag deployed. The vehicle rotated 13 degrees counterclockwise and rebounded approximately 0.6 meters (2.0 feet) from the struck tree before coming to rest facing east.

Figure 2. Police photo (east) of struck landscaping ties.

Figure 3. Police photo (east) of vehicle trajectory to final rest showing struck signpost and tree.

Figure 4. Police photo (north) of struck tree and vehicle final rest.

Post-Crash

The driver of the Dodge was removed from the vehicle by rescue personnel in an unconscious state and reportedly suffered an unspecified seizure during on-scene treatment *(per medical report)* by fire department personnel and emergency medical technicians (EMTs). He was transported by ambulance to a local hospital for treatment and released. The 1996 Dodge Caravan was towed from the scene due to disabling damage. The driver later reported to police that he "blacked out" during the initial passing maneuver, however, follow-up interview data revealed that the driver may have "just suffered from fatigue and had fallen asleep".

VEHICLE DATA

The 1996 Dodge Caravan was manufactured on 4/96 and identified by the vehicle identification number (VIN):2B4GP4534TR (production number deleted). The driver's father was reported by police as the owner of the vehicle. The vehicle was a 4-door minivan equipped with front-wheel drive and a 3.0 liter, V-6 engine. At the time of the crash, the odometer had recorded 198,269 km (123,202 miles). The seating was configured with front box mounted (van type) and rear bench seats (with a folding back). Although the owner and driver interviews reported two previous minor crashes (without air bag system deployment) and no previous maintenance on the Dodge's air bag system, the vehicle's history was unknown prior to its purchase (used) in late 1996. Reported problems with intermittent warning lights along the instrument cluster necessitated previous replacement of the airflow and cam positioning sensor. A cellular phone was present but not in-use at the time of the collision.

VEHICLE DAMAGE

Exterior

Figure 5. Frontal and left side damage to the 1996 Dodge Caravan SE.

The Dodge Caravan sustained moderate frontal damage as a result of the impact with the large diameter tree **(Figure 5)**. The direct contact damage began 8.0 cm (3.1 in) to the left of the vehicle centerline and extended inboard 34.0 cm (13.4 in). The impact deformed the full frontal width resulting in a combined direct and induced damage length (Field L) of 84.0 cm (33.1 in). Six crush measurements were documented at the level of the reinforcement bar *(bumper fascia separation)*: C1= 10.0 cm (3.9 in), C2= 63.0 cm (24.8 in), C3= 63.0 cm (24.8 in), C4= 44.0 cm (17.3 in), C5= 26.0 cm (10.2 in), C6= 0 cm. The hood was deformed up and rearward from engagement against the tree. The left headlight and grille assembly separated from the vehicle during the crash sequence. The left fender was displaced rearward which restricted the left front wheel/tire (not deflated). Reduction in the left side wheelbase measured 6.5 cm (2.6 in). Elongation in the right side wheelbase measured 4.0 cm (1.6 in). Multiple fracture sites were noted to the windshield from exterior impact forces (only).

Direct contact damage was also identified to the front left area attributed to the U-beam signpost impact. The direct contact damage began approximately 13.0 cm (5.1 in) inboard of the front left bumper corner with the impression most prominent along the forward edge of the left fender. Related direct contact damage was documented to the left side surface from the regulatory sign as it fell to the ground. The direct contact damage began 10.0 cm (3.9 in) forward of the left front axle and extended 325.0 cm (128.0 in) rearward, which confirms contact separation with the post and assignment of another event. A maximum crush value of 2.0 cm (0.8 in) was found at the left rear axle area. Although the contact pattern was concentrated below the level of the beltline, surface scratching was noted to the side mirror with the pattern tapered downward as it continued toward the rear of the vehicle *(i.e "falling object")*. Previous damage (body filler) was noted on the left front door and left fender areas. Superficial scratching was noted to the hood and roof areas from the subsequent brush contact.

Direct contact damage was identified to the right side wheels from impact with the landscaping railroad ties. The right front temporary tire was deflated (not restricted) with significant rim damage. In addition, the lug nuts were found to be placed on backwards. The right rear tire was also deflated (not restricted)

with two distinct *(closely spaced)* impact areas produced by the unstacked ties previously displaced by the right front wheel/tire. These wheel impacts were *simultaneous* and *closely spaced* in theory and did not necessitate assignment of another event.

The Collision Deformation Classification (CDC) for the above described impacts are outlined in the table below *(unknown characters are represented by 9's)*:

Impact #	Object Struck/Description	Plane of Contact	Collision Deformation Classification (CDC)	Severity
1	Driveway marker post	Front (center) area	12-F999-9	Minor (yielding object)
2	Landscaping railroad ties (two stacked pieces)	RF and RR wheels/tires *(simultaneous impacts)*	12-FRWN-9	Moderate (yielding object)
3	Brush	Front right area	12-FZAW-7	Minor (yielding object)
4	U-beam signpost	Front left area	12-FLEN-1	Minor (yielding object)
5	Regulatory sign	Left side surface	12-LDAS-1	Minor (yielding object)
6	31.0 cm (12.2 in) diameter tree	Front left area	12-FYEN-4	Moderate (fixed object)

Interior

Figure 6. Interior view of the driver space.

Interior damage to the Dodge identified through the vehicle inspection was moderate and was attributed to occupant contact and minimal component intrusion **(Figure 6)**. Indentations and scuff marks were documented on the left knee bolster (rigid plastic type) with deformation of the reinforcement panel noted. Scuff marks and a small indentation were also found on the steering wheel hub (air bag module cover) along with deformation to the steering wheel rim which measured 4.5 cm (1.8 in) at the top section and 1.5 cm (0.6 in) at the right spoke area. Column compression measured 0.5 cm (0.2 in) with separation of the steering assembly noted. The brake/gas pedals were displaced to the left. Blood pooling was found on the driver's seat cushion and arm rest. A large scuff mark was documented along the right headliner which began at the second seated area and extended forward toward the front right passenger space. Deformation was also noted to the second seat back from the spare tire (originally the right front tire) impact. Longitudinal intrusions into the driver space involved 23.0 cm (9.1 in) of toepan intrusion, 4.0 cm (1.6 in) of instrument panel intrusion, 7.0 cm (2.8 in) of brake/gas pedal intrusion and 3.0 cm (1.2 in) of center instrument panel intrusion.

MANUAL RESTRAINT SYSTEMS

The interior of the Dodge Caravan consisted of a five passenger seating configuration with front box mounted (van type) and rear bench seats (with a folding back) which accommodates three individual seating positions. The driver 3-point manual lap and shoulder belt system consisted of a continuous loop

belt webbing with a sliding latchplate and dual mode retractors (inertial lock/belt sensitive). Loading evidence consisted of abrasions to the D-ring **(Figure 7)** and associated loading marks to the shoulder portion of the webbing **(Figure 8)**. Loading marks were also identified to the lap portion of the webbing attributed to the sliding latchplate. In addition, the fractured B-pillar panel and blood spattering documented to the shoulder portion of the webbing also supported restraint usage. The front right 3-point manual lap and shoulder belt system consisted of a continuous loop belt webbing with a semi-locking latchplate and dual mode retractors (inertial lock/belt sensitive). The rear outboard seating positions were equipped with 3-point manual lap and shoulder belt systems which consisted of continuous loop belt webbings with semi-locking latchplates. The rear center seating position was equipped with a 2-point manual lap belt system with a locking latchplate.

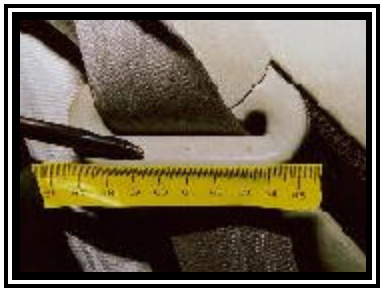

Figure 7. Abrasions to the front left restraint D-ring.

Figure 8. Loading marks to the front left shoulder belt webbing.

SUPPLEMENTAL RESTRAINT SYSTEMS

The Dodge Caravan was equipped with frontal air bags for the driver and front right passenger positions which asymmetrically deployed as a result of the impact with the large diameter tree **(Figure 9)**. The driver air bag was housed in the center of the steering wheel with a horizontally oriented flap tear seam (H-configuration). The driver air bag module was identified by the Chrysler part number: *P04680143* with a bar coded lot number of: *TCTDM0866M3097*. Non-deployment of the driver air bag was possibly related to the clock spring assembly which was meticulously documented and removed by the SCI investigator **(Figure 10)**. The SCI investigator first removed the air bag module and found the connector intact. A steering wheel puller was next used to gain access to the clock spring assembly which was noted to be in the (correct) upright position on the steering wheel shaft. The clock spring was identified by the Chrysler part number: 46876-30, 23199. The clock spring assembly was removed and forwarded to NHTSA's Office of Defect Investigations (ODI).

Figure 9. 1996 Dodge Caravan SE non-deployed driver air bag and deployed passenger air bag.

Figure 10. Disassembly process to obtain clock spring.

The front right passenger air bag deployed from the right mid-instrument panel area with a horizontally oriented flap tear seam (H-configuration). The flaps were nearly symmetrical in shape as the upper flap measured 28.0 cm (11.0 in) in width and 5.5 cm (2.2 in) in height while the lower flap measured 28.0 cm (11.0 in) in width and 5.0 cm (2.0 in) in height. Although no contact evidence was identified on the exterior surface of the module cover flaps, small puncture holes were documented along the left side aspect and upper centered portion of the air bag face attributed to cargo (hockey equipment) stowed in the backseat of the Dodge prior to the crash. The cargo was displaced in a forward trajectory during the impact with the tree and produced the noted scuff mark to the vehicle's headliner. The passenger air bag measured 47.0 cm (18.5 in) in width and 77.0 cm (30.3 in) in height in its deflated state. No vent ports or internal tether straps were present.

DRIVER DEMOGRAPHICS

Age/Sex:	20 year old male
Height:	183 cm (72 in)
Weight:	84 kg (185 lb)
Seat Track Position:	Mid-to-rear position
Manual Restraint Use:	3-point lap and shoulder belt system
Usage Source:	Vehicle inspection, driver interview, police report
Eyeware:	Contact lenses
Type of Medical Treatment:	Transported to a local hospital and released

Driver Injuries

Injury	***Severity (AIS 90)***	***Injury Mechanism***
*Fracture maxillary spine	Moderate (250800.2,8)	Driver air bag module cover/steering wheel spoke
+Laceration under left eye (3.0 in)	Minor (290602.1,2)	Driver air bag module cover/steering wheel spoke
*Contusion center forehead	Minor (290402.1,7)	Steering wheel rim
+Contusion nose	Minor (290402.1,4)	Driver air bag module cover/steering wheel spoke
+Contusion anterior left bicep	Minor (790402.1,2)	Unknown (steering wheel rim?)
*Contusion left shoulder	Minor (790402.1,2)	Shoulder belt webbing
*Abrasion left shoulder	Minor (790202.1,2)	Shoulder belt webbing
+Contusion left upper chest	Minor (490402.1,2)	Shoulder belt webbing
*Abrasion left upper chest	Minor (490202.1,2)	Shoulder belt webbing
+Contusion right hip	Minor (890402.1,1)	Lap belt webbing
*Contusion lateral right ankle	Minor (890402.1,1)	(Intruded) Brake pedal
*Abrasion lateral right ankle	Minor (890202.1,1)	(Intruded) Brake pedal

*Laceration lateral right ankle	Minor (890602.1,1)	(Intruded) Brake pedal

*Sources: *-medical report, +-driver*

Driver Kinematics

The 20 year old male driver of the 1996 Dodge Caravan was restrained by the available 3-point manual lap and shoulder belt system and presumed to be seated in an upright posture with the seat track adjusted to the mid-to-rear position. Restraint usage was confirmed by the loading marks documented on the shoulder/lap belt webbing and associated abrasions to the D-ring and sliding latchplate.

Initial impacts with the yielding roadside objects offered no significant resistance to the vehicle or produce any significant occupant kinematic response. At impact with the tree, the driver initiated a forward trajectory in response to the 12 o'clock impact force and loaded the manual restraint resulting in abrasions/contusions to the left shoulder, left upper chest and right hip. He subsequently loaded the knee bolster with no resulting injury reported. The driver's head jack knifed forward over the manual shoulder belt webbing which resulted in facial contact against the steering assembly. Contact to the air bag module cover/steering wheel spoke resulted in a fracture of the maxillary spine, a contusion of the nose and a small laceration below the left eye. These injury mechanisms were evidenced by the indentation and scuff marks documented to the air bag module cover (steering wheel hub) along with deformation identified at the right spoke area. He also loaded the upper portion of the steering wheel rim which resulted in a contusion to the forehead as evidenced by the location of the injury relative to the deformation documented to this component. He also sustained an abrasion/contusion/laceration of the right (inside/lateral) ankle from contact to the intruded brake pedal, evidenced by the displacement and intrusion of this component in conjunction with the driver's stated pre-crash placement of the right foot on the accelerator pedal. The driver was transported by ambulance to a local hospital for treatment and released.

It should be noted that deployment of the driver frontal air bag would have provided additional crash protection for the driver against further contact to the air bag module cover and steering wheel spoke/rim, thus potentially mitigating the facial injuries he sustained from the steering wheel contact.

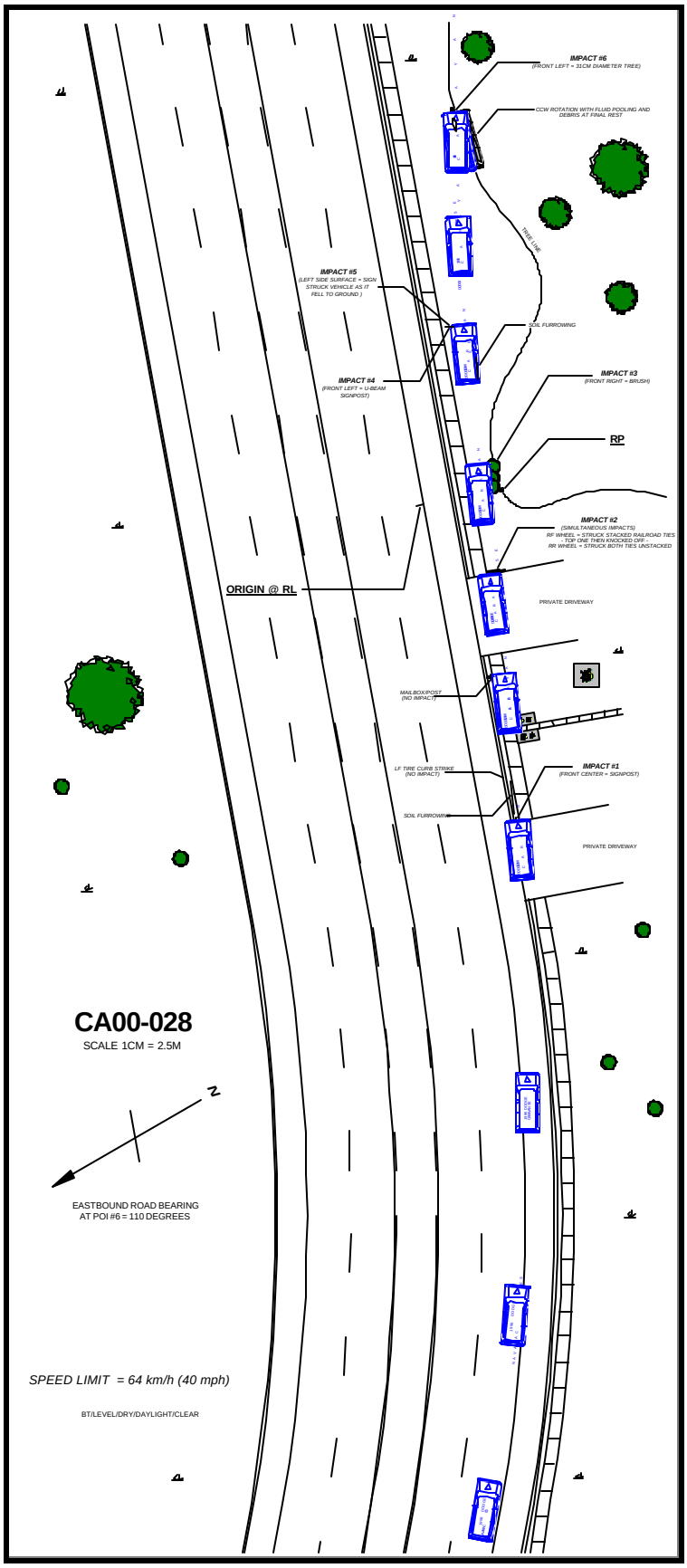

Figure 11. Scene Diagram.