INDIANA UNIVERSITY

TRANSPORTATION RESEARCH CENTER
School of Public and Environmental Affairs
501 South Morton Street Suite 105
Bloomington, Indiana 47403-2452
(812) 855-3908 Fax: (812) 855-3537

ON-SITE ROLLOVER INVESTIGATION

CASE NUMBER - IN09035
LOCATION - NEBRASKA
VEHICLE - 2008 CHRYSLER ASPEN LIMITED
CRASH DATE - August 2009

Submitted:

April 19, 2010

Contract Number: DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation
National Highway Traffic Safety Administration
National Center for Statistics and Analysis
Washington, D.C. 20590-0003

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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 be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

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

Technical Report Documentation Page

1. *Report No.* IN09035	2. *Government Accession No.*	3. *Recipient's Catalog No.*	
4. *Title and Subtitle* On-Site Rollover Investigation Vehicle - 2008 Chrysler Aspen Limited Location - Nebraska		5. *Report Date:* April 19, 2010 6. *Performing Organization Code*	
7. *Author(s)* Special Crash Investigations Team #2		8. *Performing Organization Report No.*	
9. *Performing Organization Name and Address* Transportation Research Center Indiana University 501 South Madison Street, Suite 105 Bloomington, Indiana 47403-2452		10. *Work Unit No. (TRAIS)* 11. *Contract or Grant No.* DTNH22-07-C-00044	
12. *Sponsoring Agency Name and Address* U.S. Department of Transportation (NVS-411) National Highway Traffic Safety Administration National Center for Statistics and Analysis Washington, D.C. 20590-0003		13. *Type of Report and Period Covered* Technical Report Crash Date: August 2009 14. *Sponsoring Agency Code*	
15. *Supplementary Notes* On-site rollover investigation involving a 2008 Chrysler Aspen Limited.			
16. *Abstract* The focus of this on-site investigation was on the rollover of a 2008 Chrysler Aspen Limited. The Chrysler was occupied by a restrained 23-year-old male driver. The driver was executing a left turn from a divided city street onto the entrance ramp of an interstate highway. The vehicle was impacted on the right side plane by the front plane of a 2004 Dodge Ram 1500 quad cab pickup truck. The impact caused the Chrysler to rotate clockwise. The vehicle departed the roadway and rolled over left side leading 6 quarter turns across a distance of approximately 21 m (68.9 ft). During the crash the Chrysler's right and left rollover/side impact inflatable curtain (IC) air bags deployed. The driver was transported by ambulance to a hospital where he was treated in the emergency room for minor injuries and released. The driver of the Dodge was not injured. The Chrysler was towed due to damage, while the Dodge was driven from the crash scene.			
17. *Key Words* Side Curtain Air Bag Rollover Motor Vehicle Traffic Crash Injury Severity		18. *Distribution Statement* General Public	
19 *Security Classif. (of this report)* Unclassified	20. *Security Classif. (of this page)* Unclassified	21. *No. of Pages* 29	22. *Price*

Form DOT 1700.7 (8-72) Reproduction of completed page authorized

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This on-site investigation focused on the rollover of a 2008 Chrysler Aspen Limited (**Figure 1**). This crash was brought to our attention by the National Highway Traffic Safety Administration (NHTSA) on October 9, 2009 through the sampling activities of the National Automotive Sampling System–General Estimates System (NASS-GES). This investigation was assigned on October 20, 2009. The crash involved the Chrysler and a 2004 Dodge Ram 1500 quad cab pickup truck. The crash occurred on August 17, 2009, at 2138 hours in Nebraska, and was investigated by the city police department. The crash scene and Chrysler were inspected on October 27, 2009. An interview was conducted on November 6, 2009 with the mother of the Chrysler's driver. The Dodge had been repaired and was not inspected. This report is based on the police crash report, vehicle and crash scene inspections, exemplar vehicle inspection, interview information, driver medical records, occupant kinematic principles, and evaluation of the evidence.

Figure 1: The damaged 2008 Chrysler Aspen Limited

CRASH CIRCUMSTANCES

Crash Environment: The trafficway that both vehicles were traveling on was a 5-lane, divided, city street, traversing in a northwesterly and southeasterly direction. Both vehicles were approaching a 4-leg intersection, which was located within an interchange area for an interstate highway. On the southeastern leg of the intersection, the northwest roadway had 2 through lanes and a left turn lane. The grade was negative 1.7%. The first lane from the right was 3.7 m (12.1 ft) in width, while the second through lane was 4 m (13.1 ft) in width. The left turn lane was 3.6 m (11.8 ft) in width. The outside bituminous shoulder was 3.1 m (10.2 ft) in width. The roadway pavement markings consisted of a solid white outside edge line, broken white lane lines, solid white left turn lane line, and a solid yellow median line. The northwest roadway was divided from the southeast roadway by a concrete median 8.4 m (27.6 ft) in width. On the northwestern leg of the intersection, the southeast roadway had 2 through lanes at the mouth of the intersection. The grade was positive 3.3%. The first through lane from the right 3.7 m (12.1 ft) in width, while the second through lane was 4.2 m (13.8 ft) in width. Roadway pavement markings consisted of a solid white outside edge line, broken white lane lines, and a solid yellow median edge line. The outside bituminous shoulder was 3.1 m (10.2 ft) in width. The southwest roadway was divided from the northwest roadway by a concrete median 10.7 m (35.1 ft) in width. The intersection was controlled by three-phase traffic signals. At the time of the crash, the light condition was dark with artificial lighting and the atmospheric condition was clear. The roadway was dry concrete and the speed limit was 72 km/h (45 mph). The traffic density was light and the site of the crash was urban commercial. The Crash Diagram can be seen on page 11 of this report.

Pre-Crash: The Chrysler was occupied by a restrained 23-year-old male driver. The vehicle was traveling northwest in the left turn lane (**Figure 2**) and the driver was in the process of executing a left turn onto the entrance ramp to the interstate highway. The Dodge was occupied by a restrained 24-year-old female driver. The vehicle was traveling southeast in the first through lane from the right (**Figure 3**) and the driver intended to continue straight through the intersection. The driver of the Chrysler made no avoidance maneuvers prior to the crash. The crash occurred in the 4-leg intersection of the 2 trafficways.

Crash: The Chrysler was impacted on the right quarter panel (**Figure 4**, event 1) by the front plane of the Dodge. The force direction was within the 2 o'clock sector and the impact force was sufficient to trigger deployment of the right rollover/side impact inflatable curtain (IC) air bag. The impact caused the Chrysler to rotate clockwise. The vehicle was equipped with Electronic Stability Control (ESC), but the impact-induced rotation was significant and the vehicle departed the south edge of the road (**Figure 5**) where it rolled over (**Figure 6**, event 2) left side leading 6 quarter turns. The left side IC air bag also deployed during the crash. The Chrysler came to final rest on its top plane heading northwest.

Post-Crash: The police were notified of the crash at 2139 hours. The driver of the Chrysler exited the vehicle through the left rear door with the help of the driver of the Dodge. The driver of the Chrysler was transported by ambulance to a hospital. The driver of the Dodge was not injured. The Chrysler was towed due to damage, while the Dodge was driven from the crash scene.

Figure 2: Approach of the Chrysler to the intersection; arrow shows the area of impact

Figure 3: Approach of the Dodge; arrow shows the approach of the Chrysler to impact area

Figure 4: Damage to the right quarter panel of the Chrysler from the impact by the front plane of the Dodge

The Chrysler's rollover mitigation features consisted of rollover sensing and ESC. The vehicle has been given a four star rollover rating on a five star scale by NHTSA and a Static Stability Factor of 1.19[1]. A four star rating indicates that the vehicle has a 10%-20% chance of a rollover when involved in a single vehicle crash. The specific chance of a rollover for this vehicle model was given as 19%. The Static Stability Factor (SSF) is a calculation based on the vehicle's track width and height of its center of gravity. The result of the calculation is a measure of a vehicle's resistance to rollover. A higher SSF indicates a more stable vehicle. The majority of passenger vehicles have an SSF of 1.30 to 1.50[2]. The test vehicle also did not tip-up during the dynamic steering maneuver test in which the test vehicle was put through fish-hook shaped steering maneuvers (i.e., hard left and hard right steer) at between 56 km/h-80km/h (35-50 mph).

Figure 5: View west; arrow in foreground shows area of impact with the Dodge (event 1); arrow on left in background shows area where the Chrysler rolled over (event 2); arrow on right in background shows area final rest of the Chrysler

Figure 6: Primary damage from the rollover resided on the top plane of the Chrysler

The rollover of the Chrysler was initiated following the impact with the Dodge. The Chrysler rotated clockwise an estimated 35 degrees from its original heading as it departed the south side of the road. The left rear wheel (**Figure 7**) furrowed into the ground and the vehicle tripped and rolled over left side leading. The vehicle rolled over 6 quarter turns across a distance of approximately 21 m (68.9 ft) and came to final rest on its top heading northwest.

CASE VEHICLE

The 2008 Chrysler Aspen Limited was an all wheel drive, 8-passenger, 4-door sport utility vehicle (VIN: 1A8HW58N58F------) equipped with a 4.7-liter, V-8 engine, a 5-speed automatic transmission, 4-wheel, antilock brakes with electronic brake force distribution, ESC, a tire pressure monitoring system, and an Event Data Recorder (EDR). The front row was equipped with bucket seats, adjustable head restraints, lap-and-shoulder safety belts with adjustable upper anchors, dual stage driver and front passenger frontal air bags, and rollover/side impact IC air

[1] www.safercar.gov, 11/12/09

[2] "Trends in the Static Stability Factor of Passenger Cars, Light Trucks, and Vans", NHTSA Technical Report, DOT HS 809 868, June 2005

bags protecting all outboard seating positions. The second row was equipped with a split bench seat with folding backs, adjustable head restraints, lap-and-shoulder safety belts, and Lower Anchors and Tethers for Children (LATCH). The third row was equipped with a split bench seat with folding backs, adjustable head restraints, and lap-and-shoulder safety belts. The vehicle's specified wheelbase was 303 cm (119.3 in).

Figure 7: Abrasions on sidewall of the Chrysler's left rear tire and grass embedded in the bead

CASE VEHICLE DAMAGE

Exterior Damage: The Chrysler sustained right side damage during the impact with the Dodge. There was direct damage on the right rear door, right rear wheel, quarter panel, and the right side of the back bumper fascia. The direct damage began 248 cm (97.6 in) rear of the right front axle and extended 129 cm (50.8 in) rearward along the side of the vehicle. The maximum residual crush was 12 cm (4.7 in) occurring at C_1. The induced damage involved the quarter panel and right rear door. The right side wheelbase was reduced 1 cm (0.4 in). The table below shows the right side crush profile.

Units	Event	Direct Damage		Field L	C_1	C_2	C_3	C_4	C_5	C_6	Direct	Field L
		Width CDC	Max Crush								±D	±D
cm	1	129	12	141	12	10	8	5	1	0	-159	-152
in		50.8	4.7	55.5	4.7	3.9	3.2	2.0	0.4	0.0	-62.6	-59.8

The rollover involved the top plane and both side planes. The direct damage on the top plane began at the front of the hood and extended across the full width of the roof, 117 cm (46.1 in) at the windshield header and the sunroof (**Figures 8** and **9**). The direct damage extended along the right roof side rail to approximately midway between the right B- and C-pillars. The direct damage on the left side plane (**Figure 10**) extended intermittently along the full length of the vehicle and involved the left fender, both of the left side doors, the left roof side rail, and the quarter panel. The direct damage on the right side plane (**Figure 11**) began on the right A-pillar and extended rearward the remaining length of the

Figure 8: Direct damage to the hood, windshield, and front portion of the roof from the rollover

vehicle. The maximum vertical crush (**Figure 12**) was 12 cm (4.7 in) and occurred on the windshield header near the right A-pillar. The maximum residual lateral crush was 3 cm (1.2 in) and occurred at the top of the right A-pillar (**Figure 12**).

Figure 9: The direct damage involved the full width of the roof at the sunroof and windshield header

Figure 10: Damage from the rollover on the left side plane of the Chrysler

Figure 11: Damage from the rollover on the right side plane of the Chrysler

Figure 12: The maximum vertical crush occurred on the windshield header; the maximum lateral crush occurred on the right A-pillar

Damage Classification: The Collision Deformation Classifications for the Chrysler were 02RZEW2 (60 degrees) for the right side plane impact with the front plane of the Dodge (event 1) and 00TYDO3 for the rollover (event 2). The Missing Vehicle algorithm of the WinSMASH program calculated the total Delta V for the right side plane impact as 9 km/h (5.6 mph). The longitudinal and lateral velocity changes were -3.1 km/h (-1.9 mph) and -8.5 km/h (-5.3 mph), respectively. Based on the damage on the vehicle, the results appeared reasonable. The WinSMASH program could not be used on the rollover since rollovers are out of scope for the program. Based on the extent of the roof crush, the severity of the damage from the rollover was moderate.

The vehicle manufacturer's recommended tire size was P265/60R18. The Chrysler was equipped with tires of the recommended size. The vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer'sRecommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	221	32	228	33	8	10	None	No	No
LR	83	12	228	33	8	10	None	No	No
RR	Flat	Flat	228	33	8	10	Sidwall cut	No	Yes
RF	207	30	228	33	8	10	None	No	No

Vehicle Interior: The inspection of the interior revealed a few small hair transfers on the driver's sunvisor, roof, and left roof side rail (**Figures 13** and **14**). There was also a small cut on the sunvisor. There was no discernable evidence of occupant contact on the left IC air bag. There was no damage on the steering wheel and no compression of the energy absorbing steering column.

The left front door was jammed closed while the remaining doors and the tailgate remained closed and operational. The pre-crash status of the sunroof was partially open, while the remainder of the window glazings were either fixed or closed. The windshield was in place and cracked from impact forces. The left front and right front window glazings were disintegrated from impact forces. The remaining glazings were undamaged.

The passenger compartment sustained 11 intrusions that occurred within the front row. The most severe intrusions involved the windshield header, roof, and A-pillar in the front passenger space. These components intruded vertically 12 cm (4.7 in), 11 cm (4.3 in), and 9 cm (3.5 in), respectively.

Figure 13: Yellow tape shows areas of occupant contact on the sunvisor, roof, and left roof side rail

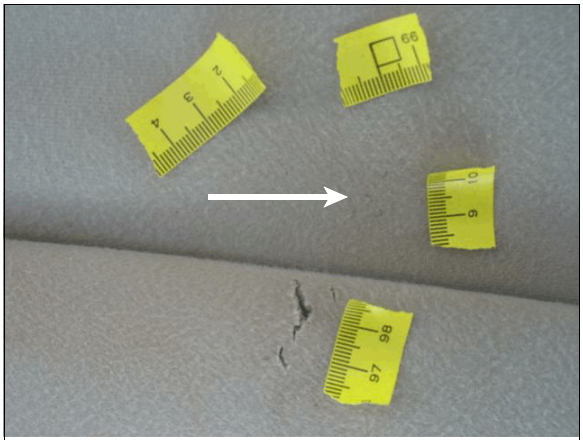


Figure 14: Close view of small cut on sunvisor and a few small hair transfer's on the roof (arrow)

The Chrysler's EDR was imaged using version 3.3 of the Bosch Crash Data Retrieval software via direct connection to the air bag control module. The EDR file was subsequently read and printed using version 3.4. The EDR recorded two events which were identified in the EDR report as the Most Recent Event (MRE) and the First Prior Event (FPE). The data indicated that the FPE was associated with the right side plane impact on the Chrysler (event 1), while the MRE was associated with the rollover (event 2). The EDR records 100 msec of longitudinal crash pulse data prior to air bag deployment and 150 msec of data after air bag deployment. No Delta V values were reported. For the FPE, the longitudinal acceleration was recorded as negative 5.88 g at deployment of the right IC air bag, while the maximum recorded acceleration was negative 11.76 g occurring at 8 msec after air bag deployment. The EDR recorded 5 seconds of pre-crash data at 0.1 sec intervals. The pre-crash data for the FPE indicated that the Chrysler was traveling 35 km/h (22 mph) 5 seconds prior to the impact with the Dodge. At 0.1 second prior to the impact, the Chrysler was recorded as traveling 19 km/h (11.8 mph), and the brake switch circuit was recorded as open. The EDR report is attached at the end of this report[3].

AUTOMATIC RESTRAINT SYSTEM

The Chrysler was equipped with a Certified Advanced 208-Compliant (CAC) frontal air bag system that consisted of dual stage driver and front passenger frontal air bags, driver seat position sensor, and retractor-mounted pretensioners. The CAC system incorporated a low-risk deployment method for the front passenger air bag. Based on the Holmatro Rescuer's Guide to Vehicle Safety Systems, the frontal air bag sensors were located on the left and right radiator supports. The manufacturer has certified that the vehicle is compliant to the Advanced Air Bag portion of the Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Neither frontal air bag deployed in this crash.

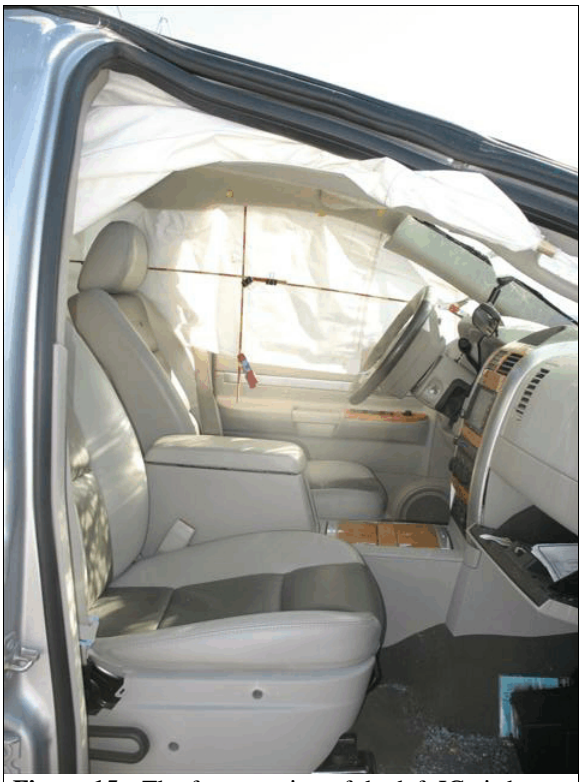


Figure 15: The front portion of the left IC air bag

The Chrysler was also equipped with rollover/side impact IC air bags. Based on the Holmatro Rescuer's Guide to Vehicle Safety Systems, the side impact sensors were located within the front doors and the lower C- and D-pillars. Both IC air bags deployed in this crash.

[3] Pages 19-25 of the EDR report have been deleted for confidentiality purposes.

The IC air bags (**Figure 15**) were located along the roof side rails inside the headliner and extended from the top of the A-pillar to the D-pillar. They were designed with inflation chambers adjacent to the outboard seat positions. The deployed IC air bags were 230 cm (90.6 in) in width and 48 cm (18.9 inches) in height. A triangular-shaped fabric panel that was 27 cm (10.6 in) in width was located at the front of the IC air bag. It was attached to the A-pillar by a 9 cm (3.5 in) rope tether. The IC air bags extended 13 cm (5.1 in) below the beltline. There was no gap between the IC air bags and the A-pillars. Inspection of the IC air bags revealed no discernable evidence of occupant contact and no damage.

MANUAL RESTRAINT SYSTEM

The Chrysler was equipped with lap-and-shoulder safety belts for all the seating positions. The driver's safety belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), sliding latch plate, and an adjustable upper anchor that was in the full-down position. The front passenger safety belt was similarly equipped and the adjustable upper anchor was also located in the full-down position. The driver and front right passenger safety belts were equipped with retractor-mounted pretensioners. The second and third row lap-and-shoulder safety belts consisted of continuous loop belt webbing, switchable ELR/Automatic Locking Retractors (ALR), and locking latch plates. The second row had adjustable upper anchors in the outboard seating positions and an integrated safety belt in the center position. The third row had fixed upper anchors in all three seating positions.

Figure 16: The driver's safety belt in the latched position; the retractor was jammed

Inspection of the driver's safety belt assembly revealed that the pretensioner had actuated during the crash. The retractor was jammed with a length of belt webbing extended out of the retractor consistent with usage (**Figure 16**). Light load abrasions were present on the safety belt webbing located 88 cm (34.6 in) above the stop loop. The latch plate showed historical usage scratches and light load abrasions were present on the latch plate belt guide. There were also light load abrasions on the D-ring. This evidence indicated that the driver was restrained by the lap-and-shoulder safety belt at the time of the crash. The remaining seat positions were unoccupied.

The driver of the Chrysler [23-year-old, male; 178 cm (70 in) and 84 kg (185 lb)] was seated in an unknown posture. At the time of the inspection, the seat track was adjusted between the middle and rear positions and the seat back was slightly reclined. The head restraint was in the full-down position and the distance from the top of the seat back to the top of head restraint was 20 cm (7.9 in). The tilt steering column was located in the full up position. The driver was not wearing glasses or contact lenses at the time of the crash.

The initial impact on the Chrysler's right quarter panel displaced the driver forward and to the right within the safety belt opposite the 2 o'clock direction of force. As the vehicle rolled over left side leading, the driver was redirected to the left and toward the roof. During the rollover, the driver contacted his head on the roof, which caused a small laceration on the top of his head. He also contacted the left roof side rail, but sustained no injury due to this contact. While there was no discernable evidence on contact on the left IC air bag, the driver sustained an abrasion on the left shoulder/upper arm area, which was probably from contact with the IC air bag. The driver remained restrained in his seat throughout the crash. Following the crash, he removed the safety belt and crawled into the second row where he exited the vehicle through the left rear door with the assistance of the driver of the Dodge.

CASE VEHICLE DRIVER INJURIES

The driver was transported by ambulance to a hospital where he was treated in the emergency room and released. The driver sustained minor injuries and received no follow-up treatment. He missed no work days due to the crash. The table below presents the driver's injuries and injury sources.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Laceration, very small, scalp, not further specified	minor 190602.1,9	Roof	Certain	EMS treatment record
2	Abrasions/friction burns left shoulder and/or upper arm	minor 790202.1,2	Air bag, driver's side inflatable curtain	Probable	EMS treatment record

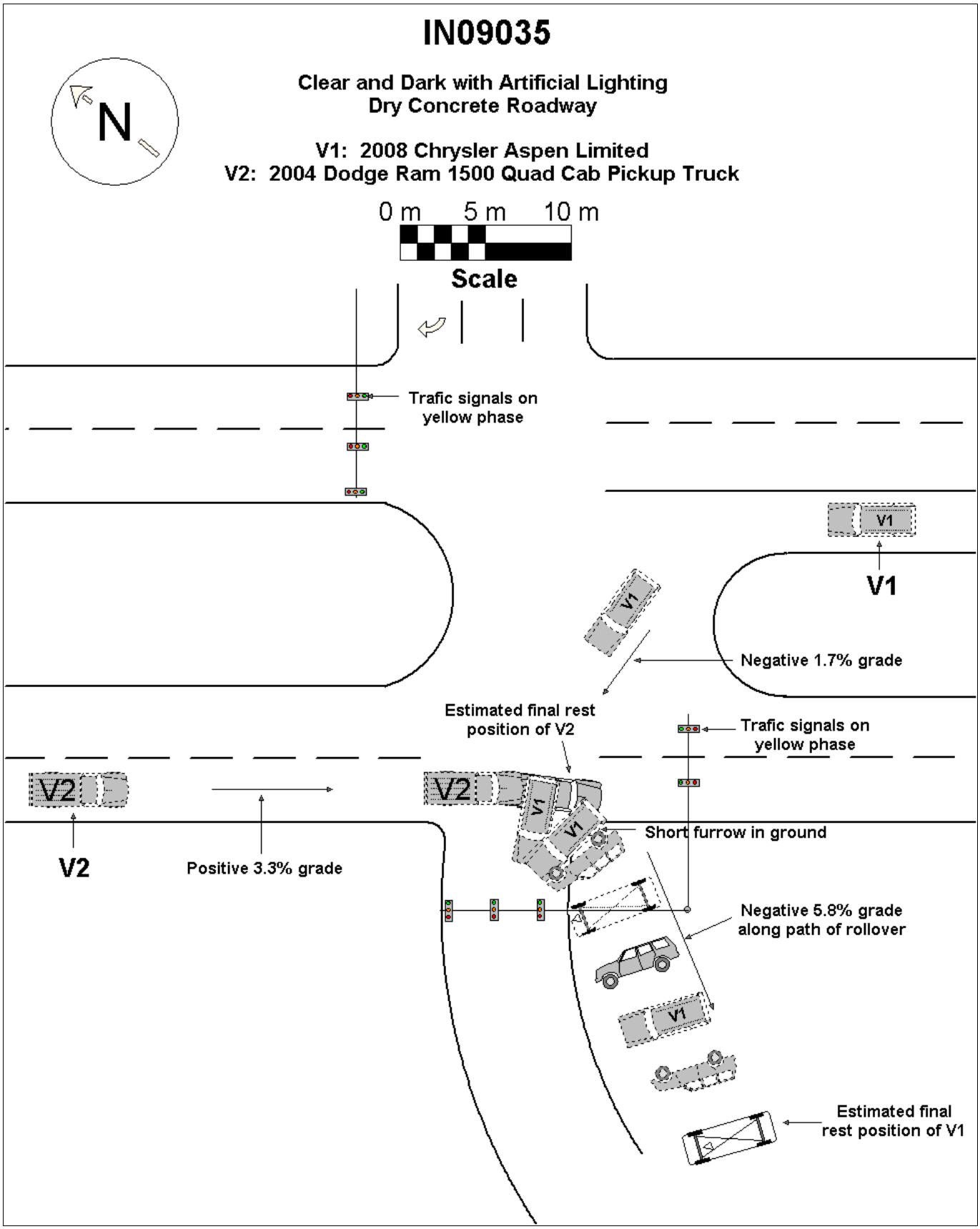
OTHER VEHICLE

The 2004 Dodge Ram 1500 was a 4-wheel drive, 6-passenger, 4-door, Quad Cab pickup truck (VIN: 1D7HU18D14S------) equipped with a 5.7-liter, V-8 engine and a 5-speed automatic transmission. The Dodge was equipped with rear wheel, anti-lock brakes and dual stage driver and front right passenger frontal air bags.

Exterior Damage: The Dodge had been repaired and was not inspected. There were no photographs of the vehicle available and a CDC could not be estimated.

The Missing Vehicle algorithm of the WinSMASH program calculated the Dodge's total Delta V for the front impact as 7 km/h (4.3 mph). The longitudinal and lateral velocity changes were –6.9 km/h (-4.3 mph) and -1.2 km/h (0.8 mph), respectively. The results were based only on the crush profile on the Chrysler and should be considered as borderline.

Other Vehicle's Occupants: The police crash report indicated that the driver of the Dodge (24-year-old, female) was not injured. Air bag deployment for the vehicle and the driver's restraint use were indicated as unknown.


IN09035
Clear and Dark with Artificial Lighting
Dry Concrete Roadway
V1: 2008 Chrysler Aspen Limited
V2: 2004 Dodge Ram 1500 Quad Cab Pickup Truck
N
0 m 5 m 10 m
Scale
Trafic signals on yellow phase
V1
V1
V1
Negative 1.7% grade
Estimated final rest position of V2
Trafic signals on yellow phase
V2
V2
V1
V1
Short furrow in ground
V2
Positive 3.3% grade
Negative 5.8% grade along path of rollover
V1
Estimated final rest position of V1