

CRASH DATA RESEARCH CENTER
Calspan Corporation
Buffalo, NY 14225

**ON-SITE CERTIFIED ADVANCED 208 COMPLIANT
VEHICLE CRASH INVESTIGATION**

CALSPAN CASE NO: CA06-003

**VEHICLE: 2005 HONDA CR-V
LOCATION: ALABAMA
CRASH DATE: NOVEMBER, 2005**

Contract No. DTNH22-01-C-17002

Prepared for:

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

DISCLAIMER

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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.

TECHNICAL REPORT STANDARD TITLE PAGE

<p>1. Report No. CA06-003</p>	<p>2. Government Accession No.</p>	<p>3. Recipient's Catalog No.</p>	
<p>4. Title and Subtitle On-Site Certified Advanced 208 Compliant Vehicle Investigation Vehicle: 2005 Honda CR-V Location: Alabama</p>		<p>5. Report Date: April 2006</p>	
		<p>6. Performing Organization Code</p>	
<p>7. Author(s) Crash Data Research Center</p>		<p>8. Performing Organization Report No.</p>	
<p>9. Performing Organization Name and Address Calspan Corporation Crash Data Research Center P.O. Box 400 Buffalo, New York 14225</p>		<p>10. Work Unit No. C00410.0000.0341</p>	
		<p>11. Contract or Grant No. DTNH22-01-C-17002</p>	
<p>12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration Washington, D.C. 20590</p>		<p>13. Type of Report and Period Covered Technical Report Crash Date: November 2005</p>	
		<p>14. Sponsoring Agency Code</p>	
<p>15. Supplementary Note An investigation of a 2005 Honda CR-V involved in an offset frontal crash with a 1995 Dodge Neon.</p>			
<p>16. Abstract</p> <p>This investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in a 2005 Honda CR-V sport utility vehicle and the injury sources for the 54 year old restrained male driver. The driver was the sole occupant of the Honda. The Certified Advanced 208-Compliant safety system in the Honda was comprised of dual-stage frontal air bags, seat track position sensors, front safety belt buckle switches, front safety belt buckle pretensioners, and a front right occupant detection sensor. The frontal air bags in the vehicle were certified by the manufacturer to be compliant with the advanced FMVSS 208 ruling. The Honda was also equipped with front seatback mounted side impact (thorax) air bags and roof-rail mounted inflatable side curtains. The Honda's driver air bag, the driver seatback mounted thorax bag, and the left roof-rail curtain deployed as a result of an offset frontal crash with a 1995 Dodge Neon. The Honda's restrained driver sustained an anterior fracture/subluxation at C4/C5 with quadriplegia (AIS 5) as a result of loading the safety belt system. The unrestrained female driver of the Dodge sustained a police reported A-level injury. Both vehicles sustained disabling damage and were towed from the crash site.</p> <p>An attorney representing the driver of the Honda notified the National Highway Traffic Safety Administration's Auto Safety Hotline of the crash on February 6, 2006. The notification was subsequently forwarded to the Calspan Special Crash Investigations (SCI) team the following day for follow-up investigation. Cooperation was established with the attorney who was in possession of the Honda. The Dodge Neon was available for inspection at a salvage facility located near the crash site and was available for inspection. The Police Accident Report (PAR) and the driver's medical records were forwarded to the SCI team by the attorney's office for review. The on-site portion of the investigation took place February 22 -23, 2006.</p>			
<p>17. Key Words FMVSS 208 Advanced Frontal Air Bag AIS 5 Injury Hyper-flexion Inertial loading of the safety belt Anterior fracture/Subluxation</p>		<p>18. Distribution Statement General Public</p>	
<p>19. Security Classif. (of this report) Unclassified</p>	<p>20. Security Classif. (of this page) Unclassified</p>	<p>21. No. of Pages 12</p>	<p>22. Price</p>

TABLE OF CONTENTS

BACKGROUND	1
VEHICLE DATA	
2005 Honda CR-V	2
1995 Dodge Neon	2
SUMMARY	
Crash Site	3
Crash Sequence	4
2005 HONDA CR-V	
Exterior Damage	5
1995 DODGE NEON	
Exterior Damage	6
2005 HONDA CR-V	
Interior Damage	7
Manual Restraint System	7
Certified Advanced Compliant Air Bag System.....	8
Inflatable Side Impact Protection.....	8
DRIVER DEMOGRAPHICS	9
DRIVER INJURY	10
DRIVER KINEMATICS	10
CRASH SCHEMATIC	12

**CALSPAN ON-SITE CERTIFIED ADVANCED 208-COMPLIANT VEHICLE
CRASH INVESTIGATION
CASE NO: CA06-003**

**VEHICLE: 2005 HONDA CR-V
LOCATION: ALABAMA
CRASH DATE: NOVEMBER 2005**

BACKGROUND

This investigation focused on the performance of the Certified Advanced 208-Compliant (CAC) safety system in a 2005 Honda CR-V sport utility vehicle, **Figure 1**, and the injury sources for the 54 year old restrained male driver. The driver was the sole occupant of the Honda. The Certified Advanced 208-Compliant safety system in the Honda was comprised of dual-stage frontal air bags, seat track position sensors, front safety belt buckle switches, front safety belt buckle pretensioners, and a front right occupant detection sensor. The frontal air bags in the vehicle were certified by the manufacturer to be compliant with the advanced FMVSS 208 ruling. The Honda was also equipped with front seatback mounted side impact (thorax) air bags and roof-rail mounted inflatable side curtains. The Honda's driver air bag, the driver seatback mounted thorax bag, and the left roof-rail curtain deployed as a result of an offset frontal crash with a 1995 Dodge Neon. The Honda's restrained driver sustained an anterior fracture/subluxation at C4/C5 with quadriplegia (AIS 5) as a result of loading the safety belt system. The unrestrained female driver of the Dodge sustained a police reported A-level injury. Both vehicles sustained disabling damage and were towed from the crash site.



Figure 1: Front left view of the Honda.

An attorney representing the driver of the Honda notified the National Highway Traffic Safety Administration's Auto Safety Hotline of the crash on February 6, 2006. The notification was subsequently forwarded to the Calspan Special Crash Investigations (SCI) team the following day for follow-up investigation. Cooperation was established with the attorney who was in possession of the Honda. The Dodge Neon was available for inspection at a salvage facility located near the crash site and was available for inspection. The Police Accident Report (PAR) and the driver's medical records were forwarded to the SCI team by the attorney's office for review. The on-site portion of the investigation took place February 22 -23, 2006.

VEHICLE DATA

2005 Honda CR-V

The 2005 Honda CR-V sport utility vehicle was identified by the Vehicle Identification Number (VIN): SHSRD78975U (production sequence deleted). **Figure 2** is a left side view of the Honda. The vehicle was manufactured in the United Kingdom in December 2004 and was purchased new by the driver from an Alabama dealership local to the crash site. The four-door,

five passenger sport utility vehicle was equipped with SE level trim. The real-time four wheel drive power train consisted of a 2.4 liter/I4 engine linked to a five speed automatic transmission. The service brakes were four-wheel disc with ABS. The vehicle was also equipped with vehicle stability assist with traction control. The manual restraint system consisted of three-point lap and shoulder belts in all five seat positions. The front safety belts utilized buckle pretensioners. The dual-stage



Figure 2: Left side view of the Honda

frontal air bags were a manufacturer certified FMVSS 208-compliant system. The inflatable side impact protection consisted of front seat back mounted thorax bags and roof-rail mounted side curtains. The Honda was equipped with BF Goodrich Traction T/A P215/65R16 98 M&S tires on alloy wheels. The recommended tire pressure was 200 kPa (29 PSI) front and rear. The specific measured tire data at the time of the SCI inspection was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	N/A – Tire damaged	6 mm (8/32)	No	Sidewall puncture/ Rim impact damage
LR	207 kPa (30.0 PSI)	7 mm (9/32)	No	None
RF	207 kPa (30.0 PSI)	6 mm (8/32)	No	None
RR	N/A – Tire flat	6 mm (8/32)	No	Debeaded

1995 Dodge Neon

The 1995 Dodge Neon, **Figure 3**, was identified by the Vehicle Identification Number (VIN): 1B3ES47C9SD (production sequence omitted). The four-door sedan was equipped with a 2.0 liter, four-cylinder engine; four-speed automatic transmission, power steering, power-front disc/rear drum brakes, and OEM steel wheels. The manual restraint systems consisted of 3-point lap and shoulder belts for the four outboard positions and a rear center lap belt. The Supplemental Restraint System consisted of air bags



Figure 3: Front right view of the Dodge Neon.

for the driver and front right passenger positions. The odometer reading at the time of the inspection was 347,690 kilometers (216,045 miles). The vehicle’s date of manufacture was unknown. It should be noted the VIN sticker on the driver door was different from the windshield VIN. This was an indicator that the left front door had been replaced prior to the crash. The Dodge was equipped with a mismatched set of tires at the time

of the crash. The left front tire was a Goodyear Conquest GL P185/65R14. The right front tire was a Firestone FR380 P175/80R13. The rear tires were Dayton Thorobred P185/80R13. The manufacturer recommended tire sizes were P175/70R14 and P185/65R14. The recommended tire pressure was 220 kPa (32 PSI). The worn front tire treads and the mismatch in tire size coupled with the wet road conditions were a probable contributing factor in the loss of control that preceded the crash. The specific measured tire data was as follows:

Tire	Measured Pressure	Tread Depth	Restricted	Damage
LF	110 kPa (16.0 PSI)	2 mm (2/32)	No	None
LR	69 kPa (10.0 PSI)	6 mm (8/32)	No	None
RF	172 kPa (25.0 PSI)	4 mm (5/32)	No	None
RR	131 kPa (19.0 PSI)	6 mm (8/32)	No	None

SUMMARY

Crash Site

This two-vehicle crash took place during the daylight hours of November 2005. At the time of the crash, it was raining and the asphalt road surface was wet. The crash occurred on a two-lane east/west road in a residential setting. The road was straight and there was a negative five percent grade in the westbound direction. The 2.9 m (9.5 ft) wide traffic lanes were separated by a broken yellow centerline. The outboard edges of the traffic lanes were delineated by solid white edge lines. The north roadside consisted of private residences. The south roadside was wooded. At the crash site, a concrete residential driveway intersected the road from the north. The speed limit in the area of the crash was 72 km/h (45 mph). **Figures 4 and 5** are views of the crash site taken during the SCI scene inspection.



Figure 4: Westbound trajectory view of the Honda.



Figure 5: Lookback view from the final rest of the Honda.

CRASH SEQUENCE

Pre-Crash

The 2005 Honda CR-V was westbound operated by a 54 year old male. He was restrained by the vehicle's three-point lap and shoulder belt and was the vehicle's sole occupant. The 1995 Dodge Neon was eastbound driven by a 37 year old unrestrained female. A witness to the crash reported that the Dodge drifted to the left across the centerline into the westbound travel lane. The driver of the Dodge then steered right in an attempt to reenter the proper travel lane, however, in the process of this maneuver she overcorrected. The driver of the Dodge then counter-steered back to the left and lost directional control of the vehicle. The Dodge reentered the westbound lane directly in the path of the Honda. The combination of the wet road, the mismatched tire size, the worn tread of the front tires, and the speed of the Dodge were contributing factors to the loss of the control. The driver of the Honda had no recollection of the crash; therefore pre-crash maneuvers by the Honda driver are unknown. A schematic of the crash is attached to the end of this narrative report as **Figure 15**.

Crash

The right and center aspects of the Dodge's frontal plane impacted the left and center aspect of the front of the Honda in an offset configuration. The directions of force were in the 1/12 o'clock sector for the Dodge and Honda, respectively. The force of the impact caused the Honda driver's seat belt buckle pretensioner to fire, and deployed the driver air bag, the left side impact air bag and left inflatable side curtain. The frontal air bags in the Dodge did not deploy. The offset nature of the impact resulted in a counterclockwise rotation of both vehicles. The Honda separated from the impact with a northwest trajectory and came to rest in the mouth of the concrete driveway. The Honda slid to rest 4.2 m (17 ft) from the impact and had rotated 50 degrees counterclockwise. The Dodge separated from the impact with a southeast trajectory and rapid rotation. The Dodge rotated 280 degrees and slid to final rest in the eastbound lane facing south 4.9 m (16 ft) from the impact. The severity of the impact (delta V) was calculated by the Damage Algorithm of the WINSMASH model. The total delta V Honda was 29.0 km/h (18.0 mph) and the longitudinal and lateral components were -28.6 km/h (-17.8 mph) and 5.0 km/h (3.1 mph), respectively. The total delta V of the Dodge was 41.0 km/h (25.5 mph). Its longitudinal and lateral delta V components were -38.5 km/h (-23.9 mph) and -14.0 km/h (8.7 mph), respectively.

Post-Crash

Ambulance personnel and the police responded to the crash. The police report indicated the ambulance arrived on-scene 8 minutes post-crash. The police arrived 18 minutes post-crash. The driver of the Honda was found slumped across the center console with his head in the front right passenger seat. The driver was removed from the vehicle by EMS and transported to a Level II trauma center located within 24 km (15 miles) of the crash site. Upon examination in the emergency room, he was alert and responsive with a GSC of 15. He was able to breath on his own, but could not move any of his extremities. The driver was diagnosed with an acute anterior fracture/subluxation of C4 with respect to C5 with an associated quadriplegia (AIS 5). He was admitted in critical but stable condition into the neurological intensive care unit. The driver underwent a cervical fusion procedure the day following the crash. He was hospitalized

22 days and discharged to a rehabilitation hospital. He has feeling in all four extremities, only limited motion in one extremity and is ventilator dependant. The unrestrained driver of the Dodge Neon sustained a police reported head injury as a result of contact to the right aspect of the windshield. She was treated and released the day of the crash.

2005 HONDA CR-V

Exterior Damage

The exterior of the Honda sustained moderate level frontal damage as a result of the impact. **Figures 6 and 7** are the front and overhead views of the vehicle. The Honda's front plane sustained 58 cm (22.8 in) of direct contact damage that began 11 cm (4.3 in) left of center and extended to the left front bumper corner. The combined width of the direct and induced damage extended across the entire 140 cm (55 in) frontal end width. The damaged exterior components included the bumper fascia, reinforcement bar, left headlamp assembly, hood, and left front fender. The residual crush measured along the bumper reinforcement was as follows: C1 = 33 cm (13.0 in), C2 = 43 cm (16.9 in), C3 = 37 cm (14.6 in), C4 = 18 cm (7.1 in), C5 = 8 cm (3.1 in), C6 = 0 cm (0 in). The maximum crush was located at C2. Visual inspection of the vehicle's undercarriage revealed deformation and buckling of the left sub-frame and floorpan rearward to approximately the left B-pillar area longitudinally and laterally inboard to the vehicle's centerline. The right wheelbase dimension was unchanged. The force of the impact fractured the upper control arm of the left front suspension and the left front wheel/tire was displaced rearward impacting the dogleg at the aft aspect of the wheel opening. The left front wheel rim was deformed and the inboard sidewall of the tire was punctured. The left lower aspect of the windshield was fractured due to the deformation of the frontal structure. Minor roof buckling was noted along the left roof rail 8 cm (3 in) forward of the left B-pillar. All the doors were operational post-crash. All the side window glazings were intact with the exception of the right rear (second row). This window was reportedly shattered by the EMS during the rescue operations. The Collision Deformation Classification of the Honda was 12-FYEW2.



Figure 6: Front view of the Honda.



Figure 7: Overhead view.

1995 DODGE NEON

Exterior Damage

Figures 8 and 9 are views of the frontal damage to the Dodge Neon. During the offset frontal impact, the vehicle sustained 77 cm (30.3 in) of direct contact damage that began at the right front corner and ended 17 cm (6.5 in) left of center. The combined width of the direct and induced damage extended across the entire 137 cm (54 in) frontal end width. The right bias of the frontal crush and lateral deformation of the frontal structures were indicative of the offset nature of the impact and the 1 o'clock direction of force. The front bumper fascia, foam absorber and reinforcement bar separated from the vehicle during the impact. These components were found inside the vehicle. The fascia and absorber were fractured 24 cm (9.5 in) right of center and 17 cm (6.5 in) right of center, respectively, consistent with the impact dynamics. The residual frontal crush profile was as follows: C1 = 11 cm (4.3 in), C2 = 25 cm (9.8 in), C3 = 37 cm (14.6 in), C4 = 31 cm (12.2 in), C5 = 24 cm (9.4 in), C6 = 22 cm (8.7 in). The maximum crush was located at C3. The right wheelbase dimension was unchanged. The left wheelbase was reduced 11 cm (4.5 in). All the doors were operational post-crash. The unrestrained driver responded to the 1 o'clock direction of the impact by translating right and forward. The transmission selector was displaced into the 1 o'clock sector. The right aspect of the windshield was fractured by occupant contact. The Collision Deformation Classification of the Dodge was 01-FZEW2.



Figure 8: Front view of the Dodge.



Figure 9: Overhead view.

2005 HONDA CR-V

Interior Damage

The interior of the Honda, **Figure 10**, sustained minor intrusion as a result of the impact. The longitudinal intrusion of the left corner of the instrument panel measured 2 cm (0.75 in). The outboard aspect of the left toe pan intruded 5 cm (2 in). The floorpan and left frame damage referred to earlier in this report caused minor intrusion of the left sill and left B-pillar. The lateral sill intrusion measured at the base of the left B-pillar was 2 cm (1 in). The intrusion of the B-pillar measured at the belt line was 4 cm (1.5 in). The driver bolster exhibited two areas of contact from the driver's lower extremities.



Figure 10: View of the driver position and bolster contacts.

The bolster was cracked from a left lower extremity contact immediately above the fuse panel access cover.

This contacted was located 20 cm (8 in) left of the steering wheel centerline and 48 cm (19 in) above the floor. A scuff mark located 15 cm (6 in) right of the steering wheel centerline and 46 cm (18 in) above the floor was related to a right lower extremity contact.

The driver seat was located in a full rear track position. This position was consistent with the driver's reported stature. The total seat track travel measured 22 cm (8.75 in). The seat back was reclined 20 degrees. The horizontal distance from the center of the steering wheel hub/driver air bag module to the seat back measured 61 cm (24 in). This horizontal distance was measured 38 cm (15 in) above the seat bight.

The four-spoke steering wheel rim was rotated approximately 120 degrees counterclockwise at the time of the SCI inspection. The tilt steering column was in the full up position. There was no deformation of the steering wheel rim and no displacement of the steering column shear capsules.

Manual Restraint System

The driver's safety belt was a three-point lap and shoulder restraint with continuous loop webbing, Emergency Locking Retractor (ELR), and a sliding latch plate. A pretensioner was incorporated into the buckle stalk that was attached to the inboard aspect of the seat. The D-ring was adjustable and was in the full-up position. **Figure 11** is a view of the driver seat and restraint. The driver was restrained by the safety belt at the time of the crash. Examination of the restraint revealed the webbing was cut in two places by the first responders during the rescue operations. The webbing was cut 30 cm (12 in) above the fixed outboard anchor and 10 cm (4 in) below the D-ring. The length of the cut webbing section measured 129 cm (51 in) and was comprised of 57 cm (22.5 in) in the lap section and 72 cm (28.5 in) in the section lying across the torso. The location of the latch plate was identified by a crease of the webbing indicative of



Figure 11: Driver seat and safety belt.

loading. An 11 cm (4.5 in) abrasion of the outer surface of the webbing (away from the driver) began 10 cm (4 in) above the latch plate and related to contact with the deployed driver air bag. The ELR retractor was in a locked condition; the webbing would not extend or return. A minor abrasion was identified on the surface of the D-ring indicative of restraint loading. The buckle pretensioner fired as a result of the impact. The height of the buckle stalk was reduced 5 cm (2 cm).

Certified Advanced 208-Compliant Air Bag System

The Certified Advanced 208-Compliant (CAC) frontal air bag consisted of advanced dual stage, dual threshold air bags for the driver and front right passenger, seat track position sensors, front safety belt buckle switches, front safety belt buckle pretensioners and a front right occupant detection sensor. The frontal air bag system was certified by the manufacturer to have met the requirements of the advanced Federal Motor Vehicle Safety Standard 208. The system was controlled and monitored by a control module located under the center console. Additionally, two crash sensors, symmetrically located on forward frame rails, were used to aid in crash detection and assess crash severity.

The driver air bag, **Figure 12**, deployed as a result of the offset frontal crash. The H-configuration driver air bag module was located in the center hub of the steering wheel rim. The symmetrical upper and lower flaps measured 6 cm x 16 cm (2.5 in x 6.3 in), height by width, respectively. The flaps opened at the designed tear seams during the deployment sequence and were free from occupant contact. The deployed driver air bag measured 61 cm (24 in) in diameter. The bag was tethered by two 6 cm (2.5 in) wide straps in the 6/12 o'clock sectors and was vented by two 4 cm (1.5 in) diameter ports located in the 11/1 o'clock sectors. The face of the bag was soiled from post-crash handling in the 6 o'clock sector and along the perimeter seam in the 3 o'clock sector.



Figure 12: Driver air bag.

The front right passenger air bag was a top mount design located in the right aspect of the instrument panel. It did not deploy during the crash sequence. The front right air bag suppressed at the time of the crash by the occupant presence detection sensor. The front right seat was not occupied. The driver was the sole occupant of the vehicle

Inflatable Side Impact Protection

The subject Honda was equipped with front seat back mounted thorax bags and roof rail mounted side curtains. The left side inflatable impact protection deployed as a result of the offset frontal crash. **Figure 13** is a lateral view of the deployed inflatable left side impact protection.

The thorax bag was housed in a module in the outboard bolster of the front seat back and expanded forward. The module measured 23 cm (9 in) in height and the base of the module was 20 cm (8 in) above the seat bight. The deployed bag was rectangular in shape and measured 33 cm x 27 cm (13 in x 10.5 in), length x height respectively. The length dimension was measured to the module recessed within the seat bolster. The bag extended 24 cm (9.5 in) forward of the seat bolster. The bag was tethered by 5 cm (2 in) wide strap. It was vented by two 3.8 cm (1.5 in) ports located on the bag's forward vertical seam. There was no evidence of driver contact to the bag.

The inflatable side curtain deployed downward from the left roof rail. The curtain provided coverage that extended from the A- and C-pillars. Upon deployment, the curtain was inflated by helium stored in a canister located in the C-pillar. The gross overall dimensions of the curtain measured 160 cm x 46 cm (63 in x 18 in), length by height respectively. The curtain was tethered at the A- and C-pillars. During the rescue operations, the first responders cut and removed a 69 cm (27 in) length of the curtain located between the left A- and B-pillar. **Figure 14** is an overall view of the cut section. This section of the bag was found in the interior of the Dodge Neon during its inspection. It was located amidst debris cleaned up from the crash site and placed in the Dodge. The inboard surface of the bag was soiled from post-crash handling and masked any potential contact evidence. There was no direct evidence of driver contact identified.



Figure 13: Interior lateral view.



Figure 14: Left curtain section cut by EMS.

DRIVER DEMOGRAPHICS

	<i>Driver</i>
Age/Sex:	54 year old/Male
Height:	185 cm (73 in)
Weight:	77g (170 lb)
Seat Track Position:	Full rear
Restraint Use:	Three-point lap and shoulder belt
Usage Source:	SCI inspection, observations of the first responders
Medical Treatment:	Hospitalized 22 days and discharged to rehabilitation
Major Injury:	Acute fracture/subluxation of C4/C5 with quadriparesis

DRIVER INJURY

<i>Injury</i>	<i>Injury Severity (AIS 98 Update)</i>	<i>Injury Source</i>
Anterior subluxation of C4/C5 by over 1 cm and fracture of the left side of the C5 vertebral body with quadriparesis	Critical (640228.5,6)	Hyper-flexion of the neck due to inertial loading of the safety belt
C4 vertebral facet fracture	Serious (650222.3,6)	Hyper-flexion of the neck due to inertial loading of the safety belt
Left shoulder contusion	Minor (790402.1,2)	Inertial loading of the safety belt
Abrasion and contusion over the left hip	Minor (890202.1,2) (890402.1,2)	Lap belt loading

The above injuries were identified in the treating hospitals Emergency Room records, Discharge Summary and Radiology reports.

Discussion

As a result of the crash, the driver sustained an acute anterior fracture subluxation of C4/C5 with resultant quadriparesis. The documented mechanism for this type of injury is hyper-flexion of the neck with a probable rotational component. In a frontal crash, a flexion/hyper-flexion kinematic pattern of the neck results during the inertial loading of the safety belt by the torso. As the chest decelerates, the unrestrained inertia of the head results in a forward and downward translation of the head relative to the body. The neck is forced into flexion. Hyper-flexion results when the deceleration causes the relative motion of the cervical anatomy to move beyond its normal limits.

Reportedly, the driver was a healthy 54 year old male. However, a further review of the driver's medical records indicated that a cervical degenerative process was evident. The CT scans of the cervical spine indicated: "...*There are diffuse degenerative changes including marked spurring of the vertebral bodies both anteriorly and laterally. This is causing bony foraminal narrowing at several exiting foramen. There is also diffuse increased density noted throughout the osseous framework...*" This pre-existing condition most likely was a contributing factor to the overall severity of the driver's injury.

The driver had no medically documented neck or facial soft tissue injuries. The lack of this type of injury coupled with the lack of physical evidence on the deployed inflatable restraints suggests the driver had minimal direct involvement with the expanding air bags. Additionally, the restrained driver's stature and rear seat track position positioned him at the outer limits of the expanded driver air bag. Therefore, these components can be ruled out as an injury source.

DRIVER KINEMATICS

Immediately prior to the crash, the 54 year old driver was seated in a full rear track seat position with a presumed upright posture. He was restrained by the vehicle's manual safety belt system

and was in the process of his morning work commute. He had no recollection of evasive pre-crash maneuvers or the impact.

Upon impact, the safety belt system's ELR locked in response to the inertial forces of the crash. The air bag control module (ACM) fired the buckle pretensioner, and deployed the advanced driver air bag and the inflatable left side impact protection. The tension created in the lap section of the safety belt by the fired pretensioner likely caused the abrasion/contusion over the driver's left hip. The driver responded to the 12 o'clock direction of the impact force by initiating a forward trajectory. The driver's chest and pelvis loaded the locked safety belt system and he began to ride down the force of the impact. The restraint loading resulted in a left shoulder contusion. The inertia of the unrestrained head (relative to the decelerating torso) caused the neck to flex forward and down. The neck hyper-flexed beyond its anatomical limits and resulted in the C4 facet fracture and the C4/C5 anterior fracture/subluxation. The C5 vertebral body was fractured on the left. The asymmetry of the fracture may be an indicator the driver's head was turned to the right. The fracture/subluxation combined with the cervical degenerative changes resulted in the driver's quadriparesis. The driver rebounded into the seat as the Honda came to rest and then he slumped to his right where he was found.

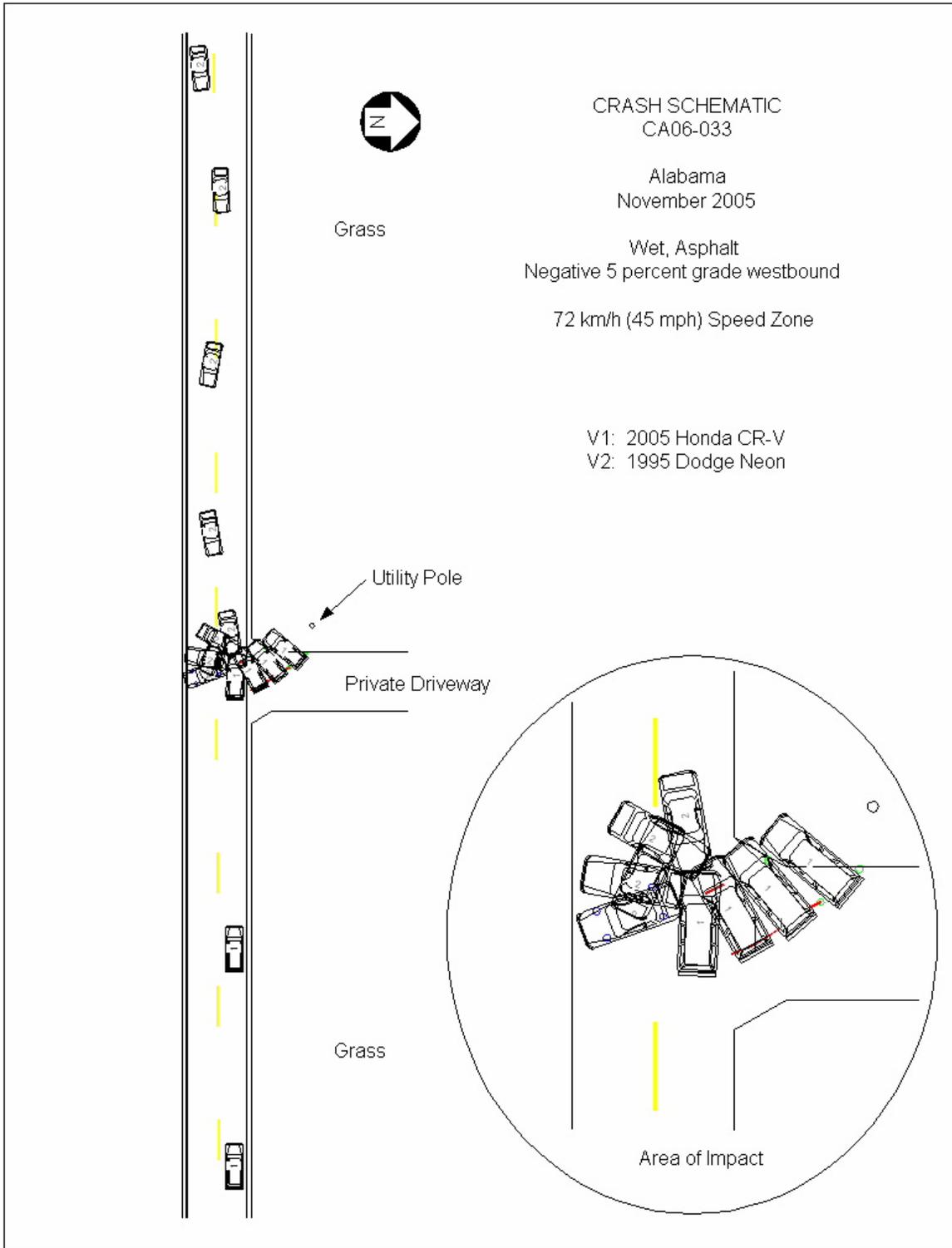


Figure15: Crash Schematic.