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ON-SITE ADAPTIVE CONTROL-EQUIPPED VEHICLE INVESTIGATION

CASE NUMBER - IN-05-030
LOCATION - INDIANA
VEHICLE - 1998 FORD E-150 ECONOLINE VAN
CRASH DATE - September 2005

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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

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15. *Supplementary Notes*
On-site adaptive control-equipped vehicle investigation involving a 1998 Ford E-150 Econoline van equipped with driver and front right passenger air bags, driver wheelchair securement device ; adaptive steering, braking and acceleration controls and an after-market, two-point driver safety belt system.

16. *Abstract*
This report covers an on-site investigation of an adaptive-control equipped 1998 E-150 Econoline van (case vehicle) and a 2000 Honda Accord (other vehicle), which were involved in an offset frontal collision on a two-lane state highway. This crash is of special interest because the case vehicle was equipped with adaptive control features and the disabled driver [34-year-old, White (non-Hispanic) female; sustained a police reported "A" injury. The case vehicle was traveling northeast in a right curve. The Honda was traveling southwest approaching the curve. As the Honda entered the curve, the case vehicle crossed the centerline into the Honda's travel lane. The front of the case vehicle impacted the front of the Honda. The impact caused the case vehicle to rotate counterclockwise and the Honda to rotate clockwise and both vehicle's traveled north and came to rest on the north side of the roadway heading slightly northwest. The case vehicle's disabled driver was seated in an Inva care Mark IV powered wheelchair with two-point lap belt. The wheelchair was equipped with a docking system that locked the wheelchair to a floor-mounted "EZ Lock" wheelchair securement device. The case vehicle was also equipped with other adaptive control features that allowed the driver to operate the vehicle without the use of her lower extremities. In addition, the driver was restrained by a two-point safety belt with a locking latch plate, which replaced the case vehicle's manual, three-point, lap-and-shoulder belt system. The driver sustained a liver and spleen laceration from loading the lower steering wheel rim during the crash. She also sustained a comminuted right distal femur fracture and fracture of the proximal tibial shaft from contact with the adaptive control equipment crossbar, which actuates the brake and accelerator control rods. She was transported from the scene by ambulance to a hospital and admitted for treatment of her injuries.

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TABLE OF CONTENTS

Page No.

This investigation was brought to NHTSA's attention on September 7, 2005 by a contact within the National Transportation Safety Board. This crash involved a 1998 Ford E-150 Econoline van (case vehicle) and a 2000 Honda Accord LX (other vehicle), which were involved in an offset frontal collision on a two-lane state highway. The crash occurred in September, 2005, at 4:06 p.m., in Indiana and was investigated by the county sheriff department. This crash is of special interest because the case vehicle was equipped with adaptive control features and the disabled driver [34-year-old, White (non-Hispanic) female] sustained a police reported "A" injury. This contractor inspected the scene and vehicles on September 28, 2005, interviewed the case vehicle driver's husband on September 29, 2005 and interviewed a witness and the investigating police officer in January 2006. The driver's husband was interviewed again on September 18, 2006. This report is based on the police crash report, scene and vehicle inspections; interviews with the case vehicle driver's husband, a witness and the investigating police officer; occupant kinematic principles and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling northeast in a right curve on a two-lane state highway. The Honda was traveling southwest approaching the curve. As the Honda entered the curve, the case vehicle crossed the centerline into the Honda's travel lane. The front of the case vehicle impacted the front of the Honda. The impact caused the case vehicle to rotate counterclockwise and the Honda to rotate clockwise. Both vehicle's traveled north and came to rest on the north side of the roadway heading slightly northwest. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry, traveled bituminous.

The case vehicle's disabled driver was seated in an Invacare Mark IV powered wheelchair. The wheelchair was equipped with a docking system that locked the wheelchair to a floor-mounted "EZ Lock" wheelchair securement device. The wheelchair was also equipped with a two-point lap belt, which the driver was using at the time of the crash. In addition, the driver was restrained by a two-point safety belt with a locking latch plate, which replaced the case vehicle's manual, three-point, lap-and-shoulder safety belt system. The case vehicle was equipped with other adaptive control features that allowed the driver to operate the vehicle without the use of her lower extremities. The investigation indicated that the wheelchair remained locked in its securement device and the driver remained restrained in her wheelchair during the crash. However, she sustained a liver and spleen laceration from loading the lower steering wheel rim during the crash. She also sustained a comminuted right distal femur fracture and fracture of the proximal tibial shaft from contact with the adaptive control equipment crossbar, which actuates the brake and accelerator control rods. The driver was transported from the scene by ambulance to a hospital and admitted for treatment of her injuries. Lastly, it is not known why the case vehicle entered the opposing travel lane. However, this contractor's investigation indicated that the case vehicle's adaptive controls were most likely not a primary pre-crash factor in this crash.

The CDC for the case vehicle was determined to be: **12-FDEW-3** (**10** degrees). The maximum residual crush to the front of the case vehicle was measured as 42 centimeters (16.5 inches) occurring at C_4. The left side wheelbase was shortened 9 centimeters (3.5 inches) while

the right side wheelbase was extended 3 centimeters (1.2 inches). The WinSMASH reconstruction program, damage only algorithm, calculated the case vehicle's Total, Longitudinal, and Lateral Delta Vs respectively as: 36 km.p.h. (22.4 m.p.h.), -35.5 km.p.h. (-22.1 m.p.h.), and -6.3 km.p.h. (-3.9 m.p.h.). The case vehicle was towed due to damage.

The CDC for the Honda was determined to be: **11-FYAW-6** (**340** degrees). The maximum residual crush to the front of the Honda was measured as 71 centimeters (28 inches) occurring at C_1. The left side wheelbase was reduced 43 centimeters (16.9 inches) while the right side wheelbase was extended 1 centimeter (0.4 inch). The WinSMASH reconstruction program, damage only algorithm, calculated the Honda's Total, Longitudinal, and Lateral Delta Vs respectively as: 55 km.p.h. (34.2 m.p.h.), -51.7 km.p.h. (-32.1 m.p.h.), and 18.8 km.p.h. (11.7 m.p.h.). The Honda was towed due to damage.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was a curved, two-lane, undivided, state highway, traversing generally in a northeasterly and southwesterly direction. The site of the crash was in a school zone, near a three-leg "Tee" intersection with a county road, located on the north side of the highway. On the approach to the "Tee" intersection, there was an outside passing lane for northeastbound traffic and a right turn lane for southwestbound traffic. The northeastbound through lane was 3 meters (9.8 feet) in width and the outside passing lane was 3.7 meters (12 feet) in width. The southwestbound through lane was 3.8 meters (12.5 feet) in width and the right turn lane was 3.7 meters (12 feet) in width. The roadway was bordered by bituminous shoulders, which were 1.4 meters (4.6 feet) in width on the north side of the roadway and 0.9 meter (3 feet) in width on the south side of the roadway. Pavement markings consisted of solid white edge lines, solid white outside passing lane line, solid white right turn lane line and reflective center line markers with a solid yellow no-passing line on each side. Curve warning signs were posted for each travel direction on the approach to the curve. A "Large Arrow" warning sign was posted at the peak of the curve providing warning of a sharp change of alignment for each travel direction. The speed limit is unknown. There was no regulatory speed limit sign posted near the crash site and none indicated on the police crash report. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was dry, traveled bituminous with an estimated coefficient of friction of 0.70. The roadway vertical alignment was 1.3 % positive for northeastbound traffic (i.e., case vehicle's approach) and 1.3% negative for southwestbound traffic. The superelevation of the curve was 4.8% positive. At the time of the crash traffic density was moderate and the site of the crash was a rural school zone. See the Crash Diagram at the end of this report.

Figure 1: Approach of case vehicle northeastbound to area of impact (arrow)

Pre-Crash: The case vehicle was traveling northeast (**Figure 1** above) and the driver was negotiating the right curve. The evidence indicates that the case vehicle began to cross the centerline and travel into the opposing lane as the case vehicle was exiting the curve. The Honda was traveling southwest (**Figure 2** below) and the driver was intending to continue southwestbound through the curve. Based on witness statements, it does not appear that the driver took any actions to avoid the crash. A witness that was traveling behind the case vehicle indicated he did not see any brake lights from the case vehicle prior to the crash. In addition, there was no indication of locked wheel braking or anti-lock braking marks from the case vehicle visible in the police on-scene photos. The crash occurred in the southwestbound lane of the roadway at the approximate end of the curve (**Figure 3** below).

It is not known why the case vehicle entered the opposing travel lane. However, this contractor's investigation indicated that the case vehicle's adaptive controls were most likely not a primary pre-crash factor in this crash. A witness that was traveling behind the case vehicle indicated that there was no abrupt or unusual movement of the case vehicle prior to it crossing over the center line. He indicated that the case vehicle's movement into the opposing lane was a "gradual swerve". Projecting the case vehicle's approximate approach path backwards from the impact point suggests that the case vehicle's driver negotiated the majority of the curve but began to travel left of center east of the curve's apex. Interview information and a review of the driver's medical records indicated that other factors existed at the time of the crash that may have played a role in distracting the driver or affected her ability to control the vehicle in a sharp curve. The driver was not familiar with the roadway, and there was a dog in the vehicle at the time of the crash. In addition, the driver had a history of two previous strokes, the second[1] of which had caused her to be physically disabled and have a history[2] of expressive aphasia, hemiplegic migraine headaches, and spastic quadriparesis. Furthermore, the driver has residual weakness in her lower

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[1] The second stroke resulted in a brainstem infarct, "locked-in" syndrome, and atretic vertebrobasilar system; see definitions below.

[2] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:

aphasia (a-fa'zha): any of a large group of *speech disorders* involving defect or loss of the power of expression by speech, writing, or signs, or of comprehending spoken or written language, due to injury or disease of the brain or to psychogenic causes. Less severe forms are known as ***dysphasia***.

atresia (a-tre'zha): congenital absence or closure of a normal body orifice or tubular organ.

atretic (a-tret'ik): without an opening; pertaining to or characterized by atresia.

hemiplegic migraine: migraine associated with varying degrees of transient hemiplegia or hemiparesis.

infarct (in'fahrkt): an area of coagulation necrosis in a tissue due to local ischemia resulting from obstruction of circulation to the area, most commonly by a thrombus or embolus.

quadriparesis (kwod"ri-pare'sis): tetraparesis.

syndrome (sin'drm) [Gr. syndrom concurrence]: a set of symptoms that occur together; the sum of signs of any morbid state; a symptom complex. In genetics, a pattern of multiple malformations thought to be pathogenetically related. See also *disease*.

locked-in syndrome: quadriplegia and mutism with intact consciousness and the preservation of voluntary vertical eye movements and blinking; usually due to a vascular lesion of the pars ventralis pontis.

stroke syndrome: a condition with sudden onset caused by acute vascular lesions of the brain, such as infarction from hemorrhage, embolism, or thrombosis, or rupturing aneurysm. It may be marked by any of a variety of symptoms reflecting the focus of infarction or hemorrhage, including hemiparesis, vertigo, numbness, aphasia, and dysarthria; it is often followed by permanent neurologic damage. Called also ***cerebrovascular accident*** and ***stroke***.

***spastic (spas'tik)* [Gr. spastikos]**: 1. of the nature of or characterized by spasms. 2. hypertonic, so that the muscles are stiff and the movements awkward.

spastic paraplegia: any of a group of diseases marked by spasticity of the muscles of the paralyzed part and increased tendon reflexes, due to damage to the corticospinal tract.

tetraparesis (tet"ra-pa-re'sis): muscular weakness affecting all four extremities.

vertebrobasilar (vrt-bro-bas'-lr): pertaining to or involving the vertebral and basilar arteries.

extremities and uses a powered wheelchair to get around. The driver indicated that she can ambulate at home with a walker. Given this "mix" of existing factors and lack of information regarding the case vehicle driver's pre-crash actions, it is unknown what, if any, specific factor, or combination thereof, resulted in the case vehicle's encroachment into the Honda's travel path.

Figure 2: Approach of Honda southwest to area of impact (arrow)

Figure 3: Police on-scene photo showing overview of impact area (arrow) and final rest of case vehicle from case vehicle's approach

Figure 4: Damage to front of case vehicle from impact with the Honda, numbers on vertical scale are tenths of meter, each increment on rods is 5 cm (2 in)

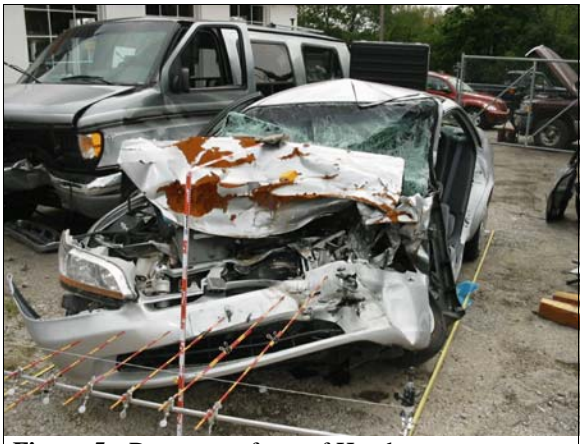


Figure 5: Damage to front of Honda

Crash: The front of the case vehicle (**Figure 4**) impacted the front of the Honda (**Figure 5**), causing the case vehicle's driver and front right passenger air bags to deploy. The Honda's driver and front right passenger air bags also deployed in the crash.

Post-Crash: As a result of the impact, the case vehicle rotated approximately 90 degrees counterclockwise and came to final rest approximately perpendicular to the roadway

Figure 6: Police photo of final rest positions

heading slightly northwest with the front of the case vehicle off the north roadside (**Figure 6** above). The Honda rotated approximately 90 degrees clockwise and came to final rest off the roadway on the north roadside heading slightly northwest with it's back wheels on the paved shoulder (**Figure 6** above).

CASE VEHICLE

The 1998 Ford E-150 Econoline van was a rear wheel drive, three-door, incomplete, full-sized van (VIN: 1FDRE1467WH------) equipped with a 4.6L, V8 engine; four-speed automatic transmission with overdrive and redesigned driver and front right passenger air bags. The case vehicle was equipped with at least rear wheel anti-lock brakes. Four wheel, anti-lock brakes were an option, but it is unknown if the case vehicle was so equipped. The case vehicle was also equipped with adaptive control equipment as described below. The case vehicle's wheelbase was 351 centimeters (138.2). The odometer reading at the time of the vehicle inspection was 87,776 kilometers (54,543 miles).

Figure 7: Front left overview of damage to case vehicle

Figure 8: Front right overview of damage to case vehicle

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's contact with the Honda involved the entire front plane of the case vehicle (**Figures 7** and **8**). The bumper, grille, radiator, hood, both headlamp/turn lamp assemblies, and the front of both fenders were all directly damaged and crushed rearward. The direct damage began at the front right bumper corner and extended 156 centimeters (61.4 inches) across the bumper. Residual maximum crush was measured as 42 centimeters (16.5 inches) occurring at C_4. The table below shows the case vehicle's front 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	156	42	180	4	15	30	42	24	19	0	0
in		61.4	16.5	70.9	1.6	5.9	11.8	16.5	9.4	7.5	0.0	0.0

The case vehicle's left side wheelbase was shortened 9 centimeters (3.5 inches) while the right side wheelbase was extended 3 centimeters (1.2 inches). There was induced damage to the hood, both fenders, the left front door, the left side panel rear of the door, and the windshield was cracked. No other obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

The case vehicle's recommended tire size was: P235/75R15XL, and the case vehicle was equipped with tires of this size. The case vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	200	29	283	41	11	14	None	No	No
RF	221	32	283	41	10	13	None	No	No
LR	221	32	283	41	11	14	None	No	No
RR	207	30	283	41	11	14	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior (**Figures 9** and **10**) revealed a possible driver right knee contact to the instrument panel and right leg contact to the brake actuator rod. No other evidence of occupant contact was observed to any interior surfaces or components. In addition, no occupant compartment intrusion was observed, and there was no deformation of the steering wheel or compression of the energy absorbing steering column. The driver's shoulder belt had been cut by rescue personnel

Figure 9: Overview of case vehicle's steering wheel, instrument panel, windshield and adaptive control equipment

Figure 10: Overview of case vehicle's center and right instrument panel, windshield and location of front right passenger air bag (arrow)

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-3** (**10** degrees). The WinSMASH reconstruction program, damage

only algorithm, was used to reconstruct the case vehicle's Delta V. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 36 km.p.h. (22.4 m.p.h.), -35.5 km.p.h. (-22.1 m.p.h.), and -6.3 km.p.h. (-3.9 m.p.h.). The case vehicle was towed due to damage.

Figure 11: Case vehicle driver's air bag module cover flap

Figure 12: Case vehicle driver's air bag vent ports

Figure 13: Case vehicle driver's air bag

AUTOMATIC RESTRAINT SYSTEM

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module cover flaps and the air bag fabric revealed that the cover flaps opened at the designated tear points (**Figure 11**), and there was no evidence of damage during the deployment to the air bag or the cover flaps. In addition, no damage was observed due to interaction of the air bag with the "Tri-Pin" type adaptive steering device that was attached to the steering wheel. The air bag module cover consisted of two semi-pliable vinyl cover flaps. The top cover flap was rounded at the top and rectangular at the horizontal tear seam. It was 19.5 centimeters (7.7 inches) in width and 11 centimeters (4.3 inches) in height at the center. The bottom cover flap was rectangular in shape and was 19.5 centimeters (7.7 inches) in width and 8 centimeters (3.2 inches) in height. The driver's air bag was designed with two tethers, each approximately 12 centimeters (4.7 inches) in width. The driver's air bag had two vent ports (**Figure 12**), each approximately 3.5 centimeters (1.4 inches) in diameter, located at the 11 and 1 o'clock positions. The deployed driver's air bag (**Figure 13** below) was round with a diameter of 63 centimeters (24.8 inches). An inspection of the driver's air bag fabric revealed no evidence of occupant contact.

The front right passenger's air bag was located in the middle of the instrument panel (**Figure 10** above). An inspection of the front right air bag module's cover flap and the air bag's fabric revealed that the cover flap opened at the designated tear points. There was no evidence of damage during the deployment to the air bag or the cover flap. However, the cover flap impacted and fractured the windshield.

The case vehicle was equipped with several devices that allowed for operation of the vehicle without the use of lower extremities. The hand control (**Figure 14**), manufactured by Crescent Industries, was located on top a "joystick" that was positioned to the left of the driver between the left front door and the steering wheel. The "joystick" assembly was bolted to the floor. The hand control consisted of a thick foam grip with two foam covered support posts in which the wrist was placed. If the hand control was tilted to the right or left, it depressed a red button. A voice module (**Figure 15**) located under the driver's instrument panel would then cycle through different options such as left turn signal, right turn signal, wiper, dimmer switch, etc. Once a desired option was electronically voiced, the driver would tilt the hand control once again, depressing the red button, which would then activate the selection. All equipment is programmed for each individual, so it is unknown exactly how many options the case vehicle had. Connected to the joystick, approximately 46 centimeters (18 inches) off the floor, was a connector rod that was attached to a horizontal bar running parallel to the instrument panel (**Figure 15** below). Two control rods were attached to this bar. One was attached to the brake pedal and the other to the accelerator pedal (**Figure 16** below). Braking was achieved by moving the joystick forward and acceleration by pulling it backward. Inspection of the system revealed that the actuator rods to the accelerator and brake pedals would not function. The joystick would move backward and forward, making the horizontal bar rotate, but this action would not cause any movement of the accelerator or brake actuator rods. It is likely that these functions were compromised as a result of the crash. The joystick was overextended forward during the crash to the extent that it impacted and damaged the accessories control box mounted on the instrument panel directly in front of it (**Figure 17** below). The accessories control box was equipped with switches that controlled the heater, left and right front windows, the head lights and the dome light.

Figure 14: Overview of hand control, "joystick" and connector rod

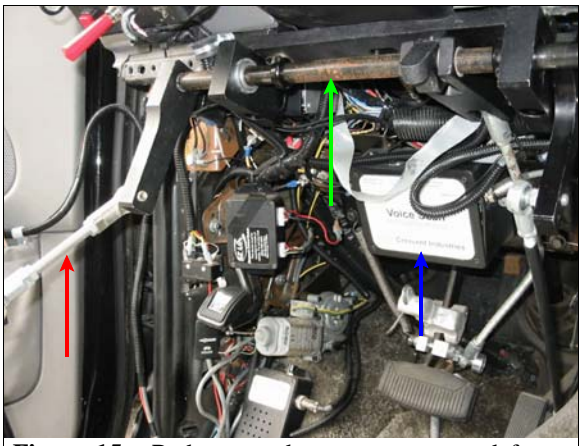


Figure 15: Red arrow shows connector rod from "joystick" to horizontal bar (green arrow) that connected to brake and accelerator actuator rods, blue arrow shows voice module

Figure 16: Red arrow shows brake actuator rod, blue arrow shows accelerator actuator rod, bend in brake actuator rod is not from occupant contact, it is bent to clear voice module

Figure 17: Damage to accessories control box mounted on left side of the steering wheel

Figure 18: "Drive Master" emergency power steering system backup control box

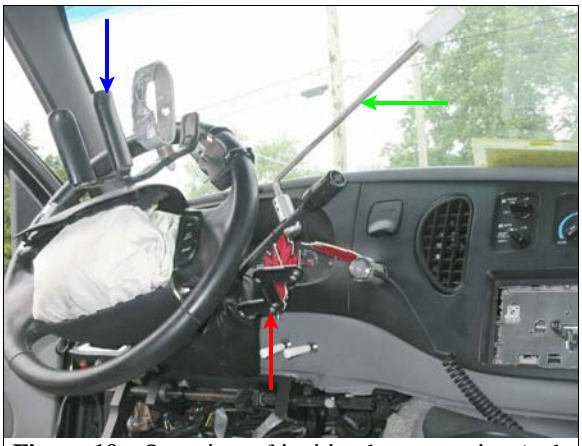


Figure 19: Overview of ignition key extension (red arrow), gear shift lever extension (green arrow) and"Tri-Pin" type adaptive steering device on steering wheel (blue arrow)

Other adaptive control equipment included a Drive-Master backup steering system. The backup steering control box was mounted on the left front door (**Figure 18**). In the event of a power steering failure, the system activates audio and visual alarms to alert the driver, and the backup system instantaneously activates. The case vehicle was also equipped with a reduced effort steering system. The ignition key was attached to a large handle allowing for more leverage when starting the vehicle (**Figure 19**), and the gear shift lever had an extension lever attached to it to facilitate gear selection (**Figure 19**). The steering wheel was equipped with a "Tri-Pin" type adaptive steering device (**Figure 19**), which allowed one-handed steering. This device is designed for drivers with no grip or diminished wrist stability. The device consisted of two pins and what appeared to be a modified palm grip (**Figure 20** below). The two pins supported the wrist and were covered with a rubber pad. The palm grip was mounted on its end and had duct tape wrapped around it, which closed the opening in the grip and appeared to be used as a hand grip by the driver. The "Tri-Pin" device was attached to the inside of the steering wheel at the 2 o'clock position by a mounting bracket. A second mounting bracket was also installed at the 10 o'clock position. The "Tri-Pin" device was attached to the mounting bracket by a pin which

allowed the device to swivel allowing steering with one hand. The location of the "Tri-Pin" device slightly overlapped the right side of the air bag module. There was no evidence on the air bag of any damage during the deployment. The case vehicle was also equipped with an "EZ Lock" wheelchair securement device (model BL 6290), which was bolted to the floor (**Figure 21**) in the driver's seating area. In addition, a wheelchair lift was installed in the right rear door. Lastly, the case vehicle's stock three-point, lap-and-shoulder safety belt system had been removed and was replaced with a two-point safety belt with a locking latch plate (**Figure 22** below). The safety belt's upper anchor was bolted to the "B"-pillar in the same location as the original upper anchor. The lower anchor was bolted to the floor near the left rear corner of the transmission tunnel adjacent to the floor-mounted wheelchair securement device. Lastly, the driver was seated in an Invacare Mark IV powered wheelchair equipped was a lap belt. It was purchased new in 2002. The wheelchair was not inspected.

Figure 20: "Tri-Pin" type adaptive steering device attached to steering wheel, arrow shows palm grip modified with duct tape and apparently used as a hand grip

Figure 21: Overview of wheelchair anchor (arrow) and adaptive control equipment

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [34-year-old, White (non-Hispanic) female; [175 centimeters and 61 kilograms (69 inches, 134 pounds)] was seated in her powered wheelchair in an unknown posture. It is unlikely that her back was against the back of the wheelchair. Her feet were likely resting on the floor or the foot rests of her wheelchair. Her left hand was in the "joystick" hand control, and her right hand was in the "Tri Pin" type adaptive steering device. The driver's wheelchair was locked in the wheelchair securement device that was attached to the floor of the case vehicle. The distance between the driver and the steering wheel is not known.

Based on this contractor's vehicle inspection, interview data and the police crash report, the case vehicle's driver was restrained by the after-market, two-point shoulder belt system and the wheelchair's two-point lap belt. Based on these sources of information, there was no indication that either belt was mis-positioned. The driver's husband indicated that the driver wore the lap belt low on her lap. No load marks were observed on the shoulder belt, but it had been cut by rescue personnel to facilitate driver removal (**Figure 22**), which suggested the belt was used in this crash.

Figure 22: Overview of case vehicle driver's safety belt, belt is clamped together at location belt was cut by rescue personnel (arrow)

It is unknown if the case vehicle's driver made any pre-crash avoidance maneuvers. The driver's position just prior to the impact is not known. The case vehicle's impact with the Honda caused the driver to continue forward and slightly rightward along a path opposite the case vehicle's 10 degree direction of principal force as the case vehicle decelerated. The driver loaded her safety belts and her face and chest impacted her deployed air bag. It is this contractor's opinion that due to the severity of the crash and the low engagement to the front of the case vehicle by the Honda, the driver also moved upward and her abdomen impacted the lower steering wheel rim lacerating her liver and rupturing her spleen. Also, the driver's left hand stayed in contact with the hand control and forced it forward into the accessories control box mounted on the instrument panel left of the steering wheel (**Figure 17** above). The driver's right knee impacted the instrument panel and her right leg impacted the adaptive control equipment crossbar, which actuates the brake and accelerator control rods, causing a distal right femur fracture and right tibia fracture. The driver remained in her wheelchair as the case vehicle rotated approximately 90 degrees counterclockwise to final rest. The driver was removed from the case vehicle by rescue personnel.

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver was transported by ambulance to the hospital and admitted for treatment of her injuries. She was hospitalized for 27 days. The table below shows the driver's injuries and injury mechanisms.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Fracture, comminuted, right distal femur {supracondylar} from distal shaft to meta-diaphyseal junction, extending into lateral condyle	serious 851822.3,1	Adaptive control equipment, cross-bar	Certain	Hospitalization records
2	Fracture, non-displaced, hairline, proximal tibial shaft	moderate 853420.2,1	Adaptive control equipment, cross-bar	Certain	Hospitalization records
	Complications include: acute respiratory failure with bilateral pleural effusions and some atelectasis–no pneumothorax	not coded			Hospitalization records
3	Laceration anterior segment right lobe of liver, extending toward right portal vein and vena cava with hemoperitoneum	moderate 541820.2,1	Steering wheel rim	Probable	Hospitalization records
4	Laceration {capsular tears} inferior pole of spleen without major disruption of parenchyma with splenectomy	moderate 544222.2,2	Steering wheel rim	Probable	Hospitalization records
5	Abrasion right chest, not further specified	minor 490202.1,1	Air bag, driver's	Probable	Emergency room records
6	Contusion right breast, not further specified	minor 490402.1,1	Air bag, driver's	Probable	Emergency room records
7	Abrasion right flank, not further specified	minor 590202.1,1	Torso portion of safety belt system	Possible	Emergency room records
8	Contusion right flank, not further specified	minor 590402.1,1	Torso portion of safety belt system	Possible	Emergency room records
9	Abrasion left flank, not further specified	minor 590202.1,2	Lap safety belt of electric wheelchair	Possible	Emergency room records
10	Abrasion right upper extremity, not further specified	minor 790202.1,1	Air bag, driver's	Probable	Emergency room records
11	Contusion right forearm, not further specified	minor 790402.1,1	Air bag, driver's	Probable	Emergency room records
12	Abrasion bilateral knees and left shin, not further specified	minor 890202.1,3	Adaptive control equipment under instrument panel	Certain	Emergency room records

The 2000 Honda Accord LX was a front wheel drive, four-door sedan (VIN: 1HGCG5640YA------). The Honda was equipped with redesigned driver and front right passenger air bags, which deployed as a result this vehicle's front impact. The Honda's wheelbase was 272 centimeters (107.1) inches. The odometer reading is not known because the Honda's interior was not inspected.

Exterior Damage: The Honda's impact with the case vehicle involved approximately two-thirds of the front plane (**Figure 23**). The front bumper, grille and hood were directly damaged and crushed rearward. Direct damage also involved the entire left fender, front portion of the left front door and the left portion of the windshield. In addition, the left "A"-pillar was severely crushed rearward (**Figure 24**). Direct damage began at the left bumper corner and extended 93 centimeters (36.6 inches) across the bumper. The maximum residual crush was measured as 71 centimeters (28 inches) occurring at C_1 (**Figure 24**). The table below shows the Honda's crush profile.

Figure 23: Damage to front of Honda from impact with case vehicle

Figure 24: Left side view of damage to Honda and crush to front bumper

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	93	71	79	71	66	47	32	19	2	-19	0
in		36.6	28.0	31.1	28.0	26.0	18.5	12.6	7.5	0.8	-7.5	0.0

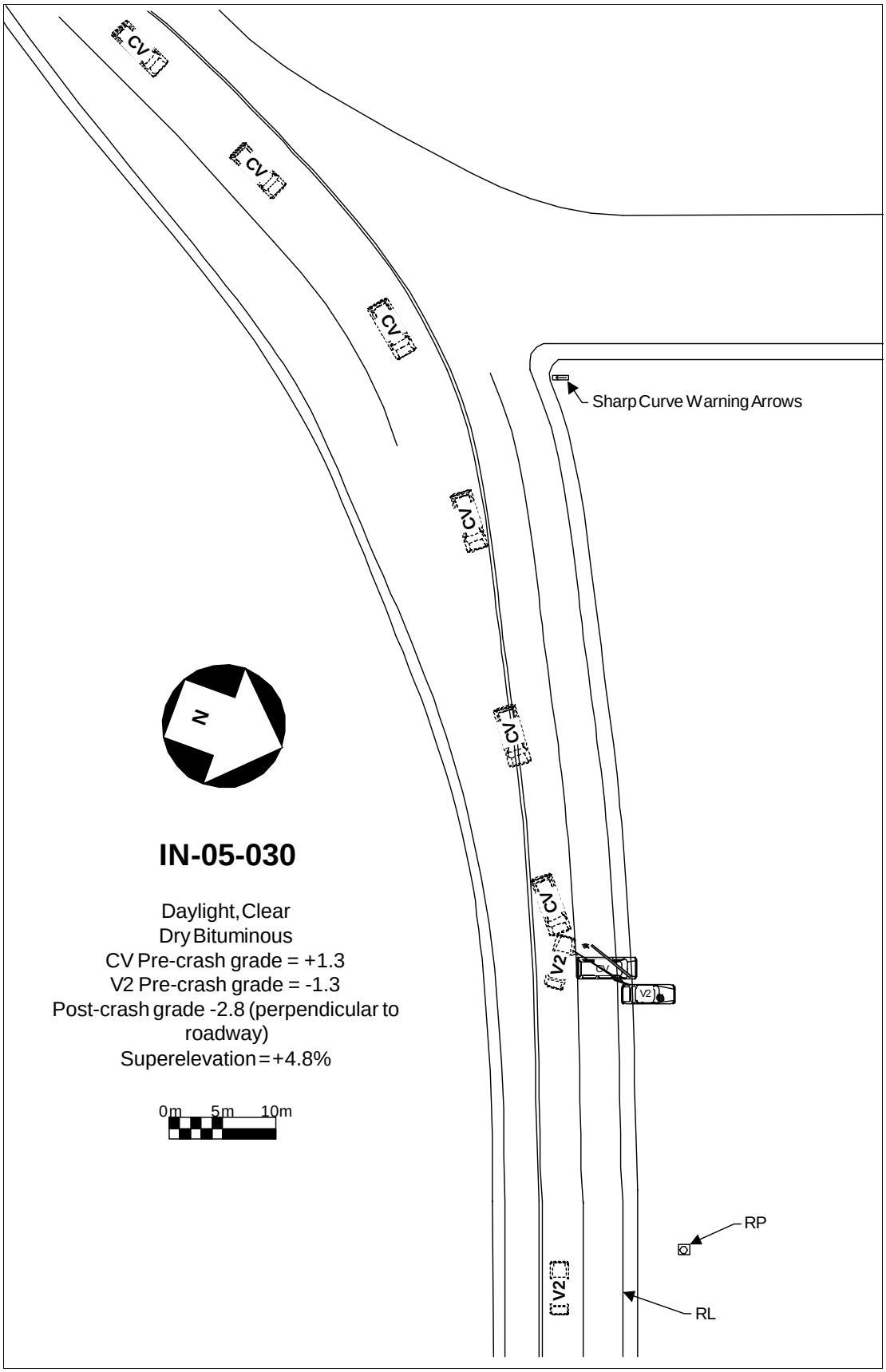
The Honda's left side wheelbase was reduced 43 centimeters (16.9 inches) while the right side wheelbase was extended 1 centimeter (0.4 inch). Induced damage involved the hood, roof, left front door, left rear door and right fender. In addition, the windshield was broken and holed.

The Honda's recommended tire size was: P195/65R15 and the vehicle was equipped with tires of this size. The Honda's tire data are shown in the table below.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	Flat	Flat	207	30	3	4	Unknown if cut or torn on inside	Yes	Yes
RF	207	30	207	30	3	4	None	No	No
LR	207	30	207	30	3	4	None	No	No
RR	186	27	207	30	3	4	None	No	No

Damage Classification: Based on the vehicle inspection, the CDC for the Honda was determined to be: **11-FYAW-6** (**340** degrees). "**A**" was assigned to column five of the CDC with extent zone 6 as a "best fit" to capture the extent of direct damage and crush to the left fender, windshield and"A" pillar. The WinSMASH reconstruction program, damage only algorithm, was used to reconstruct the case vehicle's Delta Vs. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 55 km.p.h. (34.2 m.p.h.), -51.7 km.p.h. (-32.1 m.p.h.), and 18.8 km.p.h. (11.7 m.p.h.). The Honda was towed due to damage.

Honda's Occupants: According to the police crash report, the Honda's driver [57-year-old, White (non-Hispanic) female] and front right passenger [80-year-old, White (non-Hispanic) female] were restrained by their manual, three-point, lap-and-shoulder safety belt systems. Both occupants were fatally injured as a result of the crash. The driver was pronounced dead at the scene, and the front right passenger died in route to the hospital.


CV
CV
CV
CV
CV
CV
V2
V2
V2
Sharp Curve Warning Arrows
N
IN-05-030
Daylight, Clear
Dry Bituminous
CV Pre-crash grade = +1.3
V2 Pre-crash grade = -1.3
Post-crash grade -2.8 (perpendicular to roadway)
Superelevation = +4.8%
0m 5m 10m
RP
RL