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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN-06-026
LOCATION - INDIANA
VEHICLE - 1996 CHEVROLET LUMINA LS
CRASH DATE - August 2006

Submitted:

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Contract Number: DTNH22-01-C-07002

Prepared for:

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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 child safety seat investigation involving a 1996 Chevrolet Lumina LS equipped with manual safety belts, dual front air bag system and a child safety seat installed in the back right seat position.			
16. *Abstract* This report covers an on-site child safety seat investigation that involved a 1996 Chevrolet Lumina LS (case vehicle) and a 2001 Ford Excursion Limited (other vehicle), which were involved in an offset front crash on a rural roadway. This crash is of special interest because the case vehicle's back right passenger [3-year-old, White (non-Hispanic) male] was seated in a child safety seat and sustained fatal injuries. The case vehicle had been traveling south on a county roadway and turned right onto another county roadway and was traveling westbound in a right curve. Meanwhile, the Ford was traveling east in the eastbound lane. According to the sheriff's department crash report, the case vehicle's driver turned to her right to tend to her crying son who was seated in his forward-facing child safety seat in the back right seat. As a result, the case vehicle crossed over into the eastbound lane of the roadway. The front left of the case vehicle impacted the front left of the Ford causing the case vehicle's driver and front right passenger air bags to deploy. The Ford's driver and front right passenger air bags also deployed as a result of the crash. The case vehicle rotated counterclockwise and came to rest with it's right rear wheel off the north road edge. The Ford moved forward a short distance after the crash and came to rest with it's right side off the south road edge. The case vehicle's back right passenger was improperly restrained in a Cosco hi-back booster seat and sustained fatal injury.			
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This on-site investigation was brought to NHTSA's attention by this contractor through an article in a local Indiana newspaper. This crash involved a 1996 Chevrolet Lumina LS (case vehicle) and a 2001 Ford Excursion Limited (other vehicle), which were involved in an off-set frontal crash on a county roadway. The crash occurred in August 2006, at 11:14 a.m., in Indiana and was investigated by the applicable county sheriff department. This crash is of special interest because the case vehicle's back right passenger [3-year-old, White (non-Hispanic) male] was seated in a child safety seat and sustained fatal injuries. This contractor inspected both vehicles on August 24, 2006 and downloaded the data from the onboard Event Data Recorders (EDR) in both vehicles. The scene inspection was completed on September 19, 2006. The investigating sheriff's deputy was interviewed on November 2, 2006. The case vehicle's driver was interviewed on March 7, 2007. This report is based on the sheriff's department crash report and on-scene photographs, an interview with the investigating sheriff's deputy, scene and vehicle inspections, an interview with the case vehicle's driver, back right passenger's coroner record, EDR data, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle had been traveling south on a county roadway and turned right onto a another county roadway and was traveling westbound in a right curve. Meanwhile, the Ford was traveling east in the eastbound lane. According to the sheriff's department crash report, the case vehicle's driver turned to her right to tend to her crying son who was seated in his forward-facing child safety seat in the back right seat. As a result, the case vehicle crossed over into the eastbound lane of the roadway. The front of the case vehicle impacted the front left of the Ford causing the case vehicle's driver and front right passenger air bags to deploy. The Ford's driver and front right passenger air bags also deployed as a result of the crash. The case vehicle rotated counterclockwise and came to rest with it's right rear wheel off the north road edge. The Ford moved forward a short distance after the crash and came to rest with its right side off the south road edge.

The case vehicle's CDC for the front impact with the Ford was determined to be: **12-FYEW-4** (**0** degrees). The case vehicle's residual maximum crush was measured as 88 centimeters (34.6 inches) occurring at C_3. The WinSMASH reconstruction program, damage only algorithm, calculated the case vehicle's Total, Longitudinal, and Lateral Delta Vs respectively as: 62.0 km.p.h. (38.5 m.p.h.), -62.0 km.p.h. (-38.5 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The crash fit the reconstruction model and the results appeared reasonable. The case vehicle's EDR recorded a maximum longitudinal Delta V of -45 km.p.h.(-27.97 m.p.h.), which was approximately the maximum value the EDR was capable of recording. The case vehicle was towed due to damage.

The Ford's CDC for the front impact with the case vehicle was determined to be: **12-FDEW-2** (**0** degrees). The Ford's residual maximum crush was measured as 53 centimeters (20.9 inches) occurring at C_1. The WinSMASH reconstruction program, damage only algorithm, calculated the Ford's Total, Longitudinal, and Lateral Delta Vs respectively as: 30.0 km.p.h. (18.6 m.p.h.), -30.0 km.p.h. (-18.6 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The crash fit the

reconstruction model and the results appeared reasonable. The Ford's EDR data indicated the Ford sustained a longitudinal Delta-V of approximately -30.6 km.p.h. (-19.0 m.p.h.). The Ford was towed due to damage.

The case vehicle's back right passenger was seated in a hi-back booster seat. The child safety seat was manufactured by Cosco. The label that most likely indicated the child safety seat model number, serial number, and date of manufacture was worn off the seat. The child safety seat was designed with a five-point harness. The investigation determined that the back right passenger was not properly restrained in the child safety seat at the time of the crash. He was restrained only by the lap portion of case vehicle's three-point, lap-and-shoulder safety belt system. The child safety seat's five-point harness was not used to restrain the child. He was sitting on top of it at the time of the crash. The back right passenger sustained abdominal injuries due to loading the lap portion of his safety belt as well as facial and head injuries from impacting the back of the front right seat. He died as a result of his injuries.

The case vehicle's driver was not restrained by her manual, three-point, lap-and-shoulder safety belt. She was transported by ambulance to a hospital and treated and released.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling was a two-lane, undivided, county roadway, generally traversing in an east-west direction. There were no edge lines or lane lines on the roadway. The width of the roadway was 6 meters (19.7 feet), and the roadway was bordered by narrow grass/earth shoulders. The speed limit was 63 km.p.h. (40 m.p.h.). There was no regulatory speed limit sign posted near the crash site. The case vehicle's approach roadway was curved to the right and the vertical alignment was uphill (7.7% positive grade). At the time of the crash the light condition was daylight, the atmospheric condition was cloudy, and the roadway pavement was wet, traveled bituminous with an estimated coefficient of friction of 0.65. There was no other traffic present, and the site of the crash was a wooded rural area. See the Crash Diagram at end of this report.

Pre-Crash: The case vehicle had been traveling south on a different roadway and turned right onto the westbound roadway and was traveling westbound in a right curve (**Figure 1**) in the westbound lane. The driver was intending to continue westbound through the right curve. Meanwhile, the Ford was traveling east in the eastbound lane of the roadway (**Figure 2** below). The Ford's driver was intending to continue eastbound through the curve. According to the heriff's departments crash report, the case vehicle's driver turned to her right to tend to her crying son, who was seated in his forward-facing child safety seat in the back right seat. As a

Figure 1: Approach of case vehicle westbound, approximately 30 meters (98 feet) from impact area

result, the case vehicle crossed over into the eastbound lane of the roadway. The case vehicle's driver most likely made no avoidance maneuvers prior to the crash. The Ford's driver steered right and traveled at least partially off the roadway, and most likely applied the brakes in an attempt to avoid the crash. The crash occurred in the eastbound lane in the curve (**Figure 3**).

Figure 2: Approach of Ford eastbound approximately 20 meters (66 feet) from impact area

Figure 3: Area of impact viewed from Ford's approach, arrow shows impact gouges in the roadway

Figure 4: Overview of damage to front of case vehicle from impact with front of Ford, tape measure graduated in tenths of meter, each increment on rods is 5 cm (2 in)

Figure 5: Overview of damage to front of Ford from impact with front of case vehicle

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

Post-Crash: As a result of the impact, the case vehicle rotated counter clockwise approximately 60 degrees and came to rest with it's right rear wheel off the north road edge (**Figure 6** below). The Ford moved forward a short distance after the crash and came to rest with it's right side off the south road edge (**Figure 7** below).

The 1996 Chevrolet Lumina LS was a front wheel drive, four-door sedan (VIN: 2G1WN52M2T9------) equipped with a 3.1 L, V6 engine; four-speed automatic transmission and four wheel anti-lock brakes. The front seating row was equipped a with split bench seat with separate seat backs, adjustable head restraints, redesigned driver and front right passenger air bags and manual, three-point, lap-and-shoulder safety belts with adjustable upper anchors. The front middle seat position was equipped with a two-point lap belt. The back seating row was equipped with a bench seat with integral head restraints, a two-point lap belt in the middle seat position and three-point lap-and-shoulder safety belts in the outboard seating positions. The case vehicle's specification wheelbase was 273 centimeters (107.5 inches), and the odometer reading at inspection was 247,155 kilometers (153,579 miles).

Figure 6: Sheriff's department on-scene photo showing case vehicle's final rest position, Ford at final rest on left in foreground, view is to west

Figure 7: Sheriff's department on-scene photo showing Ford's final rest position, view is to southwest

CASE VEHICLE DAMAGE

Exterior Damage: The case vehicle's impact with the Ford involved the front plane. The front bumper, bumper fascia, hood, grille, radiator, left headlamp/turn signal assembly and front of the left fender were directly damaged and crushed rearward. Direct damage began at the left front bumper corner and extended approximately 88 centimeters (34.6 inches) across the front bumper. The front bumper fascia was not present at the vehicle inspection, so direct damage was determined based on damage to the bumper bar and hood. Crush measurements were taken to the bumper bar, and the residual maximum crush was measured as 88 centimeters (34.6 inches) occurring at C_3 (**Figure 8** below). 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	88	88	99	64	75	88	76	56	16	-32	0
in		34.6	34.6	39.0	25.2	29.5	34.6	29.9	22.0	6.3	-12.6	0.0

The left side wheelbase was reduced by 22 centimeters (8.7 inches) while the right side wheelbase was extended 5 centimeters (2 inches). Induced damage included the right headlamp/turn signal assemblies, both fenders, left front wheel, left "A"-pillar, left front door, windshield, and roof. There was no other induced damage to the remainder of the case vehicle's exterior.

Figure 8: Top view of crush to front of case vehicle

The case vehicle's recommended tire size was P205/70R15. The case vehicle was equipped with tires sized P215/60R15. 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	0	0	207	30	8	10	Sidewall cut	Yes	Yes
RF	228	33	207	30	8	10	None	No	No
LR	221	32	207	30	8	10	None	No	No
RR	234	34	207	30	9	11	None	No	No

Vehicle Interior: Inspection of the case vehicle's interior (**Figure 9** and **Figure 10** below) revealed evidence the driver heavily loaded the steering wheel and knee bolster. The steering wheel rim was significantly deformed forward (**Figure 11** below) and the steering wheel had broken off the steering column tilt hinge. The driver's knee bolster and instrument panel were also broken out. Blood stains were found on the upper left quadrant of the driver's air bag. Finally, the left edge of the right front seat back was deformed forward and the seat back twisted clockwise as a result of contact by the back right passenger. Intrusions occurred at the left toe pan, which was intruded longitudinally 21 centimeters (8.3 inches) and the left A-pillar, which intruded longitudinally 7 centimeters (2.8 inches).

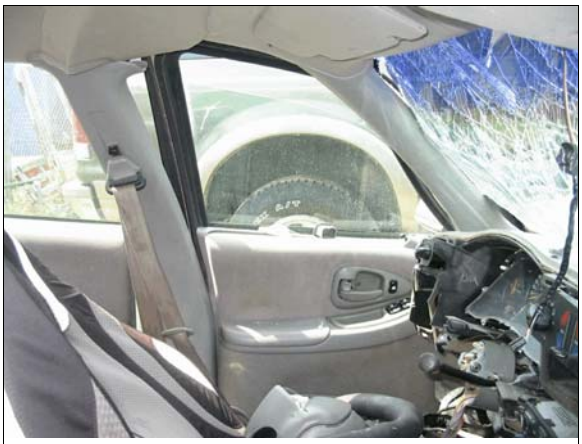


Figure 9: Overview of case vehicle driver's seat position, broken steering column and left instrument panel

Damage Classification: Based on the vehicle inspection, the case vehicle's CDC for the front impact with the Ford was determined to be: **12-FYEW-4** (**0** degrees). 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: 62.0 km.p.h. (38.5 m.p.h.), -62.0 km.p.h. (-38.5 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The case vehicle's EDR recorded a maximum longitudinal Delta V of -45 km.p.h.(-27.97 m.p.h.), which was approximately the maximum value the EDR was capable of recording. The case vehicle was towed due to damage.

Figure 10: Overview of case vehicle's back right seat position and deformation of front right seat back

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 (**Figure 11**) and the air bag fabric revealed that the cover flaps opened at the designated tear points and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag (**Figure 12**) was designed without any tethers or vent ports. The deployed driver's air bag was round with a diameter of 63 centimeters (24.8 inches). An inspection of the driver's air bag revealed blood stains from the driver on the air bag's top left quadrant.

Figure 11: Case vehicle steering wheel deformation and air bag module cover flaps

Figure 12: Case vehicle driver's air bag

The front right passenger's air bag was located in the top of the instrument panel. An inspection of the front right air bag module cover flap revealed that it opened at the designated tear points. The cover flap sustained minor cuts due to contact with the windshield during the deployment. Furthermore, the windshield was significantly cracked as the air bag and cover flap impacted the windshield during the deployment and the case vehicle's hood contacted and cracked the windshield during the crash. Inspection of the front right air bag revealed a small hole at the top of the upper right quadrant as well as smaller

holes in the center area of the upper left quadrant. This air bag damage resulted from contact with the damaged windshield during the crash.

The front right passenger's air bag was designed with two tethers, each approximately 10 centimeters (3.9 inches) in width. The front right passenger's air bag had two vent ports, each approximately 2 centimeters (0.9 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 65 centimeters (25.6 inches) and a width of approximately 62 centimeters (24.4 inches). Inspection of the front right passenger air bag was revealed no evidence of occupant contact.

CRASH DATA RECORDING

The case vehicle's EDR was downloaded during the vehicle inspection via direct connection to the Sensing and Diagnostic Module (SDM). The downloaded data indicated that a deployment and a non-deployment event were recorded. The non-deployment event was not related to this crash because it was recorded 236 ignition cycles prior to this crash. The EDR reports for the deployment event are presented in **Figures 18** and **19** at the end of this report. The deployment event data indicated that the SIR warning lamp was recorded as off and the time from algorithm enable (AE) to the deployment command criteria being met was 15 milliseconds. The driver's safety belt switch circuit was recorded as buckled; however, inspection of the driver's safety belt assembly and the severe deformation of the steering wheel indicated the driver was not restrained in this crash. The driver's belt switch circuit is wired directly to the SDM, and if the connection had been broken the circuit will be recorded as buckled. The recorded velocity change data indicated that the maximum recorded longitudinal Delta V occurred at 80 milliseconds following AE and was recorded as 45 km.p.h. (-27.97 m.p.h), which was approximately the maximum value the EDR was capable of recording. No pre-crash data was available. This model SDM does not record pre-crash data.

Figure 13: Overview of front of child safety seat

CHILD SAFETY SEAT

The case vehicle's back right passenger was seated in a hi-back booster seat (**Figure 13**). The child safety seat was manufactured by Cosco. The label that most likely indicated the child safety seat model number, serial number, and date of manufacture was worn off the seat. The child safety seat was designed with a five-point harness, which buckled between the toddler's legs. There

were two slots at shoulder level to thread the harness straps through, depending on the child's height. The harness straps were threaded through the top slots, and there was a harness retainer clip attached to the left harness strap (**Figure 13** aove). Each harness strap had a latch plate. The buckle was sewn to a crotch strap. The child safety seat also had safety belt paths located on each side of the seat at the back corners of the seat cushion to accommodate a vehicle's lap belt (**Figures 13** above and **Figure 14**). In addition, there were three slots on each side of the seat back to position a vehicle's shoulder belt (**Figure 14**). Lastly, there was a vehicle's belt path on the back of the child safety seat to be used to secure the child safety seat when it was being used with the five-point harness.

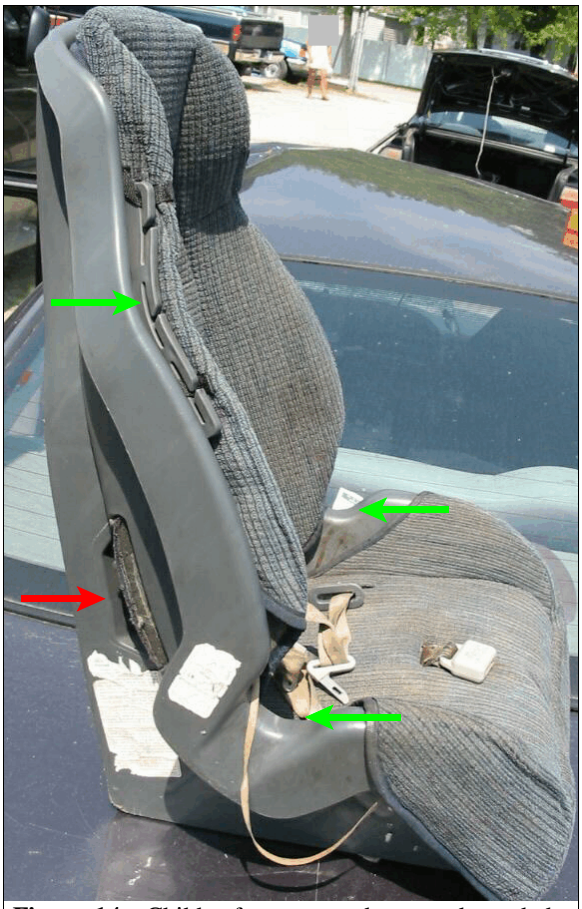


Figure 14: Child safety seat, red arrow shows belt path, green arrows shows shoulder belt slots and lap belt path for use as a belt positioning booster

The child safety seat consisted of a one-piece plastic shell. The shell was fitted with a cloth covered foam pad over the seat and back support. There were only two manufacturer's labels remaining on the child safety seat. One label was located on the left side of the seat back, which indicated the routing path for the vehicle's safety belt. The other label, also located on the left side of the child safety seat, was a warning that stated not to use the child safety seat as a belt positioning seat with a lap belt only.

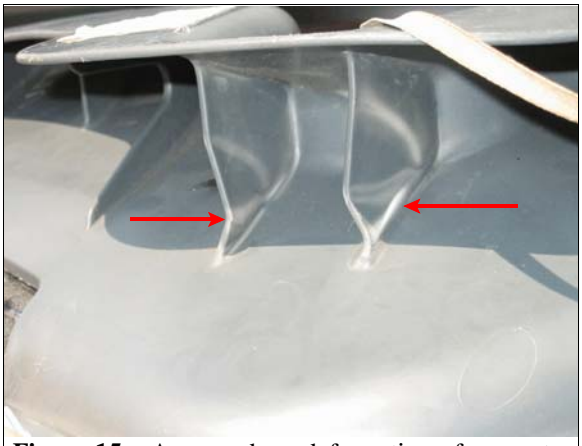


Figure 15: Arrows show deformation of supports under right lap belt path due to loading from lap belt, similar load pattern was found on supports under left belt path

Inspection of the child safety seat showed areas under the lap belt paths where the plastic frame supports had been stressed under load during the crash (**Figure 15** below). There were also lap belt webbing abrasions in the plastic of both belt paths. In addition, there were significant abrasions on the case vehicle's lap belt webbing and latch plate belt guide. No evidence was observed that indicated usage of the child safety seat's five-point harness. The evidence indicated that the child was restrained only by the lap portion of the case vehicle's three-point, lap-and-shoulder safety belt. The investigating sheriff's deputy indicated that the shoulder portion of the safety belt was found behind the child safety seat. The on-scene sheriff's department photographs support the investigating deputy's statement. They show the child safety seat in the back right seat

position following the removal of the child (**Figure 16**). The photographs show the safety belt unbuckled with the lap belt diagonally across the child safety seat's seat back and the shoulder belt behind the child safety seat's seat back. In summary, the evidence indicates that the child was not restrained by the child safety seat's five point harness. The child seat was being used as a belt positioning booster seat and the child was improperly restrained by only the lap portion of the lap-and-shoulder belt. The shoulder portion of the safety belt was positioned behind the child safety seat at the time of the crash.

Figure 16: Sheriff's department on-scene photo of child safety seat in case vehicle's back right seat position

CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's back right passenger [3-year-old, White (non-Hispanic) male; unknown height and 15 kilograms (33 pounds)] was improperly restrained in his child safety seat. He most likely had his back against the seat back and his feet dangling over the front edge of the child safety seat and his hands were in his lap. The case vehicle's seat back and seat track were not adjustable.

Based on this contractor's vehicle inspection, inspection of the child safety seat, on-scene sheriff's department photographs and an interview with the investigating sheriff's deputy, the case vehicle's back right passenger was restrained only by the lap portion of his manual, three-point, lap-and-shoulder, safety belt system. The lap belt was routed across the lap belt path on each side of the child safety seat. The shoulder belt was positioned behind the child safety seat at the time of the crash. The back right passenger was not restrained by the child safety seat's five-point harness.

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the back right passenger's use of his lap belt, his pre-impact body position did not change just prior to impact. The case vehicle's impact with the Ford caused the case vehicle's back right passenger to continue forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated. The force of the impact caused the child safety seat, which was restrained only by the lap belt, to pivot forward. The child's abdomen heavily loaded the lap belt causing probable internal abdominal injury and his face and upper body impacted the back left portion of the front right seat back deforming the seat back and causing a deep laceration to his chin and fractures with dislocation to his teeth. The child and his child safety seat rebounded back into the seat position as the case vehicle rotated counterclockwise and came to a rest. The back right passenger remained restrained by the lap belt in his child safety seat. A significant blood stain was found on the middle of the back seat cushion indicating the child came to rest slumped over to his left.

The sheriff's department crash report indicated that the back right passenger sustained a fatal injury and was transported by ambulance to the hospital. The coroner's record indicated that the back right passenger died en route to the hospital The table below shows the back right passenger'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	Blunt head trauma, direct blow to middle of forehead in line with glabella[1]	unknown 115999.7,0	Seat back, front right passenger's	Certain	Coroner's record
2	Fractured {breaking} teeth, not further specified	minor 251404.1,8	Seat back, front right passenger's	Certain	Coroner's record
3	Dislocation teeth; incisors, canines, pre-molars and first molars driven upward into sinus {maxillary} cavity	minor 251402.1,8	Seat back, front right passenger's	Certain	Coroner's record
4	Laceration, 5.1 cm (2 in) between lip {lower} and chin creating an opening to inside of mouth exposing lower body area of mandible.	minor 290602.1,8	Seat back, front right passenger's	Certain	Coroner's record
5	Blunt abdominal injury, slight distension suggestive on internal bleeding, not further specified	unknown 515999.7,0	Lap portion of safety belt system	Probable	Coroner's record
6	Abrasions, straight-line, across abdomen at waist	minor 590202.1,8	Lap portion of safety belt system	Certain	Coroner's record
7	Contusions, straight-line, across abdomen at waist	minor 590402.1,8	Lap portion of safety belt system	Certain	Coroner's record
8	Abrasions, various locations, not further specified	minor 990200.1,9	Unknown contact mechanism	Unknown	Coroner's record
9	Contusions, various locations, not further specified	minor 990400.1,9	Unknown contact mechanism	Unknown	Coroner's record

[1] The following term(s) {is | are} defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
glabella (gle-bel′e): 1. the smooth area on the frontal bone between the superciliary arches. 2. the most prominent point in the median plane between the eyebrows; used as an anthropometric landmark.

Immediately prior to the crash, the case vehicle's driver [27-year-old, White (non-Hispanic) female; 160 centimeters and 52 kilograms (63 inches, 115 pounds)] was most likely seated in an upright position with at least one hand on the steering wheel, her left foot was most likely on the floor and her right foot most likely on the accelerator. She was most likely looking over her shoulder to the right into the back right seat position at her crying son. Her seat track was adjusted to between its middle and forward-most position. Her seat back was adjusted to its upright position and the tilt steering wheel was located in its middle position. At the time of the vehicle inspection, the seat back was significantly reclined and the tilt steering wheel was separated from the steering column.

Based on inspection, the case vehicle's driver was not restrained by her manual, three-point, lap-and-shoulder, safety belt system. Inspection of the driver's safety belt webbing, "D"-ring, and latch plate revealed no evidence of loading. In addition, the driver heavily loaded and deformed the steering wheel during the impact.

The case vehicle's driver made no known pre-crash avoidance maneuvers. As a result and independent of the non-use of her lap-and-shoulder belt, her pre-impact body position most likely did not change just prior to impact. The case vehicle's impact with the Ford caused the driver to continue forward along a path opposite the case vehicle's 0 degree direction of principal force as the case vehicle decelerated. The driver's face and chest impacted her deployed air bag. She rode down the air bag and her chest loaded the steering wheel, significantly deforming the steering wheel and most likely breaking it off the steering column tilt hinge. The driver's knees also heavily loaded the knee bolster causing a contusion and fracture to her left patella and lacerations to her left leg. The driver rebounded back into her seat. It is not known if the driver remained in her seat as the case vehicle rotated counterclockwise to final rest.

CASE VEHICLE DRIVER INJURIES

The sheriff's department crash report indicated the driver sustained "B" (non-incapacitating-evident) injury and was transported by ambulance to a hospital. The case vehicle's driver indicated that she was treated and released from the emergency room. The table below show's the injuries reported by the driver. This contractor was unable to obtain any official injury documentation because the treating hospital refused to cooperate.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Fracture {shattered} left patella, not further specified	moderate 852400.2,2	Knee bolster, driver's, left of steering column	Certain	Interviewee (same person)
2	Contusion {bruising} around left patella {kneecap}	minor 890402.1,2	Knee bolster, driver's, left of steering column	Certain	Interviewee (same person)

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
3	Lacerations {cuts}, random, on left leg, not further specified	minor 890600.1,2	Knee bolster, driver's, left of steering column	Certain	Interviewee (same person)

OTHER VEHICLE

The 2001 Ford Excursion Limited was a four wheel drive, four-door sport utility vehicle (VIN: 1FMNU43S01E------). The Ford was equipped with four wheel, anti-lock brakes and redesigned driver and front right passenger air bags, which deployed as a result of the Ford's front impact with the case vehicle.

Exterior Damage: The Ford's impact with the case vehicle involved the front plane. The front bumper, hood, grille, radiator, left headlamp/turn signal assembly and the left fender were directly damaged and crushed rearward. Direct damage began at the left front bumper corner and extended approximately 91 centimeters (35.8 inches) across the front bumper. Crush measurements were taken at the bumper. The residual maximum crush was measured as 53 centimeters (20.9 inches) occurring at C_1 (**Figure 17**). The table below shows the Ford's front crush profile.

Figure 17: Top view of crush to front of Ford

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	91	53	166	53	29	43	16	0	0	-52	0
in		35.8	20.9	65.4	20.9	11.4	16.9	6.3	0.0	0.0	-20.5	0.0

The left side wheelbase was reduced by 25 centimeters (9.8 inches) while the right side wheelbase was extended by 5 centimeters (2 inches). Induced damage included the hood, left fender, left front door, and the windshield was cracked.

Damage Classification: Based on the vehicle inspection, the CDC for the Ford was determined to be: **12-FDEW-2** (**0** degrees). The WinSMASH reconstruction program, damage only algorithm, was used to reconstruct the on the Ford's Delta Vs for the front impact with the case vehicle. The Total, Longitudinal, and Lateral Delta Vs are, respectively: 30.0 km.p.h. (18.6 m.p.h.), -30.0 km.p.h. (-18.6 m.p.h.), and 0.0 km.p.h. (0.0 m.p.h.). The crash fit the reconstruction model and the results appeared reasonable. The Ford's EDR data indicated the

Ford sustained a longitudinal Delta-V of approximately -30.6 km.p.h. (-19.0 m.p.h.). The Ford was towed due to damage.

The Ford's recommended tire size was P265/75R16. The Ford's tire information was not obtained.

Crash Data Recording: The Ford's EDR was downloaded during the vehicle inspection via direct connection to the Restraint Control Module (RCM). The downloaded data are presented at the end of this report in **Figures 20-25**.

Fords's Occupants: According to the sheriff's department crash report, the Ford's driver [39-year-old, (unknown race and ethnic origin) female]; was restrained by her manual, three-point, lap-and-shoulder, safety belt system. According to the sheriff's department crash report, the driver refused medical treatment. A supplement to the sheriff's department crash report indicated there were also five children in the Ford at the time of the crash. No other information regarding the children was provided in the report.

CDR File Information

Vehicle Identification Number	2G1WN52M2T9******
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	IN06026LUMINA.CDR
Saved on	Thursday, August 24 2006 at 11:12:39 AM
Collected with CDR version	Crash Data Retrieval Tool 2.800
Collecting program verification number	9238B95E
Reported with CDR version	Crash Data Retrieval Tool 2.800
Reporting program verification number	9238B95E
Interface used to collected data	Block number: 00 Interface version: 4A Date: 11-08-05 Checksum: 7500
Event(s) recovered	Crash 1 Deployment Non-Deployment

SDM Data Limitations

SDM Recorded Crash Events:
There are two types of SDM recorded crash events. The first is the Non-Deployment Event. A Non-Deployment Event is an event severe enough to "wake up" the sensing algorithm but not severe enough to deploy the air bag(s). The SDM can store up to one Non-Deployment Event. This event can be overwritten by an event that has a greater SDM recorded forward velocity change. This event will be cleared by the SDM after the ignition has been cycled 125 times.
The second type of SDM recorded crash event is the Deployment Event. The SDM can store up to two different Deployment Events. The first Deployment Event will be stored in the #1 Deployment Event file (this would have been the event that deployed the air bag) and the second Deployment Event will be stored in the #2 Deployment Event file. Deployment Events cannot be overwritten or cleared from the SDM. Once the SDM has two Deployment Events recorded, the SDM must be replaced.
The data in the Non-Deployment Event file will be locked after a Deployment Event, if the Non-Deployment Event occurred within 7.65 seconds before the Deployment Event unless a Deployment Level Event occurs within 5 seconds after the Deployment Event, and then the Deployment Level Event will overwrite the Non-Deployment Event file.

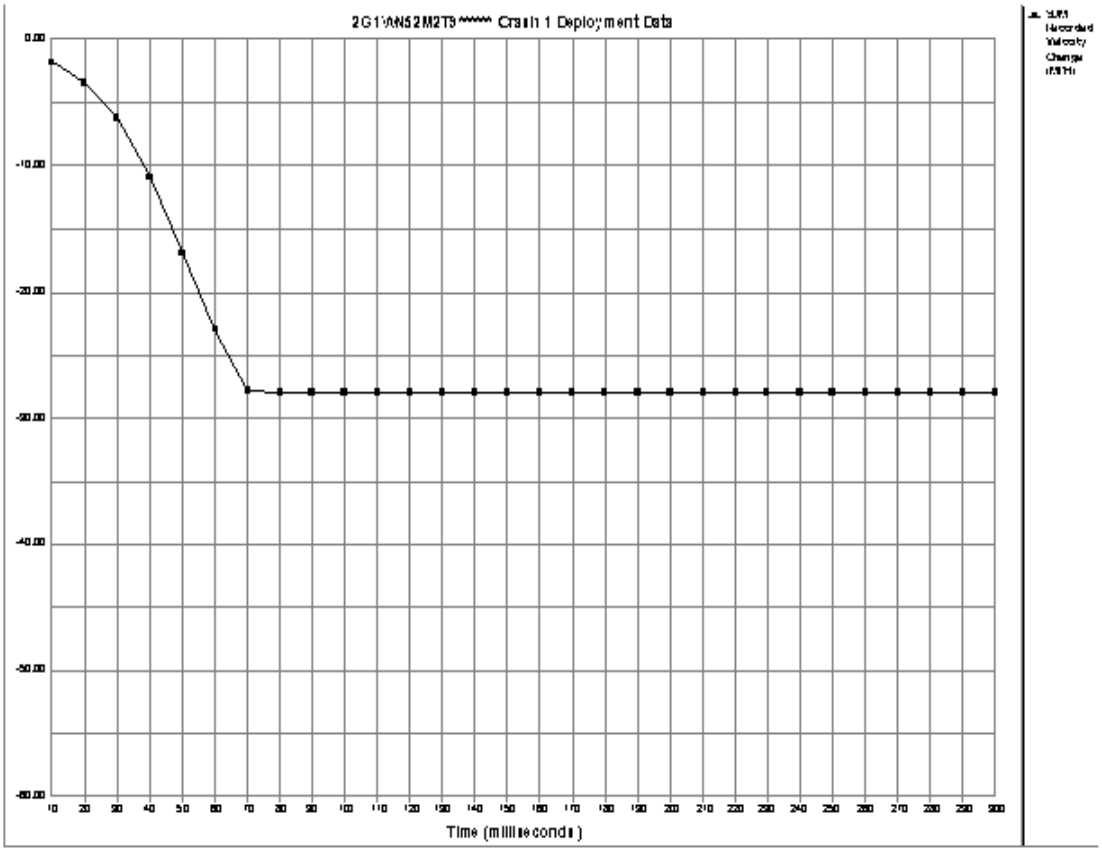
SDM Data Limitations:
-SDM Recorded Vehicle Forward Velocity Change reflects the change in forward velocity that the sensing system experienced during the recorded portion of the event. SDM Recorded Vehicle Forward Velocity Change is the change in velocity during the recording time and is not the speed the vehicle was traveling before the event, and is also not the Barrier Equivalent Velocity. This data should be examined in conjunction with other available physical evidence from the vehicle and scene when assessing occupant or vehicle forward velocity change. The SDM records the first 300 milliseconds of Vehicle Forward Velocity Change after Algorithm Enable. The maximum value that can be recorded for Vehicle Forward Velocity Change is 28 MPH.
-Driver's Belt Switch Circuit Status indicates the status of the driver's seat belt switch circuit.
-The Time between Non-Deployment and Deployment Events is displayed in seconds. If the time between the two events is greater than five seconds, "N/A" is displayed in place of the time.
-If power to the SDM is lost during a crash event, all or part of the crash record may not be recorded. An indication of a loss of power would be if the ignition cycles at the event is recorded as zero. Data recorded after that may not be reliable, such as Time Between Non-Deployment and Deployment Events and Driver Belt Switch Circuit Status.

SDM Data Source:
All SDM recorded data is measured, calculated, and stored internally, except for the following:
-The Driver's Belt Switch Circuit is wired directly to the SDM.

Figure 18: Case vehicle's CDR File Information and SDM Data Limitations

System Status At Crash 1

SIR Warning Lamp Status	OFF
Driver's Belt Switch Circuit Status	BUCKLED
Ignition Cycles At Deployment	21572
Ignition Cycles At Investigation	21573
Time From Algorithm Enable to Deployment Command Criteria Met (msec)	15
Time Between Non-Deployment And Deployment Events (sec)	N/A



Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-1.76	-3.40	-6.14	-10.86	-16.89	-22.93	-27.75	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97
Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Recorded Velocity Change (MPH)	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97	-27.97

Figure 19: Case vehicle's system status at deployment and longitudinal velocity change data

CDR File Information

Vehicle Identification Number	1FMNU43S01E******
Investigator	
Case Number	
Investigation Date	
Crash Date	
Filename	IN06026EXCURSION.CDR
Saved on	Thursday, August 24 2006 at 03:22:13 PM
Collected with CDR version	Crash Data Retrieval Tool 2.800
Collecting program verification number	9238B95E
Reported with CDR version	Crash Data Retrieval Tool 2.800
Reporting program verification number	9238B95E
Interface used to collected data	Block number: 00 Interface version: 4A Date: 11-08-05 Checksum: 7500
Event(s) recovered	Deployment

Module Information

The retrieval of this data has been authorized by the vehicle's owner, or other legal authority such as a subpoena or search warrant, as indicated by the CDR tool user on Thursday, August 24 2006 at 03:22:13 PM .

Important Limitations on Vetronix Crash Data Retrieval (CDR) Tool Capabilities.

Disclaimer: This Restraint Control Module (RCM) records longitudinal deceleration data for the purpose of understanding the input data the Restraint Control Module used to determine whether or not to deploy restraint devices. This module does not record vehicle speed, throttle position, brake on-off, and other data, which may be recorded in some 1999 model year and later General Motors modules. The deceleration data recorded by Ford's module during a crash can subsequently be mathematically integrated into a longitudinal Delta-V. Delta-V is the change in velocity during the recording time and is NOT the speed the vehicle was traveling before the accident, and is also not the Barrier Equivalent Velocity. The Vetronix CDR Tool will read and interpret both acceleration in G's and Delta-V in mph. RCM's in Ford vehicles that can be read by the Vetronix CDR tool are listed in the Vetronix Help Files.

Important

If there is any question that the restraint system did not perform as it was designed to perform, please read the system only through the diagnostic link connector. The Vetronix CDR kit provides an RCM interface cable to plug directly into the restraint control module. The Vetronix CDR RCM Interface Cable connects only power, ground, and memory read pins to the relevant vehicle restraint control module. The other RCM pins normally connect to inputs, such as sensors, and outputs, such as airbags, are not connected when you use the RCM Interface Cable to plug directly into the module. Since the vehicle restraint control module is constantly monitoring airbag system readiness (when powered), it will detect that the sensors and airbags are not connected. The restraint control module may record a new diagnostic trouble code into memory for each device that is not connected. These new diagnostic trouble codes may record over previously written diagnostic trouble codes present prior to the accident and spoil evidence necessary to determine if the restraint system performed in the accident as it was designed to perform. Not only could this prevent Ford from being able to determine if the system performed as it was designed to perform, but, regardless of innocent inadvertence, you could raise issues of evidence spoliation in any litigation that may arise out of the accident. If you cannot read the module via the diagnostic link connector, and if you suspect improper system performance, contact Ford Motor Company and request their assistance to read the module with a proper vehicle simulator attached.

While data stored in RCM's is accurate, accident reconstructionists must be aware of the limitations of the data recorded in Ford's control modules and should compare the recorded data with the physical evidence at the accident scene using professional accident reconstruction techniques (i.e. vehicle crush characteristics, skid marks, etc) before making any assumptions about the import and validity of the data recorded in the module with respect to the crash event being analyzed. The following describes specific limitations that must be considered when analyzing recorded data. Investigators should obtain permission of the vehicle owner or have sufficient legal authority prior to reading any data.

1. There may be no deceleration data recorded in the module.

Figure 20: Ford's CDR File Information and Module Information

Loss of power (cut wires, damaged battery, crushed fuse box) to the module during or immediately after the crash may prevent the crash data from being recorded. A backup power supply within the module has sufficient power to continue to analyze the deceleration data and deploy restraint devices if needed, but there is no backup power for recording.

If the deceleration input does not create a vehicle longitudinal Delta-V above 4 mph within 100 milliseconds, there may not be any data recorded.

2. In unusual circumstances, deceleration data stored in the module may be from a crash other than the one you are currently analyzing.
The module will record data from some non-deploy events. If, after the module has recorded data from a non-deploy event, and there is a subsequent event in which there is a loss of power and no new recording is made for that subsequent event, the deceleration data in the module's memory may be from the prior event. If the new, subsequent event is a deploy event and recording has occurred, the deployment times should be recorded. If there are no deployment times recorded, but airbags or other restraint devices are observed to have deployed, the recorded data that you read are most likely from a prior event.

Once an airbag or other restraint device has been commanded to deploy, the data recorded in connection with that deployment are "locked", and subsequent crashes cannot be recorded.

If a vehicle is being repaired, the RCM should be replaced after any crash in which restraint devices deploy. Early printed shop manuals refer to re-using modules by clearing the "crash data memory full" code, but this is no longer true and the latest on-line electronic shop manual directs that modules be replaced.

Crashes that involve multiple impacts will record only one of the impacts. If there is a deployment, the deployment event will be recorded and locked. If no restraint device is commanded to deploy, the recorded data are not "locked", and subsequent impacts may record over any previous recorded data. Further analysis will be required to determine which of the events was actually recorded.

3. The computed longitudinal Delta-V may understate the total Delta-V

Many real-world crashes can last longer than the memory has the capacity to record. Therefore, the actual Delta-V of the event may be higher than the Delta-V calculated and displayed by the Vetronix CDR System output. Review the end of the longitudinal acceleration/deceleration pulse - if it has not settled to zero G's by the end of the recording, the vehicle longitudinal Delta-V is most likely understated. If there is a clear decaying trend line you may choose, at your own risk, to estimate the total Delta-V by extrapolating the decay trend to zero and to calculate the additional Delta-V not captured.

Under some circumstances where power is interrupted, during the recording of data, or the module re-sets during the recording of data, a partial recording may occur. This will be shown as "no data" in the data table and will not be plotted on the graph of acceleration. When some portion of the acceleration data is not recorded, the Delta-V during that time cannot be calculated. A Delta-V will be calculated for the points that are valid, but the user must be aware that the partial Delta-V calculated will further underestimate the actual event total Delta-V.

4. This module records only longitudinal acceleration/deceleration of the vehicle. You must compute lateral or resultant total acceleration based on your estimated Principal Direction of Force (PDOF).

5. Vertical acceleration/decelerations are not recorded. Vehicle spin about a point not centered on the Restraints Control Module sensor may add or subtract from bulk vehicle motion.

6. This module is not intended to record acceleration/deceleration in a side-impact event. If the side impact generates a longitudinal deceleration component sufficient to wake up the frontal deployment algorithm, there may be a recording of longitudinal deceleration in a side impact event.

Any Longitudinal Delta-V determined by using data read from the air bag module should be verified with physical evidence from the crash (such as vehicle crush, skid marks) and assumed accident sequence. Multiple impacts, angular collisions, side impacts, vehicle spin, etc should be considered in addition to the data read from the air bag module.

Figure 21: Fords Module Information continued

System Status At Deployment

Diagnostic codes active when event occurred	0
Passenger Airbag Switch Position During Event	Activated
Time From Side Safing Decision to Left (Driver) Side Bag Deployment (msec)	Not Deployed
Frontal and Pretensioner Fire time (ms)	21.5

Figure 22: Ford's System Status at Deployment report

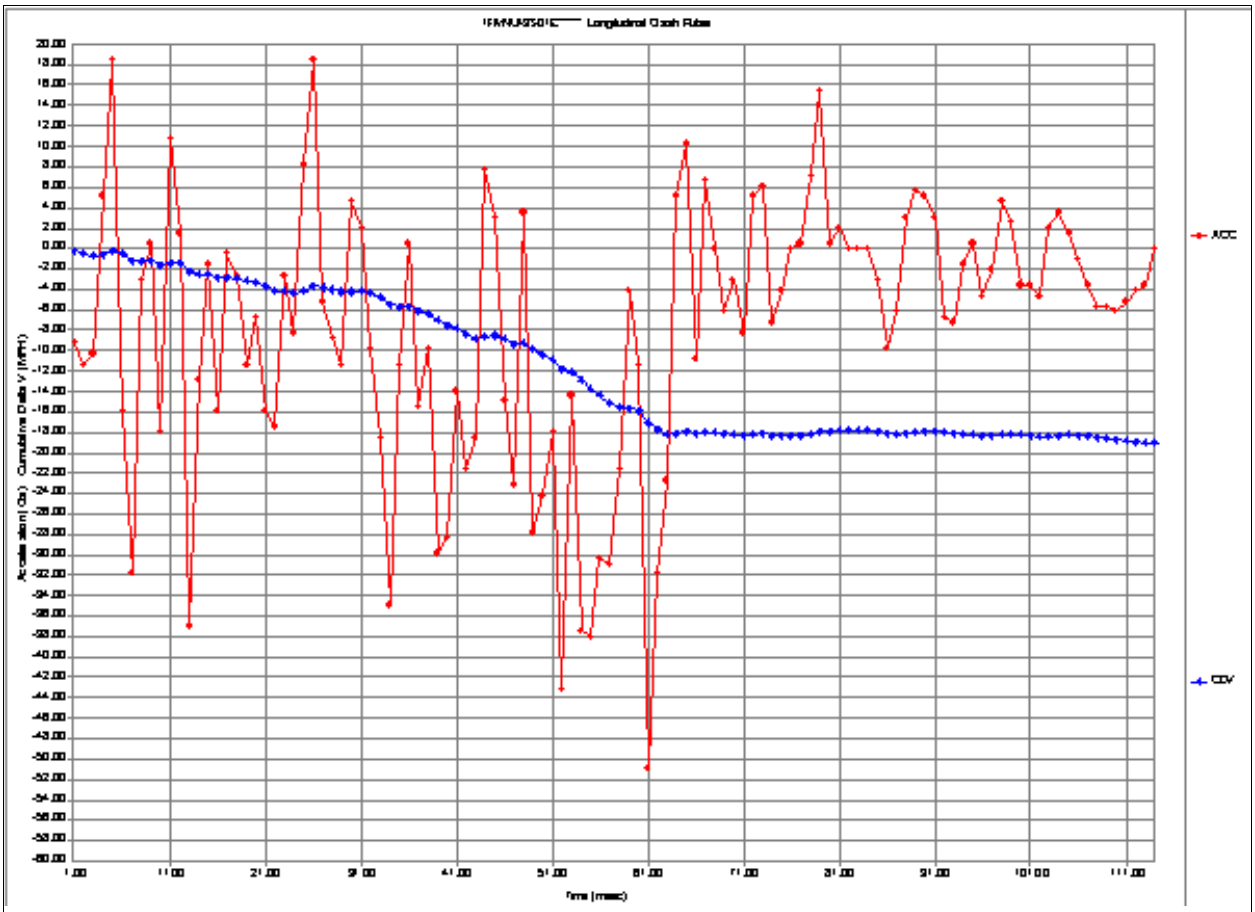


Figure 23: Ford's deployment longitudinal crash pulse

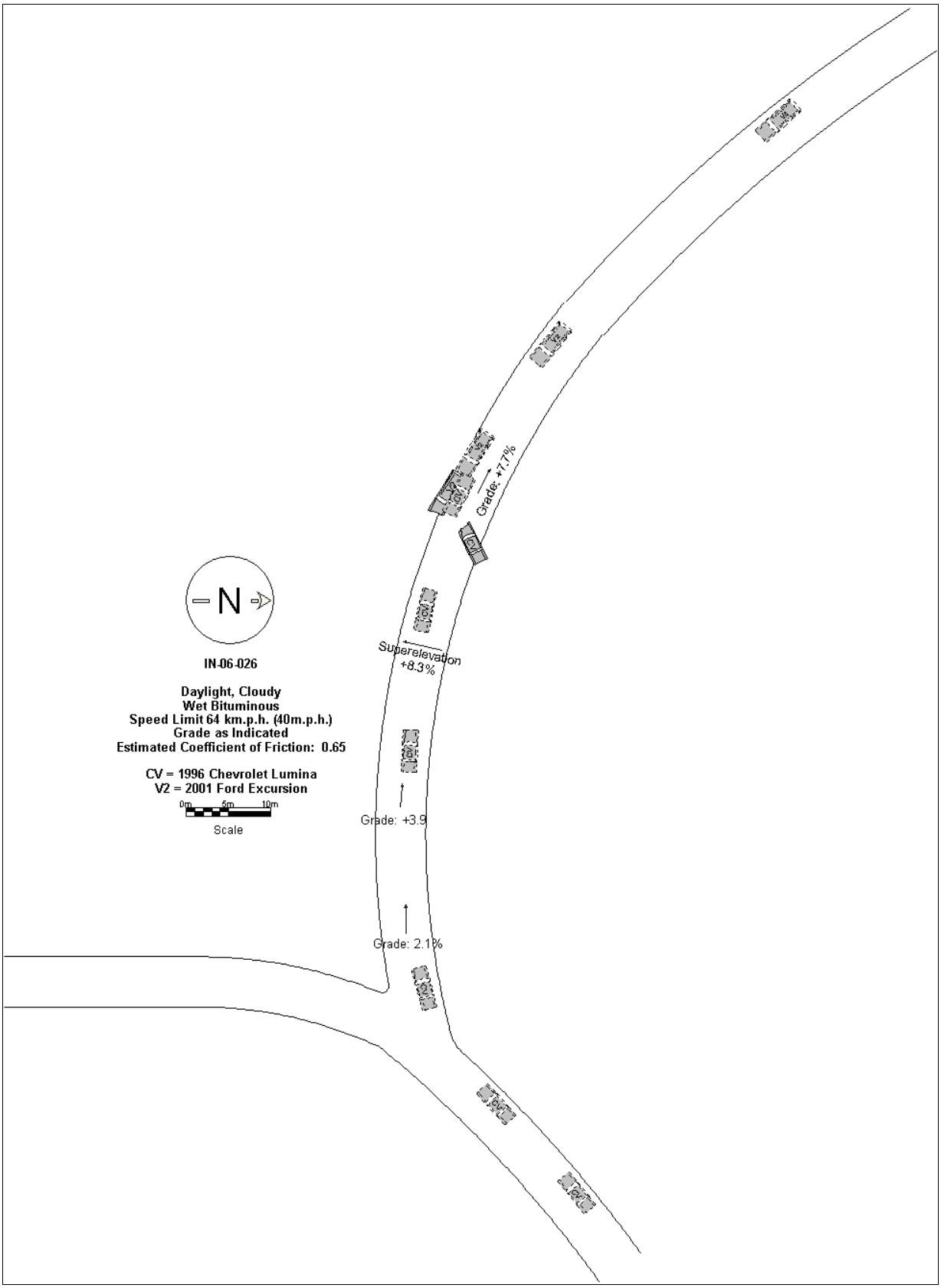
Crash Pulse Data

Milliseconds	Long. Acceleration (Gs)	Long. Cumulative Delta V (MPH)
1	-9.25	-0.20
2	-11.31	-0.45
3	-10.28	-0.68
4	5.14	-0.56
5	18.50	-0.16
6	-15.93	-0.51
7	-31.87	-1.21
8	-3.08	-1.28
9	0.51	-1.26
10	-17.99	-1.66
11	10.79	-1.42
12	1.54	-1.39
13	-37.01	-2.20
14	-12.85	-2.48
15	-1.54	-2.52
16	-15.93	-2.87
17	-0.51	-2.88
18	-2.57	-2.93
19	-11.31	-3.18
20	-6.68	-3.33
21	-15.93	-3.68
22	-17.48	-4.06
23	-2.57	-4.12
24	-8.22	-4.30
25	8.22	-4.12
26	18.50	-3.71
27	-5.14	-3.83
28	-8.74	-4.02
29	-11.31	-4.27
30	4.63	-4.16
31	2.06	-4.12
32	-9.77	-4.33
33	-18.50	-4.74
34	-34.95	-5.51
35	-11.31	-5.76
36	0.51	-5.74
37	-15.42	-6.08
38	-9.77	-6.30
39	-29.81	-6.95
40	-28.27	-7.57
41	-13.88	-7.88
42	-21.59	-8.35
43	-18.50	-8.76
44	7.71	-8.59
45	3.08	-8.52
46	-14.91	-8.85
47	-23.13	-9.36
48	3.60	-9.28
49	-27.76	-9.89
50	-24.16	-10.42

Figure 24: Ford's crash pulse data

Milliseconds	Long. Acceleration (Gs)	Long. Cumulative Delta V (MPH)
51	-17.99	-10.81
52	-43.18	-11.76
53	-14.39	-12.07
54	-37.52	-12.90
55	-38.04	-13.73
56	-30.33	-14.40
57	-30.84	-15.08
58	-21.59	-15.55
59	-4.11	-15.64
60	-11.31	-15.89
61	-50.89	-17.01
62	-31.87	-17.71
63	-22.62	-18.20
64	5.14	-18.09
65	10.28	-17.86
66	-10.79	-18.10
67	6.68	-17.95
68	0.00	-17.95
69	-6.17	-18.09
70	-3.08	-18.16
71	-8.22	-18.34
72	5.14	-18.23
73	6.17	-18.09
74	-7.20	-18.25
75	-4.11	-18.34
76	0.00	-18.34
77	0.51	-18.33
78	7.20	-18.17
79	15.42	-17.83
80	0.51	-17.82
81	2.06	-17.77
82	0.00	-17.77
83	0.00	-17.77
84	0.00	-17.77
85	-3.08	-17.84
86	-9.77	-18.06
87	-6.17	-18.19
88	3.08	-18.12
89	5.65	-18.00
90	5.14	-17.89
91	3.08	-17.82
92	-6.68	-17.97
93	-7.20	-18.12
94	-1.54	-18.16
95	0.51	-18.15
96	-4.63	-18.25
97	-2.06	-18.29
98	4.63	-18.19
99	2.57	-18.13
100	-3.60	-18.21
101	-3.60	-18.29
102	-4.63	-18.39
103	2.06	-18.35

Figure 25: Ford's crash pulse data continued


N
IN-06-026
Daylight, Cloudy
Wet Bituminous
Speed Limit 64 km.p.h. (40m.p.h.)
Grade as Indicated
Estimated Coefficient of Friction: 0.65
CV = 1996 Chevrolet Lumina
V2 = 2001 Ford Excursion
0m 5m 10m
Scale
Grade: +7.7%
Superelevation +8.3%
Grade: +3.9
Grade: 2.1%