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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN-05-001
LOCATION - MINNESOTA
VEHICLE - 2003 KIA SEDONA
CRASH DATE - January 2005

Submitted:

May 3, 2006

Contract Number: DTNH22-01-C-07002

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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 2003 Kia Sedona mini van with manual safety belts and redesigned air bag system.			
16. *Abstract* This report covers an on-site investigation of a crash involving a 2003 Kia Sedona (case vehicle), which was impacted in the back end by a 1996 GMC/Bluebird school bus (other vehicle) on a two lane county roadway. This crash is of special interest because the case vehicle's second seat row, left passenger [3-year-old, White (non-Hispanic) male] was restrained in a child safety seat and sustained a fatal injury as a result of the crash. The case vehicle was southbound on a two lane county roadway and was stopped at a “Tee” intersection with a church/school driveway. The case vehicle was stopped with its left turn signal on behind a vehicle that had initiated a left turn into the driveway just prior to the crash. The school bus was traveling south at a reconstructed speed of 71 to 77 km.p.h. (44 to 48 m.p.h.). The bus driver was intending to proceed straight ahead. The case vehicle's driver took no actions to avoid the crash. The front of the school bus impacted the back of the case vehicle. The bus driver locked his brakes following the impact, and the case vehicle was pushed forward approximately 29 meters (95 feet) to its final rest position. Both vehicles remained in contact, did not rotate and skidded to final rest in the southbound lane facing slightly southwest. The second seat, left passenger was restrained in his forward facing convertible child safety seat, which was being used as a belt positioning booster seat. The impact caused him to move backward into his child seat and he ramped up the back of the seat and loaded his lap belt. The case vehicle’s seat back was deformed rearward. His child safety seat was not damaged, however he sustained a fatal injury. The driver was restrained by his manual, three-point, lap-and-shoulder safety belt. The impact caused him to move backward, and he deformed his seat back rearward. He sustained a police reported B” (non-incapacitating-evident) injury and was transported by ambulance to a local hospital.			
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TABLE OF CONTENTS

Page No.

This investigation was brought to NHTSA's attention on or before January 5, 2005 through a Minnesota newspaper article. This crash involved a 2003 Kia Sedona (case vehicle) and a 1996 GMC/Bluebird school bus (other vehicle). The crash occurred in January, 2005, at 9:11 a.m., in Minnesota and was investigated by the applicable local and state police agencies. This crash is of special interest because the case vehicle's second seat row, left passenger [3-year-old, White (non-Hispanic) male] was restrained in a child safety seat and sustained a fatal injury as a result of the crash. This contractor inspected the case vehicle and the child safety seat, and discussed crash details with investigating police and EMS personnel on January 12, 2004. The crash scene was inspected on January 13, 2005. In addition, this contractor made an in-person contact with the case vehicle's driver on January 13, 2005, but only very limited information was obtained and the interview was terminated. A subsequent interview attempt was refused by the attorney representing the driver. This report is based on the police crash report, Minnesota State Patrol Crash Investigation Report; scene, vehicle and child safety seat inspections; discussions with investigating police and EMS personnel, local newspaper articles, occupant kinematic principles, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was southbound on a two lane county roadway and was stopped at a "Tee" intersection with a church/school driveway. The driver was stopped with his left turn signal on waiting to turn left into the driveway. The case vehicle was stopped behind a vehicle that had initiated a left turn into the driveway just prior to the crash. The school bus was traveling south at a reconstructed speed of 71 to 77 km.p.h. (44 to 48 m.p.h.). The bus driver was intending to proceed straight ahead. The case vehicle's driver took no actions to avoidance the crash. The front of the school bus impacted the back of the case vehicle. There was full overlap to the back of the case vehicle, and the bus' front bumper overrode the case vehicle's back bumper. The bus driver locked his brakes following the impact. The case vehicle was pushed forward approximately 29 meters (95 feet) to its final rest position. Both vehicles remained in contact, did not rotate and skidded to final rest in the southbound lane facing slightly southwest. At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was level, dry bituminous. Traffic density is not known, and the site of the crash was rural.

The CDC for the case vehicle was determined to be: **06-BDAW-4** (**180** degrees). An in-line momentum analysis was used to calculate the impact speed and Delta V of the school bus and the Delta V of the case vehicle. The analysis indicated the school bus was traveling 71 to 77 km.p.h. (44 to 48 mph) when it impacted the back of the case vehicle resulting in a Delta-V to the case vehicle of 55 to 61 km.p.h. (34 to 38 mph). The Delta V of the school bus was 15 to 16 km.p.h. (9 to 10 mph). The case vehicle was towed from the scene. The school bus was driven from the scene.

Immediately prior to the crash, the case vehicle's second seat row, left passenger (3-year-old, male) was seated in a convertible child safety seat that was positioned in the forward-facing configuration as a belt-positioning booster seat. The child was secured in the child seat by the case

vehicle's manual, three-point, lap-and-shoulder safety belt. The child safety seat was a COSCO "Alpha-Omega"manufactured by Dorel Juvenile Group, Inc. The seated position of the child and the type of clothing he was wearing at the time of the crash is not known. He was holding a toy car at the time of the crash. The school bus impact to the back of the case vehicle caused the child to move backward in his seat along a path opposite the case vehicle's 180 degree direction of principal force as the case vehicle was accelerated forward. The passenger's back and back of his head contacted the child safety seat's seat back and head rest, and the child safety seat loaded into the case vehicle's seat back. It appears that the case vehicle's seat back was displaced rearward as a result of the impact force. The passenger most likely ramped up the seat back of the child safety seat to some degree and loaded his lap belt. The passenger remained in the child safety seat as the case vehicle was pushed to final rest by the school bus. Police personnel cut the safety belt and removed the passenger from the case vehicle. The passenger's injuries are not known.

Immediately prior to the crash, the case vehicle's driver (36-year-old, male) was most likely seated in a nominal upright driving position with both hands on the steering wheel, and he had one of his feet on the brake. At the time of the case vehicle inspection, the driver's seat track was positioned in its approximate middle position. The pre-crash seat back adjustment is not known. The driver was restrained by his manual, three-point, lap-and-shoulder safety belt system. The school bus impact to the back of the case vehicle caused the driver to move backward in his seat along a path opposite the case vehicle's 180 degree direction of principal force as the case vehicle was accelerated forward. The driver loaded his seat back and displaced the seat back rearward dynamically to an angle beyond 45 degrees. The driver most likely ramped up the back of his seat to some degree and loaded his lap belt. The driver remained in his seat as the school bus pushed the case vehicle to final rest. It is not known how the driver exited the case vehicle. The driver's injuries are not known.

CRASH CIRCUMSTANCES

Crash Environment: The trafficway on which both vehicles were traveling (**Figure 1**) was a two-lane, undivided, county roadway, traversing in a north-south direction. The trafficway formed a "Tee" intersection with a three-lane divided driveway to a church/school complex located on the east side of the trafficway. In the area of the crash, the trafficway widened. There was one northbound lane north of the driveway, and two northbound and two southbound lanes south of the driveway. For southbound traffic (i.e., both vehicle's travel direction), the outside lane was a passing lane to accommodate through traffic when vehicles were waiting to turn left into the church/school complex. It was 3.3 meters (10.8 feet) in width. The inside southbound lane was 3.5 meters (11.5 feet) in width. For northbound traffic, south of the driveway, there was one through lane, 3.2 meters (10.5 feet) in width, and

Figure 1: Overview of the trafficway and approach of the school bus southbound to impact, arrow shows area of impact

a right turn lane into the church/school complex, 2.3 meters (7.5 feet) in width. The roadway was bordered by bituminous shoulders. Roadway markings for southbound traffic consisted of a solid yellow centerline and broken white passing lane line. Roadway markings for northbound traffic consisted of a broken yellow centerline and solid white turn lane line. The speed limit was 89 km.p.h. (55 m.p.h.). At the time of the crash the light condition was daylight, the atmospheric condition was clear, and the roadway pavement was level, dry bituminous with an estimated coefficient of friction of 0.65. Traffic density is not known, and the site of the crash was rural. See the Crash Diagram at the end of this report.

Pre-Crash: The case vehicle was stopped at the "Tee" intersection in the southbound through lane. The driver was intending to turn left into the church/school driveway. The driver stated to police that he was stopped with his left turn signal on. The case vehicle was stopped behind a vehicle that had initiated a left turn into the school/church driveway just prior to the crash. The school bus was traveling south in the southbound through lane at a reconstructed speed of 71 to 77 km.p.h. (44 to 48 m.p.h.). The bus driver was intending to proceed straight ahead. The case vehicle's driver made no avoidance maneuvers prior to the crash. The crash occurred in the southbound through lane of the roadway (**Figure 2**).

Crash: The front of the school bus impacted the back of the case vehicle. There was full overlap to the back of the case vehicle. The bus' front bumper overrode the case vehicle's back bumper. At impact, the centerline of the bus and case vehicle were approximately aligned (**Figure 3** and **Figure 4** below).

Figure 2: Police on-scene photo showing point of impact (arrows show gouges from case vehicle) and final rest position of school bus

Figure 3: Right side view of impact overlap of the case vehicle and school bus, and final rest of the two vehicles

Post-Crash: As a result of the impact, the case vehicle was pushed forward approximately 29 meters (95 feet) to its final rest position. Neither vehicle rotated as a result of the impact. They angled slightly westward as they traveled to final rest. Both vehicles remained in contact and were facing slightly southwest at final rest (**Figure 4** below). The police on-scene photographs show

that the school bus driver locked his brakes post-impact, and the bus skidded to final rest. Skid marks are visible in the photographs from the front and rear wheels of the school bus (**Figure 2** above and **Figure 4**). In addition, the police photographs show no pre-impact skid marks from the school bus. At final rest, the right side wheels of both vehicles were just over the lane line dividing the through lane and passing lane.

Figure 4: Final rest position of case vehicle and school bus and view of school bus' left front and left rear skid marks

CASE VEHICLE

The 2003 Kia Sedona was a front wheel drive, five-door minivan (VIN: KNDUP131536------) equipped with a 3.5L, V6 engine and four speed automatic transmission. The front seating row was equipped with redesigned driver and front right passenger air bags and bucket seats with manual, three-point, lap-and-shoulder safety belts equipped with pretensioners and adjustable upper anchors. The second seating row was equipped with bucket seats with manual, three-point, lap-and-shoulder safety belts with adjustable upper anchors. The third seating row was equipped with a split bench seat with folding backs; manual, three-point, lap-and-shoulder safety belts in the outboard seat positions and a lap belt in the middle seat position. Four wheel, anti-lock brakes were optional for this vehicle, but it is unknown if the vehicle was so equipped. The case vehicle's wheelbase was 291 centimeters (114.6 inches). The odometer reading at the time of the vehicle inspection is unknown because the case vehicle was equipped with an electronic odometer.

CASE VEHICLE DAMAGE

Exterior Damage: The impact to the back of case vehicle involved the entire rear plane (**Figure 5**). The case vehicle's rear bumper, bumper fascia, rear door, both turn signal/tail lamp assemblies, backlight, backlight header, and both right and left rear side panels were directly damaged and crushed forward. Direct damage began at the left rear bumper corner and extended 150 centimeters (59 inches) along the rear bumper. Residual maximum crush at the bumper was measured as 10 centimeters (3.9 inches) occurring at C_5. The front of the school bus overrode the case vehicle's back bumper resulting in severe crush above the back bumper. The residual maximum above-bumper crush (**Figure 6** below) was measured as 96 centimeters (37.8 inches) occurring at C_6. The table below shows the average of the case vehicle's bumper level crush and above bumper crush.

Figure 5: Overview of damage to back of case vehicle

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	150	96	157	36	48	51	50	51	52	0	0
in		59.1	37.8	61.8	14.2	18.9	20.1	19.7	20.1	20.5	0.0	0.0

The wheelbase on the case vehicle's left side was extended 2 centimeters (0.8 inches) while the right side wheelbase was unaltered from the crash. Induced damage involved the roof and both right and left quarter panels and rear doors. In addition, the rear-most glazing on the left side and both rear glazing panels on the right side were broken out, and all the side doors were jammed closed. No obvious induced damage or remote buckling was noted to the remainder of the case vehicle's exterior.

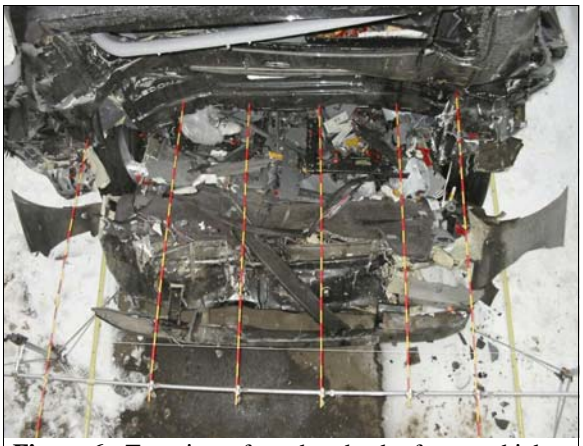


Figure 6: Top view of crush to back of case vehicle, measurements above the bumper, each increment on rods is 5 cm (2 in)

The recommended tire size is unknown because the tire placard was not accessible due to the jammed driver's door. The case vehicle was equipped with tires of size P215/70R15. The case vehicle's left rear tire was deflated due to cuts in the sidewall from damaged sheet metal. The right rear tire was not deflated but was restricted by intruding sheet metal. The case vehicle's tire data are shown in the following table.

Tire	*Measured Pressure*		*Recommend Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kpa	psi	kpa	psi	milli-meters	32nd of an inch			
LF	200	29	unk	unk	6	8	None	No	No
RF	207	30	unk	unk	5	6	None	No	No
LR	0	0	unk	unk	6	8	Circular cuts in sidewall	No	Yes
RR	193	28	unk	unk	6	8	Scrapes and cuts	Yes	No

Vehicle Interior: Inspection of the case vehicle's interior revealed blood stains on the driver's head restraint, seat back, and arm rest, as well as the right arm rest of the seat directly behind the driver. The driver's seat back was bent rearward (**Figure 7** below) to an angle of about 45 degrees due to the driver loading the seat back during the crash. In addition, the seat back of the seat directly behind the driver (i.e., where the child was seated in the child safety seat) was also

bent rearward at about the same angle (**Figure 8**). Despite the severity of the crash, there were no other occupant contacts found in the remainder of the case vehicle.

Figure 7: The case vehicle driver's seat back

Figure 8: The second seat row, left seat

There were numerous intrusions to the case vehicle's interior. The most severe intrusions involved the driver's seat back intruding longitudinally into the second row, left seat position; the third row seat backs intruding longitudinally into the third row seat, and the tailgate and backlight header intruding longitudinally into the rear cargo area.

Damage Classification: Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **06-BDAW-4** (**180** degrees). The WinSMASH reconstruction program could no be used to reconstruct the case vehicle's Delta V because heavy vehicle's such as the school bus are out-of-scope for the program. An in-line momentum analysis was used to calculate the impact speed and Delta V of the school bus and the Delta V of the case vehicle. The analysis indicated the school bus was traveling 71 to 77 km.p.h. (44 to 48 mph) when it impacted the back of the case vehicle resulting in a Delta-V to the case vehicle of 55 to 61 km.p.h. (34 to 38 mph). The Delta V of the school bus was 15 to 16 km.p.h. (9 to 10 mph). The case vehicle was towed due to damage.

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with redesigned driver and front right passenger air bags. No air bags deployed as a result of this crash because the impact was to the back of the case vehicle.

CHILD SAFETY SEAT

The second seat row, left passenger was a 3-year-old, male [White (non-Hispanic), unknown height and weight]. He was seated in a convertible child safety seat that was positioned in a forward-facing configuration as a belt-positioning booster seat. The child safety seat was a COSCO "Alpha-Omega" (**Figure 9** below) manufactured by Dorel Juvenile Group, Inc., of Columbus, Indiana on November 13, 2001 and identified by model number 02-537-EBN. The child seat was designed to be used as a rear facing infant seat, forward facing toddler seat with

harness straps and shield, or as a belt-positioning booster seat. It is unknown at this time when the child seat was purchased. The child seat consisted of a plastic one-piece shell with a padded "Eddie Bauer" pullover cloth cushion with head rest. The child seat was being used without the shield and harness, which had been removed. There was a plastic shoulder belt guide bracket (**Figure 10**) with three slots on each wing of the child seat. It is not known if the shoulder belt was in fact positioned in one of the slots. The case vehicle's lap-and-shoulder belt for this position had been cut out of the vehicle and was not available for inspection.

Figure 9: Front view of child safety seat, a COSCO "Alpha-Omega"

Figure 10: Overview of left side of child safety seat, arrow shows shoulder belt guide bracket

Inspection of the child safety seat revealed no apparent damage or fractures to the shell. There were some worn and discolored areas on the head rest cushion and sides of the seat cover, but no load marks or occupant contact marks were found. There was a manufacturer's warning label affixed to both sides of the seat stating "do not use as a belt positioning seat with lap belt only" In addition, labels were affixed to the seat illustrating the proper installation procedure and occupant weight limitations for the forward-facing toddler position and the rear-facing infant position as follows: "Forward-facing with shield/harness, 22-40 lbs (10-18 kg)"; "Forward-facing 30-80 lbs. (13.6-36.6 kg)"; Rear-facing position, 5-22 lbs (2.3-10kg); "See instructions for using rear-facing for infants 22-35 lbs (10-15.9 kg)".

CASE VEHICLE SECOND SEAT ROW, LEFT PASSENGER KINEMATICS

Immediately prior to the crash, the case vehicle's second seat row, left passenger [3-year-old, White (non-Hispanic) male; (unknown height and weight)] was seated in an unknown position in his child safety seat. The type of clothing the child was wearing and the position of his legs and arms at the time of the crash are not known. He was reportedly holding a toy car at the time of the crash. The child safety seat was positioned facing forward on the case vehicle's bucket seat. The bucket seat was equipped with dual arm rests, and the seat track was adjusted to its rear-most position. The seat back was most likely slightly reclined prior to the impact. The seat back was

found angled rearward approximately 45 degrees during the vehicle inspection, the approximate same angle as the driver's seat back.

The second seat row, left passenger was restrained in the child safety seat by the case vehicle's lap-and-shoulder belt. The lap-and-shoulder belt was routed over the child, securing the child and the child safety seat. It is not known if the shoulder belt was routed through one of the three shoulder belt guides on the left side wing of the child safety seat. The lap-and-shoulder safety belt was reportedly cut in two places by police personnel to extricate the child from the vehicle. The safety belt was not available for inspection during this contractor's field investigation. Inspection of the safety belt buckle revealed no damage to the buckle. The shoulder belt anchor was found adjusted to its full-down position.

The school bus impact to the back of the case vehicle caused the second seat row, left passenger to move backward in his seat along a path opposite the case vehicle's 180 degree direction of principal force as the case vehicle was accelerated forward. The passenger's back and back of his head contacted the child safety seat's seat back and head rest, and the child safety seat loaded into the case vehicle's seat back. It appears that the case vehicle's seat back was displaced rearward as a result of the impact force (**Figure 8** above). The passenger most likely ramped up the seat back of the child safety seat to some degree and loaded his lap belt. The passenger remained in the child safety seat as the case vehicle was pushed to final rest by the school bus. Police personnel cut the safety belt and removed the passenger from the case vehicle.

CASE VEHICLE SECOND SEAT ROW, LEFT PASSENGER INJURIES

The police crash report indicated the second seat row, left passenger sustained a fatal injury as a result of the cash and was transported by ambulance to a local hospital. The passenger's injuries are unknown. The treating medical facility refused to release the passenger's medical records.

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash, the case vehicle's driver [36-year-old, White (non-Hispanic) male; (unknown height and weight)] was most likely seated in a nominal upright driving position with both hands on the steering wheel, and he had one of his feet on the brake. At the time of the case vehicle inspection, the driver's seat track was positioned in its approximate middle position, and the seat back was found angled rearward approximately 45 degrees. The pre-crash seat back adjustment is not known.

Based on the police crash report, the case vehicle's driver was restrained by his manual, three-point, lap-and-shoulder safety belt system. Inspection of the safety belt assembly showed only usage scratches on the latch plate.

The school bus impact to the back of the case vehicle caused the driver to move backward in his seat along a path opposite the case vehicle's 180 degree direction of principal force as the case vehicle was accelerated forward. The driver loaded his seat back and displaced the seat back

rearward dynamically to an angle beyond 45 degrees. The driver most likely ramped up the back of his seat to some degree and loaded his lap belt. The driver remained in his seat as the school bus pushed the case vehicle to final rest. It is not known how the driver exited the case vehicle.

CASE VEHICLE DRIVER INJURIES

The police crash report indicated the case vehicle's driver sustained a B" (non-incapacitating-evident) injury and was transported by ambulance to a local hospital. The driver was admitted to the hospital for treatment of a back injury. The driver's specific injuries, length of hospital stay, follow-up treatment and number of lost work days are not known. The treating medical facility refused to release his medical records.

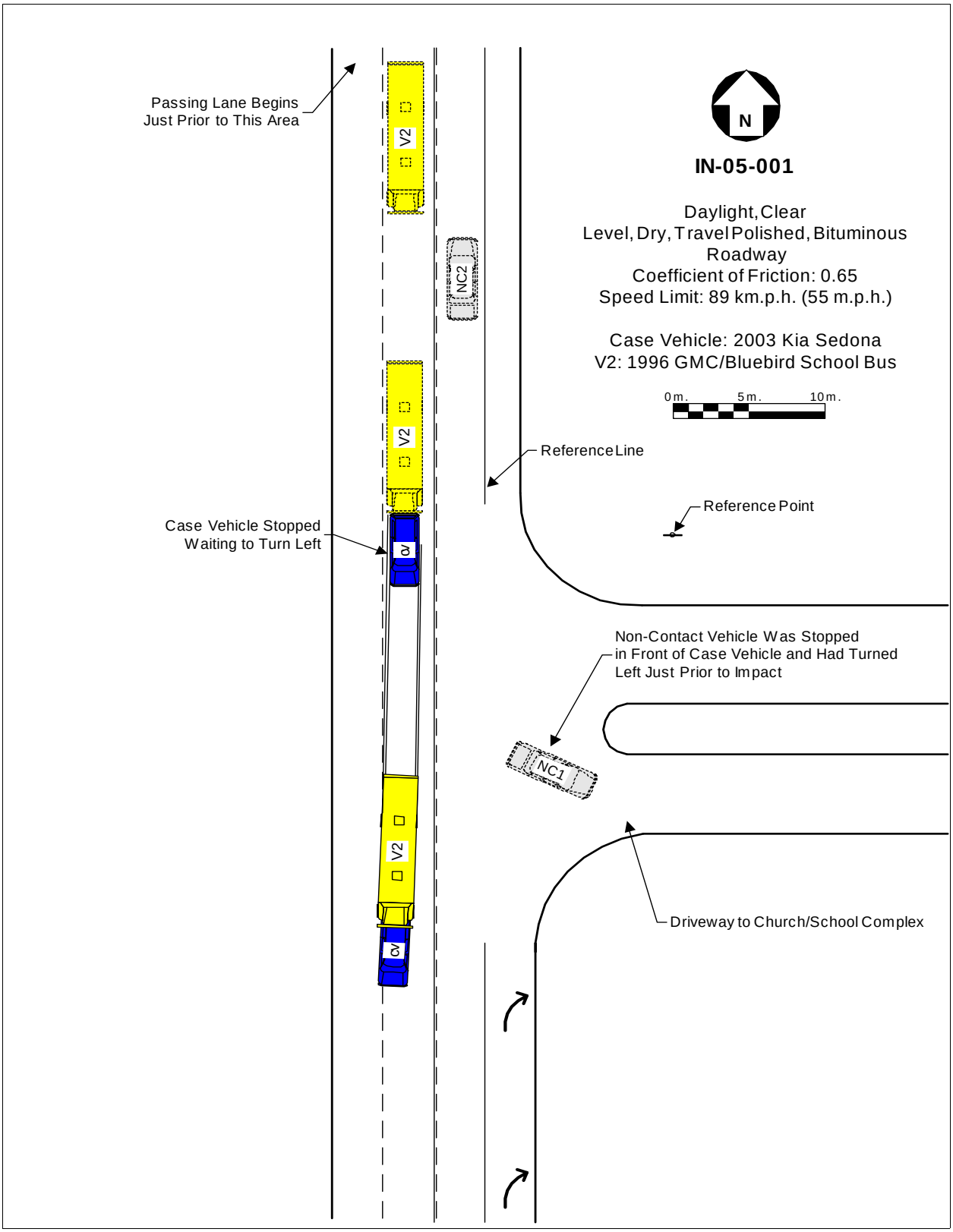
OTHER VEHICLE

The 1996 GMC/Bluebird was a rear wheel drive school bus (VIN: 1GDL7T1J7TJ------) equipped with a 6.6L diesel engine and hydraulic brakes. The school bus chassis was a GMC 7000 series, medium duty. The school bus was occupied only by the driver at the time of the crash.

Exterior Damage: The school bus' impact with the case vehicle involved the front bumper, hood headlamps and grille. The direct damage extended across the full length of the front bumper. The bumper, headlamps, grille, hood and the left side view mirror were all directly damaged. The fibre glass of the hood was fractured, and the left headlamp was broken off its mount. The corners of the front bumper were crushed rearward to a point where they nearly contacted the left front wheels.

Damage Classification: No damage classification could be assigned to the school bus because school buses are out-of-scope for CDC and TDC. An in-line momentum analysis was used to calculate the impact speed and Delta V of the school bus. The analysis indicated the school bus was traveling 71 to 77 km.p.h. (44 to 48 mph) when it impacted the back of the case vehicle. The school buse's Delta V was 15 to 16 km.p.h. (9 to 10 mph). The school bus was driven from the scene.

School Bus Occupants: According to the police crash report, the school bus driver [36-year-old (unknown race, Hispanic) male] was restrained by his manual, three-point, lap-and-shoulder, safety belt system. The police crash report indicated the driver sustained no injuries, but was transported to a local hospital. Based on a local newspaper article, the driver was a part-time school bus driver for the local school district and had completed all the required training and periodic testing. He had no prior accidents on his driving record.


Passing Lane Begins
Just Prior to This Area
V2
NC2
V2
Case Vehicle Stopped
Waiting to Turn Left
CV
V2
CV
N
IN-05-001
Daylight, Clear
Level, Dry, Travel Polished, Bituminous
Roadway
Coefficient of Friction: 0.65
Speed Limit: 89 km.p.h. (55 m.p.h.)
Case Vehicle: 2003 Kia Sedona
V2: 1996 GMC/Bluebird School Bus
0m. 5m. 10m.
Reference Line
Reference Point
Non-Contact Vehicle Was Stopped
in Front of Case Vehicle and Had Turned
Left Just Prior to Impact
NC1
Driveway to Church/School Complex