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ON-SITE CHILD SAFETY SEAT INVESTIGATION

CASE NUMBER - IN10010
LOCATION - MINNESOTA
VEHICLE - 2007 KIA RONDO
CRASH DATE - March 2010

Submitted:

September 27, 2010

Contract Number: DTNH22-07-C-00044

Prepared for:

U.S. Department of Transportation
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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 Restraint System (CRS) investigation involving a 2007 Kia Rondo EX.			
16. *Abstract* This on-site investigation focused on the second row left passenger (14-month-old, male) of a 2007 Kia Rondo EX and the Britax Roundabout convertible CRS in which he was seated. This crash occurred on a 6-lane divided U.S. highway at a signalized 4-leg intersection. The vehicles involved in the crash were the Kia, a 1998 Ford Escort ZX2, and a 1997 Nissan Maxima. The Kia was occupied by a restrained 38-year-old male driver and the second row left passenger who was restrained in the CRS. The Kia's driver was stopped at the intersection heading south directly behind the Nissan, which was stalled. The Ford was traveling south approaching the back of the Kia. According to police, as the driver of the Ford was reaching for a dropped cellular telephone, the front plane of the Ford impacted the back plane of the Kia (event 1), which projected the Kia forward. The front plane of the Kia impacted the back plane of the Nissan. The second row left passenger of the Kia was transported by ambulance to a hospital where he was pronounced deceased. The driver of the Kia was not injured. The CRS was not damaged during the crash.			
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This on-site investigation focused on the second row left passenger (14-month-old, male) of a 2007 Kia Rondo EX and the Britax Roundabout convertible Child Restraint System (CRS) in which he was seated. This crash was brought to the attention of the National Highway Traffic Safety Administration on March 21, 2010 through an internet news article. This investigation was assigned on April 5, 2010. The crash involved the Kia (**Figure 1**), a 1998 Ford Escort ZX2, and a 1997 Nissan Maxima. This crash occurred in March, 2010, at 1100 hours in Minnesota and was investigated by the city police. The Kia was inspected on April 7, 2010. The Ford and the crash scene were inspected on April 8, 2010. The attorney for the Kia's driver would not grant permission for an interview. The Nissan was not inspected since it could not be located. This report is based on the police crash report, Kia, Ford, and crash scene inspections, discussions with the investigating police officers, occupant kinematic principles, and evaluation of the evidence.

Figure 1: The damaged 2007 Kia Ronda EX

CRASH CIRCUMSTANCES

Crash Environment: This crash occurred during daylight hours and clear weather conditions on a 6-lane state highway that traversed in a north-south direction. The involved vehicles were traveling in the same direction approaching a signalized 4-leg intersection with a city street. On the northern leg of the intersection, both the north and southbound roadways had two through lanes in each direction. The southbound roadway also had right and left turn lanes and was separated from the northbound roadway by a raised median that was 5.4 m (17.7 ft) in width. Each turn lane was approximately 4.2 m (13.8 ft) in width. The first through lane from the right was 3.6 m (11.8 ft) in width and the second through lane was 4 m (13.1 ft) in width. The roadway pavement markings consisted of broken white through lane lines, solid white turn lane lines with solid white directional arrows, and a broken white through lane line. The posted speed limit was 64 km/h (40 mph). The intersection was controlled by 3-phase traffic signals. The roadway pavement was dry bituminous and the grade was level for all the vehicles. The site of the crash was suburban commercial and the traffic density was moderate. The Crash Diagram is on page 11 of this report.

Pre-Crash: The Kia was occupied by a restrained 38-year-old male driver and a 14-month-old male second row left passenger who was restrained in a Britax Roundabout convertible CRS. The Kia's driver was stopped heading south in the second through lane from the right directly behind the Nissan, which was stalled. The Ford was driven by a restrained 28-year-old female who was traveling south approaching the back of the Kia (**Figure 2**). According to police, the driver of the Ford was reaching for a dropped cellular telephone just prior to the crash. The police crash report indicated that there were no pre-impact braking marks from the Ford and none were found during the SCI crash scene inspection.

Crash: The front plane of the Ford (**Figure 3**) impacted the back plane of the Kia (**Figure 4**, event 1). The impact projected the Kia forward and the front plane impacted the back plane of the Nissan (event 2). No air bags deployed in the Kia. The Kia remained in its lane and came to final rest 12.5 m (41 ft) south of the point of impact with the Ford. The Ford came to final rest in the left turn lane heading southeast, 15.5 m (51 ft) south of the point of impact (**Figure 5**). The Nissan remained in its lane and came to final rest 6.7 m (22 ft) south of the Kia's final rest position.

Figure 2: Area of the impact between the Ford and Kia

Figure 3: Damage on the front plane of the Ford from the impact with the back plane of the Kia

Figure 4: Damage on the back plane of the Kia from the impact with the front plane of the Ford

Figure 5: Police photo of the final rest positions of the Ford and the Kia

Post-Crash: The police, emergency medical, and rescue services responded to the crash scene. The Kia's second row left passenger was removed from the CRS and from the vehicle by the driver and a passerby. The passerby was a nurse and began Cardio-Pulmonary Resuscitation (CPR) on the child. The child was transported by ambulance to a hospital. The driver of the Kia was not injured and rode in the ambulance with the child. The front right passenger of the Nissan was transported by ambulance to a hospital. The drivers of the Ford and the Nissan were not transported to a medical facility. The Kia and Ford were towed from the crash scene due to damage. The Nissan was driven from the crash scene.

The 2007 Kia Rondo EX was a front-wheel drive, 5-door station wagon (VIN: KNAFG526077------) equipped with a 2.7L, V-6 engine, a 5-speed automatic transmission, and 4-wheel anti-lock brakes with electronic brake force distribution and electronic stability control. The front row was equipped with bucket seats, adjustable and active head restraints, lap-and-shoulder safety belts with pretensioners and force limiters, driver and front right passenger frontal air bags, front seat-mounted side impact air bags, and side impact inflatable curtain (IC) air bags that provided protection for the front and second rows. The second row was equipped with a split bench seat with folding backs, lap-and-shoulder safety belts, adjustable head restraints and Lower Anchors and Tethers for Children (LATCH) in the outboard seating positions. The specified wheelbase was 270 cm (106.3 in).

CASE VEHICLE DAMAGE

Exterior Damage: The Kia sustained damage on the back plane during the impact with the Ford. The back bumper, tailgate, right quarter panel, and right taillight assembly were directly damaged. The direct damage began at the back right bumper corner and extended 130 cm (51 in) along the bumper. A second set of crush measurements was taken above the bumper level since the hatch and right quarter panel sustained more crush than the bumper. The maximum residual crush on the bumper was 49 cm (19.3 in) occurring at C_6 (**Figure 6**), while the maximum crush above the bumper was 62 cm (24.4 in) also occurring at C_6. The right side wheelbase was reduced 9 cm (3.5 in) and the left side wheelbase was reduced 1 cm (.4 in). There was induced damage on both quarter panels, the backlight, and tailgate. The table below presents the average of the crush at the bumper and above bumper levels.

Figure 6: Right side view of the crush on the back bumper of the Kia

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	130	62	138	7	27	42	50	51	56	7	0
in		51.2	24.4	54.3	2.8	10.6	16.5	19.7	20.1	22.0	2.8	0.0

The Kia sustained front plane damage on the bumper during the impact with the Nissan. The direct damage began at the front left bumper corner and extended 123 cm (48.4 in) along the front bumper (**Figure 7**). The crush measurements were taken at the bumper level and the residual

maximum crush was 4 cm (1.6 in) at C_1. There was no induced damage. The following table presents the 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	2	123	4	149	4	0	1	3	1	0	-11	0
in		48.4	1.6	58.7	1.6	0.0	0.4	1.2	0.4	0.0	-4.3	0.0

Damage Classification: The Kia's Collision Deformation Classification was 06BDEW3 (180 degrees) for the impact with the Ford and 12FDEW1 (0 degrees) for the impact with the Nissan. The Damage Algorithm of the WinSMASH program calculated the Kia's total Delta V for the back plane impact as 42 km/h (26.1 mph). The longitudinal and lateral velocity changes were 42 km/h (26.1 mph) and 0 km/h, respectively. Based on the damage on the Ford and Kia, the results appeared reasonable. The Missing Vehicle algorithm calculated the Kia's total Delta V for the front impact with the Nissan as 14 km/h (8.7 km/h). The longitudinal and lateral velocity changes were -14 km/h (-8.7 mph) and 0 km/h, respectively. Based on the damage on the Kia, the results appeared reasonable.

Figure 7: Damage on the front plane of the Kia from the impact with the back plane of the Nissan

The manufacturer's recommended tire size was P225/50R17. The Kia was equipped with the recommended size tires. The vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	221	32	221	32	4	5	None	No	No
LR	214	31	221	32	5	6	None	No	No
RR	214	31	221	32	5	6	None	Yes	No
RF	214	31	221	32	4	5	None	No	No

Vehicle Interior: The inspection of Kia's interior revealed that the driver's head restraint was displaced rearward 5.5 cm (2.2 in) from contact by the driver's head (**Figure 8**). A police on-scene photo showed that the driver's seat back was also displaced rearward (**Figure 9**). There was no deformation of the steering wheel or compression of the energy absorbing steering column. There was no discernable evidence of occupant contact in the second row.

Figure 8: Driver's deformed head restraint

Figure 9: Police on-scene photo showing the position of the driver's seat back and the second row left CRS; driver's seat was moved to the full forward track position (arrow) when the child was removed from the vehicle; CRS in second row right seat position was not occupied at time of crash

The tailgate and right rear door were jammed shut. The remaining doors were closed and operational. Prior to the crash the window glazings were either closed for the operable windows or fixed for the others. The backlight and third right rear glazings were disintegrated from impact forces. The remaining glazings were undamaged.

The Kia sustained intrusions in the cargo area from the back plane impact. The most severe intrusions involved the tailgate and right D-pillar which intruded longitudinally 37 cm (14.6 in) and 36 cm (14.2 in), respectively.

AUTOMATIC RESTRAINT SYSTEM

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

The Kia's side impact air bag system consisted of front seat-mounted side impact air bags and roof side rail-mounted side impact IC air bags. Based on the Holmatro Rescuer's Guide to

Vehicle Safety Systems, the side impact sensors were located within the lower B- and C-pillars. None of the side impact air bags deployed in this crash.

MANUAL RESTRAINT SYSTEM

The Kia was equipped with lap-and-shoulder safety belts in all the seating positions. The driver's safety belt consisted of continuous loop belt webbing, an Emergency Locking Retractor (ELR), sliding latch plate, and an adjustable upper anchor that was in the full down position. The front right passenger safety belt consisted of continuous loop belt webbing, a switchable ELR/Automatic Locking Retractor (ALR), sliding latch plate, and adjustable upper anchor that was located in the full down position. The safety belts were also equipped with buckle and retractor-mounted pretensioners. Neither pretensioner actuated during the crash. The second row safety belts were equipped the same as the front right passenger safety belt, but had fixed upper anchors and were not equipped with pretensioners.

The inspection of the driver's safety belt assembly revealed significant historical usage scratches on the latch plate and load marks on the latch plate belt guide. This evidence indicated that the driver was restrained at the time of the crash.

The inspection of the second row left safety belt assembly revealed a few usage marks. Police information and a police on-scene photograph (**Figure 9**) indicated that this safety belt was not used to secure the CRS. The CRS was secured with the CRS's lower anchor. The tether was not used.

CHILD RESTRAINT SYSTEM

The Kia's second row left passenger (14-month-old, male; unknown height and weight) was seated in a Britax Roundabout convertible CRS (**Figure 10**) restrained by the internal 5-point harness. The CRS was manufactured on January 31, 2005 and the model number was E9L0285. The CRS was used in the forward facing position. When used in this position, the CRS was designed for children who weigh between 9 and 18 kg (20 and 40 lbs) and whose height is 102 cm (40 in) or less.

Figure 10: The Britax Roundabout convertible CRS

The CRS was equipped with a LATCH system and a 5-point harness. A harness retainer clip was present, but it is not known if it was used. The CRS was equipped with adjustable harness straps and three sets of adjustment slots. The harness straps were routed through the highest set if slots. The CRS was constructed of

a one-piece plastic shell with an adjustable, non-detachable base, which was adjusted to the forward position. The CRS was covered with a 2 cm (0.8 in) thick foam pad. There was also a 2 cm (0.8 in) thick styrofoam liner on the interior of the seat back and a 1 cm (0.4 in) thick fabric cover over the seat and the seat back. Based on police information and on-scene police photographs, the lower anchor was used to secure the CRS tightly within the vehicle. Neither the tether nor the vehicle's safety belt were used to secure the CRS.

Inspection of the CRS revealed no damage or stress marks on the shell and base. There were no load marks present on the harness strap webbing, latch plates, or buckle. There were no discernable occupant contact marks on the CRS.

The police on-scene photographs showed that a second CRS was in the second row right seating position at the time of the crash. This CRS was not occupied at the time of the crash.

CASE VEHICLE DRIVER KINEMATICS

The driver (38-year-old male, unknown height and weight) of the Kia was seated in an unknown posture. The adjustment of the driver's seat track and seat back are not known. The steering column was adjusted to the full up position.

The back plane impact with the front of the Ford displaced the driver of the Kia rearward, opposite the 6 o'clock direction of force. He contacted the seat back and head restraint, which bent the head restraint posts 6 cm (2.4 in) rearward and displaced the seat back rearward to a recline angle of approximately 45 degrees. The driver was redirected forward and loaded the safety belt when the front plane of the Kia impacted the back plane of the Nissan. The driver then rebounded backward into the seat.

CASE VEHICLE DRIVER INJURIES

According to the police crash report, the driver did not sustain any injury as a result of the crash. He accompanied the second row left passenger to the hospital in the ambulance.

Figure 11: CRS placed in the Kia at the SCI inspection and driver's seat back positioned to contact the CRS; the distance from the head restraint to the back of the CRS was approximately 35 cm (13.8 in)

CASE VEHICLE SECOND ROW LEFT PASSENGER KINEMATICS

The second row left passenger (14-month-old male, unknown height and weight) of the Kia was seated in the forward facing CRS in an unknown posture, and restrained by the 5-point harness.

The impact on the back plane of the Kia (event 1) displaced the child rearward, within the CRS opposite the 6 o'clock direction of force. He contacted the seat back of the CRS shell probably causing the traumatic brain injury. According to the driver's statement to the investigating police officer, the driver's seat back was displaced rearward and struck the CRS (**Figure 11**). The child probably contacted the driver's head restraint during rebound from the first event and/or the secondary impact with vehicle 3. The driver and a passer-by removed the child from the CRS and vehicle. The passer-by was a nurse and performed CPR on the child until emergency medical personnel arrived.

CASE VEHICLE SECOND ROW LEFT PASSENGER INJURIES

The second row left passenger was transported by ambulance to a medical facility and was pronounced deceased. According to a newspaper article, the child sustained a traumatic brain injury. Further injury details are unknown. The medical examiner refused a request for an autopsy report. The table below presents the child's injury.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source	Source Confidence	Source of Injury Data
1	Traumatic brain injury	unknown 100999.9,0	CRS shell	Probable	Other: newspaper article

FIRST OTHER VEHICLE

The 1998 Ford Escort ZX2 was a front-wheel drive, 2-door coupe (VIN: 3FALP1133WR------), equipped with a 2.0 liter, I-4 engine and a 5-speed, manual transmission. The Ford was equipped with redesigned frontal air bags, both of which deployed as a result of the crash.

Exterior Damage: The Ford sustained front plane damage during the impact with the Kia. The front bumper, bumper fascia, hood, grille, left headlamp/turn signal assembly, left fender, and left front wheel were directly damaged. The direct damage began at the front left bumper corner and extended 100 cm (39.4 in) along the front bumper (**Figure 12**). The crush measurements were taken at the bumper level and the maximum residual crush was 54 cm (21.2 in) occurring at C_3. The left side wheelbase was reduced 7 cm (2.8 in) and the right side wheel base was extended 2 cm (0.8 in). The induced damage involved the hood, both fenders, and the windshield. The table below presents the front crush profile.

Figure 12: Front plane damage on the 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	100	54	117	43	48	54	38	15	7	-20	0
in		39.4	21.3	46.1	16.9	18.9	21.3	15.0	5.9	2.8	-7.9	0.0

Damage Classification: The Ford's CDC for the front plane impact (event 1) was 12FDEW3 (0 degrees). The damage algorithm of the WinSMASH program calculated the Ford's total Delta-V as 55 km/h (34.2 mph). The longitudinal and lateral velocity changes were -55 km/h (-34.2 mph) and 0 km/h, respectively. Based on the damage to both vehicles, the results appeared reasonable.

The manufacturer's recommended tire size was P185/65R14 or P185/60R15. The Kia was equipped with P185/70R14 size tires. The vehicle's tire data are shown in the table below.

Tire	*Measured Pressure*		*Vehicle Manufacturer's Recommended Cold Tire Pressure*		*Tread Depth*		*Damage*	*Restricted*	*Deflated*
	kPa	psi	kPa	psi	milli-meters	32nd of an inch			
LF	Flat	Flat	221	32	5	6	None	No	Yes
LR	Flat	Flat	221	32	4	5	None	No	Yes
RR	269	39	241	35	4	5	None	No	No
RF	276	40	241	35	4	5	None	No	No

First Other Vehicle's Driver: According to the police crash report, the Ford's driver (28-year-old female) was restrained by the lap-and-shoulder safety belt. She sustained a C (possible) injury but was not transported to a hospital.

SECOND OTHER VEHICLE

The 1997 Nissan Maxima was a front-wheel drive, 4-door sedan (VIN: JN1CA21D7VT----), equipped with a 3-liter, V-6 engine and a 4-speed automatic transmission. The Nissan was also equipped with dual frontal air bags, neither of which deployed as a result of the crash.

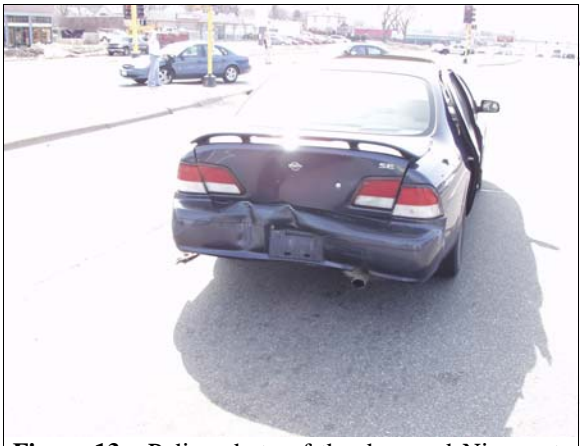


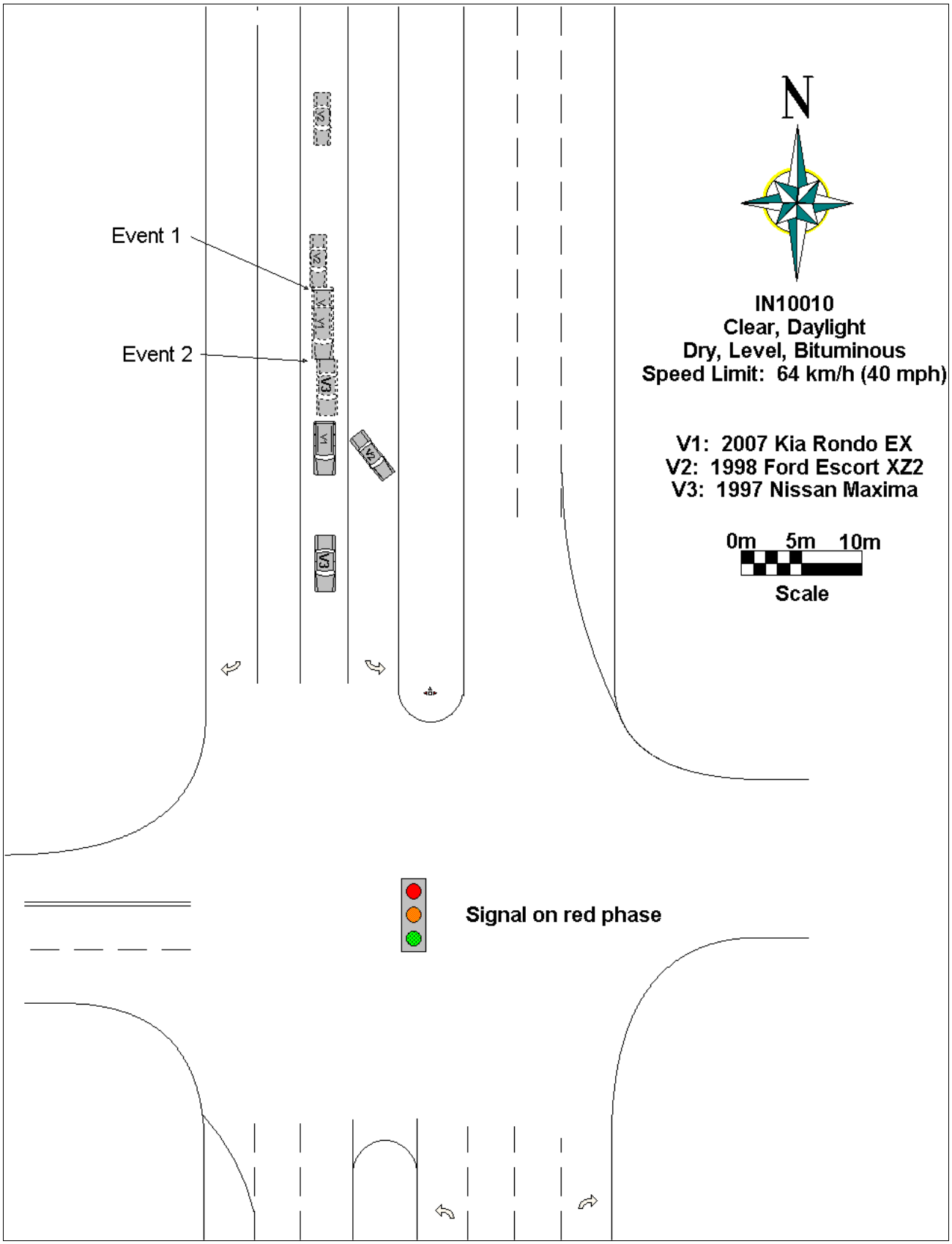
Figure 13: Police photo of the damaged Nissan at the crash scene

Damage Classification: The Nissan's CDC for the back plane impact (event 2) was 06BDEW1 (180 degrees). The CDC was based on a police on-

scene photograph of the vehicle (**Figure 13**). The Missing Vehicle algorithm of the WinSMASH program calculated the Nissan's total Delta V for the front impact with the Nissan as 15 km/h (9.3 mph). The longitudinal and lateral velocity changes were 15 km/h (9.3 mph) and 0 km/h, respectively. These results appeared reasonable.

Second Other Vehicle's Driver: According to the police crash report, the Nissan's driver (31-year-old, male) was restrained by the lap-and-shoulder safety belt. He did not sustain any injury and was not transported to a medical facility.

Second Other Vehicle's Passenger: The Nissan's front right passenger was restrained by the lap-and-shoulder safety belt. She sustained a C (possible) injury and was transported by ambulance to a medical facility.


N
Event 1
Event 2
V2
V1
V3
IN10010
Clear, Daylight
Dry, Level, Bituminous
Speed Limit: 64 km/h (40 mph)
V1: 2007 Kia Rondo EX
V2: 1998 Ford Escort XZ2
V3: 1997 Nissan Maxima
0m 5m 10m
Scale
Signal on red phase