On-Scene / Vehicle to Vehicle / Front to Back
Dynamic Science, Inc. / Case Number: DS97008
1995 Ford Crown Victoria LX
North Carolina
May/1997

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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 crash worthiness performance of the involved vehicle(s) or their safety systems.

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The collision occurred in a rural area of North Carolina in May 1997 at 1555 hours. Vehicle 1, a 1995 Ford Crown Victoria LX driven by a 55-year-old female, was traveling northbound at a police reported 89 km/h (55 mph). The right front seat was occupied by a 5-month-old female seated in a Fisher-Price 2100 convertible safety child seat. The child seat was in the rearward-facing position. The right rear seat was occupied by a 6-year-old male. Vehicle 2, a 1997 Nissan Sentra 4-door driven by a 39-year-old female, was traveling northbound at a police reported 80.5 km/h (50 mph) directly in front of Vehicle 1.

Two non-contact vehicles, a pickup truck and a school bus, were initially traveling south along the same road. Just prior to the collision the school bus was passed on the left, in the northbound traffic lane, by the pickup truck. The driver of Vehicle 2 braked and came to a stop to avoid colliding with the pickup truck. Vehicle 1 was unable to stop and the front dove downward and struck the rear of Vehicle 2 at an estimated speed of 68.9 km/h (42.8 mph). Both air bags in Vehicle 1 deployed at this time. The passenger air bag struck the back of the child seat which in turn struck the back of the child's head.

The right front passenger was transported to a local hospital. From there she was transported to a medical center where she arrived at 1745 hours, and she expired at 2100 hours that same day.

16. Abstract

17. Key Words	18. Distribution Statement
Air bag, deployment, injury, accident, child, fatality	

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Dynamic Science, Inc.
Accident Investigation
Case Number: DS97008

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BACKGROUND:

Description:	This case was initiated in response to a report of a child fatality in a rear facing child seat in the right front seat position, and the interaction with the air bag. Vehicle 1, a 1995 Ford Crown Victoria LX was driven by a 55-year-old female. The right front seat was occupied by a 5-month-old female seated in an upright position in a Fisher Price Model 9100 convertible child seat that was in a rearward facing position.
Investigation Type:	On-Scene
Crash Location:	North Carolina
Crash Date:	May, 1997
Notification Date:	May 7, 1997
Field Work Completed:	May 9, 1997

SUMMARY:

The collision occurred in a rural area of North Carolina in May 1997 at 1555 hours. Vehicle 1, a 1995 Ford Crown Victoria LX driven by a 55-year-old female (160 cm / 63 in. - 86 kg. / 190 lbs.), was traveling northbound at a police reported 89 km/h (55 mph). The right front seat was occupied by a 5-month-old female (71 cm / 28 in. - 9.5 kg / 21 lbs.) seated in a Fisher-Price 2100 convertible child safety seat. The child seat was in the rearward-facing position. The right rear seat was occupied by a 6-year-old male. Vehicle 2, a 1993 Nissan Sentra 4-door driven by a 39-year-old female (157.5 cm / 62 in), was traveling northbound at a police reported 80.5 km/h (50 mph) directly in front of Vehicle 1.

Two non-contact vehicles, a pickup truck and a school bus, were initially traveling south along the same road. Just prior to the collision the school bus was passed on the left, in the northbound traffic lane, by the pickup truck. The driver of Vehicle 2 braked and came to a stop to avoid colliding with the pickup truck. The driver of Vehicle 1 braked hard, “jamming” both of her feet on the brake pedal. Vehicle 1 left 26.8 m (88.0 ft) of right front locked wheel skid marks. Vehicle 1 was unable to stop and the front bumper of Vehicle 1 struck the rear of Vehicle 2.

Calculate pre-braking travel speed for Vehicle 1 using pre-crash and post-crash skids and using velocity change as the impact speed.

Pre-crash skids:

$$S_1 = \sqrt{30(d(f}$$
$$\text{where } S_1 = \text{skid speed, } d = \text{skid distance} = 53.0 \text{ ft.}$$
$$f = \text{drag factor} = 0.7,$$
$$S_1 = \sqrt{30(53(.7} = 33.4 \text{ MPH} = 53.8 \text{ KPH}$$

Post-crash skids:

$$S_1 = \sqrt{30(d(f}$$
$$\text{where } S_1 = \text{skid speed, } d = \text{skid distance} = 35.0 \text{ ft.}$$
$$f = \text{drag factor} = 0.7,$$
$$S_1 = \sqrt{30(35(.7} = 27.1 \text{ MPH} = 43.6 \text{ KPH}$$

Combine pre-crash and post-crash speeds:

$$S_1 = \sqrt{S_s^2 + S_i^2}$$
$$\text{where } S_s = \text{speed at start of skid, } S_i = \text{post impact speed}$$
$$S_1 = \sqrt{33.4^2 + 27.1^2} = 43.0 \text{ MPH} = 69.2 \text{ KPH}$$

Calculate pre and post-crash speeds with velocity change as impact speed:

$$S_1 = \sqrt{S_s^2 + S_i^2}$$
$$\text{where } S_s = \text{speed at start of skid, } S_i = \text{impact speed}$$
$$S_1 = \sqrt{43.0^2 + 6.8^2} = 43.5 \text{ MPH} = 70.0 \text{ KPH}$$

Pre-braking speed (travel speed) was 70.0 KPH (43.5 MPH). Both air bags in Vehicle 1 deployed at this time. The passenger air bag struck the back of the child seat which in turn struck the back of the child's head, and was the cause of severe closed head injuries.

After impact, Vehicle 1 rotated slightly clockwise and came to final rest heading north-east on the roadway. Vehicle 2 was moved to the right shoulder after impact prior to the arrival of the police.

According to the PAR, an ambulance was requested and arrived on the scene at 1606 hours. The child in Vehicle 1 had respiratory effort when rescuers arrived, and they identified severe head

injuries. She was transported to a local hospital which was relatively close to the scene of the accident. From there she was transported to a medical center where she arrived at 1745 hours. She required ventilatory support, and attempts were made to maintain vital signs with resuscitative efforts until she expired at 2100 hours that same day.

The driver of Vehicle 1 sustained injuries consisting of abrasions to her left inner forearm from contact with the air bag, and a lap/shoulder belt contusion to her chest and right lower abdomen area. She was transported to a local hospital via ambulance where she received ER treatment, and was released. The right rear occupant of Vehicle 1 was not injured. He was transported to a local hospital where he was checked out and released.

The driver of Vehicle 2 complained of pain to her chest, neck and back area. She went to a doctor she was sent to by her lawyer a day later.

Both vehicles were towed from the scene, and both vehicles were subsequently repaired.

The driver of Vehicle 1 was aware of the dangers that air bags pose to small statured women as drivers of air bag equipped vehicles. Her insurance company had provided her with a video tape that highlighted the dangers they pose to drivers. As a result, she adjusted her seat track position as far back as possible. She was not however aware of the dangers air bags pose to children in the right front seat, and more specifically she was not aware that there was a possibility of serious injury to children in rear facing child seats in the right front seat position. She was not aware of the warnings posted on the right front lap belt, and the sun visor (see photos #41 & 62).

DETAILED INFORMATION

Vehicles

Vehicle 1

Description:	1995 Ford Crown Victoria LX
VIN:	2FALP74W5SXxxxxxx
Odometer:	63540 km (39483 miles)
Engine:	4.6L 8 cyl
Reported Defects:	None
Cargo:	None
Damage Description:	Minor damage across the front bumper, and grille area.
CDC:	12FDEW1

Figure 1. Exterior damage.

Delta V[1]:

Total	11.0 km/h (6.8 MPH)
Longitudinal	-11.0 km/h (-6.8 MPH)
Latitudinal	0.0 km/h (0.0 MPH)
Energy	9,596 Joules (7,082 ft-lbs)

The results fit the collision model, but appear low.

[1] Missing Vehicle routine of WinSmash

This vehicle is equipped with two rows of seats. The front seat is a split bench type. The driver's seat track was at the rear most track position, but it had been moved by body shop personnel. The right front seat track was between middle and rear most track position. The seatbacks were slightly reclined. The driver's air bag had two tethers, and two vents. The front right passenger's air bag had no tethers and one vent. The front right passenger's air bag had a maximum deployed excursion of 68 cm^2 (26.8 in.). There was paint transfer on the top right corner of the front right passenger's air bag as a result of contact with the module cover. The front right passenger's air bag had been cut off by body shop personnel and was lying on the floor of Vehicle 1. There were no other contacts or damage noted to the air bag as a result of contact with the back side of the child seat. There were no contacts or damage noted to the air bag's module cover.

[2] This was measured from a similar vehicle at a salvage yard.

Vehicle 2

Description:	1993 Nissan Sentra 4-door	
VIN:	1N4EB31P1PCxxxxxx	
Odometer:	Unknown	
Engine:	1.6L 4 cyl	
Reported Defects:	None	
Cargo:	Unknown	
Damage Description:	Unknown, this vehicle was not inspected. Police estimated damage to be at $4,500. Vehicle was repaired by insurance company. No photographs were taken.	
CDC:	Unknown, Missing Vehicle	
Delta V[3]:	Total	18.3 km/h (11.3 MPH)
	Longitudinal	18.3 km/h (11.3 MPH)
	Latitudinal	0.0 km/h (0.0 MPH)
	Energy	13,162 Joules (9,713 ft-lbs)

[3] Missing Vehicle routine of WinSmash

Occupants

Vehicle 1	Occupant 1	Occupant 2
Age/Sex:	55/Female	5 months/Female
Seated Position:	Left front	Right front
Seat Type:	Split Bench	Split Bench
Height:	160 cm (63 in.)	71 cm (28 in.)
Weight:	86 kg (190 lbs.)	9.5 kg (21 lbs.)
Occupation:	Unknown	None
Pre-existing Medical Condition:	Diabetes	None noted
Alcohol/Drug Involvement:	None	None
Driving Experience:	. 39 years	NA
Body Posture:	Upright, normal	Sitting upright, facing rear of vehicle in child seat.
Hand Position:	Both hands on steering wheel	Unknown
Foot Position:	Both feet on brake pedal	Unknown
Restraint Usage:	Lap and shoulder belts used correctly	Lap belt used incorrectly with child seat. Locking clip not used.
	Air bag deployment (frontal)	Air bag deployment (frontal)

Vehicle 1	Occupant 3
Age/Sex:	6/Male
Seated Position:	Right rear
Seat Type:	Bench
Height:	Unknown
Weight:	Unknown
Occupation:	NA
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	NA
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder used correctly

Vehicle 2	Occupant 1
Age/Sex:	39/Female
Seated Position:	Left front
Seat Type:	Unknown
Height:	157.5 cm (62 in.)
Weight:	Unknown, did not want to state
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	No
Driving Experience:	. 23 years
Body Posture:	Upright, normal
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder used correctly, per PAR

Injuries and Injury Mechanisms

Vehicle 1

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Abrasion to left inner forearm	790202.1,2	913	Air bag
	Chest contusion	490402.1,2	922.1	Shoulder belt webbing
	Contusion to right abdomen	50402.1,1	922.2	Lap belt webbing
Occupant 2:	Scant subdural hemorrhage	140650.4,2	852.2	Rebound injury
	Right parietal laceration	140688.4,1	851.6	Child seat back
	Bilateral upper lung lobe contusion	441410.4,3	861.21	Child seat back
	Focal right lower lung lobe contusion	441406.3,1	861.21	Child seat back
	Subarachnoid hemorrhage	140684.3,3	852	Rebound injury
	Brain edema NFS	140668.3, 9	348.5	Child seat back
	Linear horizontal fractures across posterior parietal bones from left to right and from midline to left with additional more complex fractures at right side of head through frontal, parietal, temporal and sphenoid bones and on left involving temporal bone	150200.3,8 150400.2,1 150400.2,2	800.15 800.15 800.15	Child seat back Child seat back Child seat back
	Contusion to right parietal lobe, 1.2 cm x .2 cm (3 in x .5 in)	140606.3, 1	851.4	Child seat back

The head is markedly deformed by scalp hemorrhage, ecchymosis and edema which is greater on the right than on the left. Ecchymosis and edema extends 8.9 cm x 8.9 cm (3.5 in x 3.5 in) on the right and 6.4 cm 5.1 cm (2.5 in x 2 in) on the left.	190402.1,1 190402.1,2	920.0 920.0	Child seat back Child seat back
1.9 cm x 1.3 cm (.75 in x .5 in) punctate contusion in the left occiput.	190402.1,6	920.0	Child seat back
Horizontal oriented contusion measuring 5.1 cm x 1.3 cm (2 in x .5 in) extends to the right of the posterior midline	190402.1,6	920.0	Child seat back
Small contusions on lower head and upper neck	190402.1, 6	920.0	Child seat back
Contusion to right ear	290402.1,1	920.0	Child seat back
Periorbital ecchymosis and edema to right eye	297402.1, 1	921.2	Seat back

Occupant 3:

No injuries were sustained. He was transported to the hospital to be checked out, and was then released with no injuries.

Vehicle 2

INJURY

Driver:

No codeable injuries were reported. She complained of pain to her chest, neck and back. She went to a doctor that her attorney sent her to a day later.

Occupant Kinematics

The driver of Vehicle 1 was seated in a normal, upright position with both of her hands on the steering wheel. At impact with Vehicle 2, the hands of the driver of Vehicle 1 were braced on the steering wheel. Her forward momentum loaded on the steering wheel, and the top half of the steering wheel was deformed forward 2.5 cm - 1.0 in (see photo # 34). On impact, the air bag in the steering wheel hub deployed and the air bag caused abrasions to the left arm of the driver (see photo #91).

The right front seat of Vehicle 1 was occupied by a 5-month-old female seated in a Fisher-Price 9100 convertible child seat. The child seat had been bought by the driver of Vehicle 1, and the only instructions she received in how to install the child seat into her vehicle was from the manual provided with the child seat. This child seat is designed for use with children from birth to 9 kg (20 lbs), this child was .5 kg (1 lb) over the weight limit. The child seat was in the rear-facing position, and in an upright position. For the rear facing position, the child seat recline adjustment should have been in the fully reclined position so that the child seat would have been reclined at a 45 degree angle. The seat was secured in the vehicle using the lap portion of the lap and shoulder belt. The lap belt was slotted through the child seat using the slots intended for the rear facing position, as is recommended. This vehicle has a switchable locking retractor type seat belt with a sliding latch. The driver was not aware of how to switch the retractor to an automatic locking retractor. She did not pull the seat belt completely out and therefore the retractor was in an emergency locking retractor mode. In this mode, the use of a locking clip is required and suggested both by the vehicle and child seat manufacturers (see photo #41). A locking clip was not in use at the time of the collision. The child was belted into the child seat using the T-shield arrangement, but the shoulder harnesses were routed through the top slots rather than the lower ones, as is recommended for a child in a rear facing position. At impact, the passenger side air bag deployed and because the retractor was in the emergency retractor mode it moved forward closer to the air bag. The deploying air bag struck the rear of the child seat, causing vertical and horizontal cracks to the rear right side of the child seat (see photos #86-87). The child seat was loaded rearward by the air bag forcing the child seatback into the back of the child's head. The majority of the child's injuries were caused by the back of the child seat.

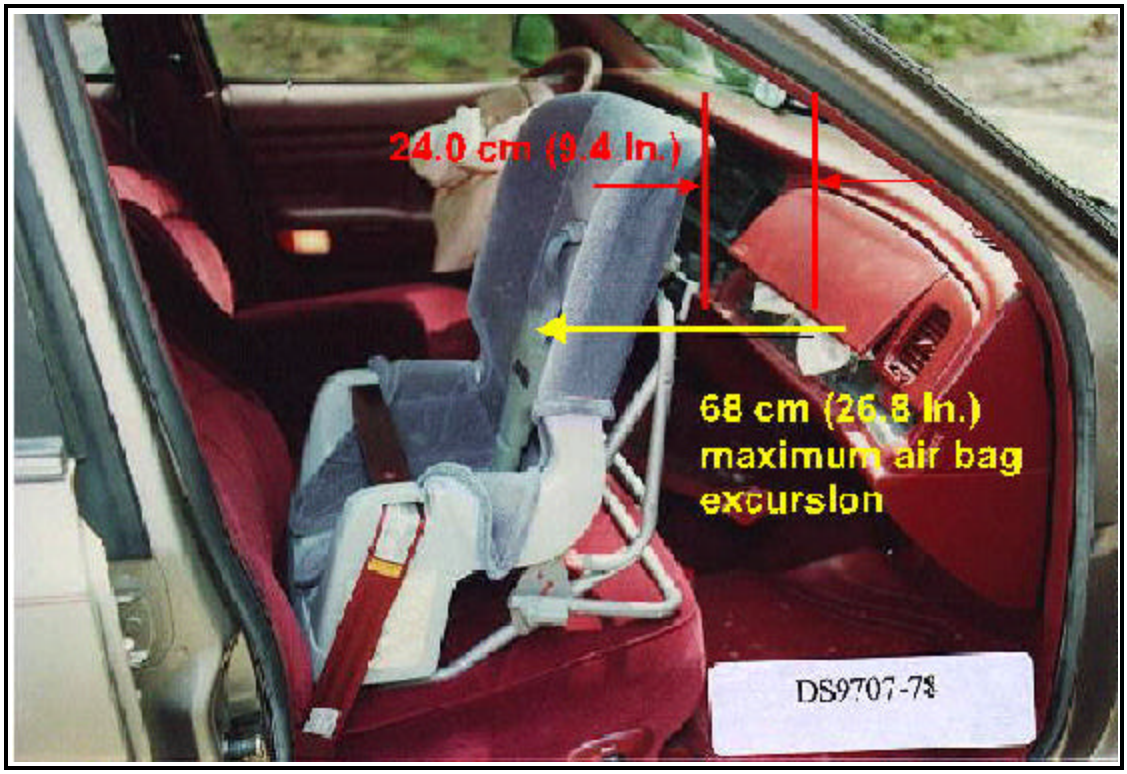

Figure 1. Child seat Fisher-Price model 9100 in Vehicle 1.

Scene diagram

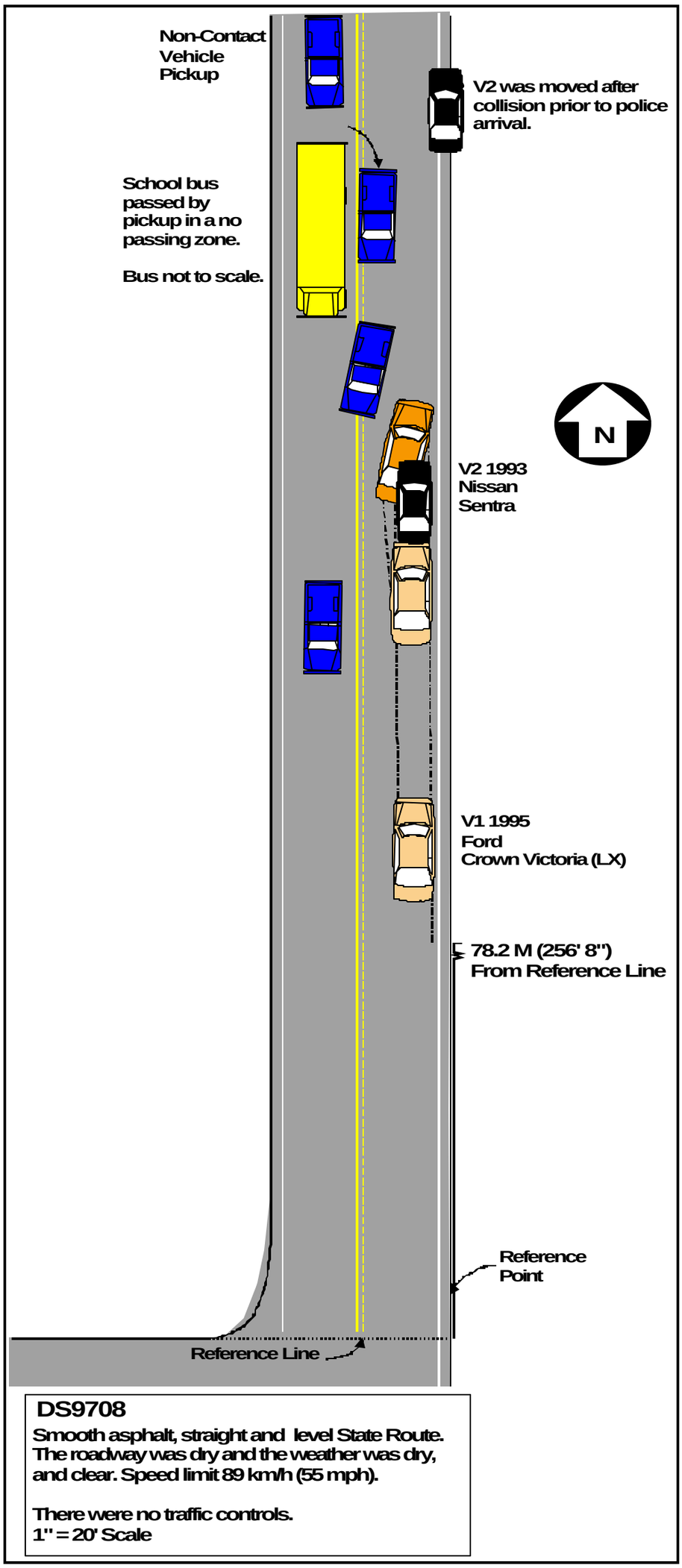

Figure 3. Scene Diagram.

Collision Measurements (Field Measurements)

COLLISION MEASUREMENTS

Reference Point: Northbound East edge of Roadway	Reference Line: Road Post (RP)--North edge of East/West Roadway	
ITEM	Distance and Direction from RP	Distance and Direction
Beginning of V-1 R/F locked wheel skid/pre-impact	0.86m (2'10") W	78.2m (256'8") N
End of V-1 R/F Locked wheel skid Final Rest	0.97m (3'2") W	104.7m (343'6") N
Beginning of V-1 L/F locked wheel skid/pre-impact	2.5m (8'2") W	85.0m (278'10") N
End of V-1 L/F locked wheel skid at Final Rest	2.6m (8'5") W	105.2m (345'0") N
Beginning of V-1 R/R locked wheel skid/at impact with V-2	1.0m (3'3") W	94.5m (310'1") N
End of V-1 R/R locked wheel skid at Final Rest	16.3m (5'4") W	101.9m (334'4") N
Beginning of V-1 L/R locked wheel skid/at impact with V-2	2.6m (8"6") W	94.6m (310"5") N
End of V-1 L/R locked wheel skid at final rest	3.2m (10"7") W	102.9m (337"3") N

Photo Index

Photo no.	Vehicle No.	Direction of Picture	Subject Matter
DS9708-1 - DS9708-2	1	North	Approach to area of impact.
DS9708-3	1	North	Beginning of right front skid mark.
DS9708-4 - DS9708-5	1	North	Beginning of left front skid mark.
DS9708-6 - DS9708-7	1	North	Beginning of rear wheels skid marks.
DS9708-8	1	North	Ending of rear wheels skid marks.
DS9708-9 - DS9708-10	1	North	Ending of front wheels skid marks.
DS9708-11	1	South	Looking back along initial path of travel.
DS9708-12	2	North	Area of final rest, after vehicle was moved out of roadway.
DS9708-13	2	South	Looking back along initial path of travel.
DS9708-14 DS9708-26	1	CCW	Exterior of vehicle.
DS9708-27 DS9708-77	1	NA	Interior of vehicle.
DS9708-78 DS9708-84	1	NA	Photo #78-84 show child seat in vehicle- note that seat was put in position by investigator after obtaining child seat from driver of Vehicle 1.
DS9708-85 DS9708-92	1	NA	Shows child seat after being removed from vehicle.
DS9708-93	1	NA	Driver of Vehicle 1, abrasions to left arm from air bag.