

Child Safety Seat Fatality Investigation / Vehicle v. Tree  
Dynamic Science, Inc. / Case Number: DS04005  
2001 Mazda Protégé  
California  
April, 2004

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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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1. Report No. DS04005		2. Government Accession No.		3. Recipient Catalog No.	
4. Title and Subtitle  Child Safety Seat Fatality Investigation				5. Report Date September 15, 2004	
				6. Performing Organization Report No.	
7. Author(s) Dynamic Science, Inc.				8. Performing Organization Report No.	
9. Performing Organization name and Address  Dynamic Science, Inc. 530 College Parkway, Ste. K Annapolis, MD 21401				10. Work Unit No. (TRAIS)	
				11. Contract or Grant no.  DTNH22-01-C-27002	
12. Sponsoring Agency Name and Address  U.S. Dept. of Transportation (NRD-32) National Highway Traffic Safety Administration 400 7th Street, SW Washington, DC 20590				13. Type of report and period Covered [Report Month, Year]	
				14. Sponsoring Agency Code	
15. Supplemental Notes					
16. Abstract  This single vehicle crash occurred in April, 2004 at 0835 hours. The crash occurred on the east roadside of a divided two-lane state highway. The asphalt roadway was straight and level. The speed limit is 105 km/h (65 mph).  The case vehicle is a 2001 Mazda Protégé four-door sedan driven by a restrained, pregnant 34-year-old female. The rear middle seat was occupied by a 22-month-old female who was seated in a forward facing Cosco Alpha Omega Booster/Convertible (BSS/CSS) child safety seat. The Mazda Protégé was traveling northbound. For unknown reasons, the driver veered onto the left shoulder/median area. The driver then steered back to the right and lost control of the vehicle. The vehicle crossed both northbound lanes and departed the roadway on the right. The driver steered to the left and began a counterclockwise rotation. The Protégé traveled approximately 27 m (89 ft) and had rotated 45 degrees prior to contacting the first of three eucalyptus trees. It struck the tree with the right rear tail light area. This initial impact was minor and did not alter the travel path of the case vehicle. The Protégé continued on approximately 6 m (20 ft) and had rotated 90 degrees prior to striking a 58 cm (23 in) diameter eucalyptus tree with its right side. The impact caused the case vehicle to rotated sharply 180 degree where its struck a 45 cm (18 in) in diameter eucalyptus tree with its left rear.					
17. Key Words  Air bag, deployment, child safety seat, rear seat, fatality, passenger.			18. Distribution Statement		
19. Security Classif. (of this report)		20. Security Classif. (of this page)		21. No of pages	22. Price

**Dynamic Science, Inc.**  
**Crash Investigation**  
**Case Number: DS04005**

**TABLE OF CONTENTS**

Background .....	1
Description .....	1
Investigation Type .....	1
Crash Location .....	1
Crash Date .....	1
Notification Date .....	1
Field Work Completed .....	1
Summary .....	1
Crash Site .....	1
Pre-crash .....	1
Crash .....	2
Post-crash .....	4
Vehicle Data -2001 Mazda Protégé .....	5
Vehicle Damage .....	6
Exterior Damage .....	6
Interior Damage .....	8
Manual Restraint Systems .....	8
Frontal Air Bag System .....	9
Child Safety Seat .....	10
Occupant Demographics .....	11
Occupant Injuries .....	12
Occupant Kinematics .....	13
Attachment 1. Scene Diagram .....	15
Attachment 2. Calculations .....	16

## BACKGROUND:

**Description:** This Child Safety Seat fatality case was identified by NHTSA through a news article. DSI was assigned the case on April 2, 2004. The scene investigation was conducted on April 5, 2004. The vehicle inspection was conducted on April 6, 2004. An officer from the investigating agency was present during the first hour of the vehicle inspection.

**Investigation Type:** Child Safety Seat Fatality  
**Crash Location:** California  
**Crash Date:** April, 2004  
**Notification Date:** April 2, 2004  
**Field Work Completed:** April 6, 2004

## SUMMARY

### Crash Site

This single vehicle crash occurred in April, 2004 at 0835 hours. The crash occurred on the east roadside of a divided two-lane state highway. The roadway is bordered on the west side by an asphalt shoulder and a metal guardrail. The roadway is bordered on the east side by an asphalt shoulder, followed by loose gravel, then grass, and finally eucalyptus trees planted parallel to the roadway. There is a west to east negative slope for the grass that increases from 8.3% near the point of road departure to 20% at the point of impact with the first tree. The weather was clear and dry. The asphalt roadway was straight and level. The speed limit is 105 km/h (65 mph).



**Figure 1.** Approach to area of roadway departure (north)

## Pre-Crash

The case vehicle is a 2001 Mazda Protégé four-door sedan (VIN: JM1BJ222210xxxxx) driven by a restrained, pregnant (4.1 months<sup>1</sup>) 34-year-old female. The rear middle seat<sup>2</sup> was occupied by a 22-month-old female (76 cm/30 in, 11 kg/25 lbs) who was seated in a forward facing Cosco Alpha Omega BSS/CSS child safety seat (serial number, manufacture date unknown<sup>3</sup>). The manufacturer recommends that the seat be used as a rear facing infant seat for children weighing between 2-16 kg (5-35 lbs) and as a forward facing seat from 9-18 kg (20-40 lbs) and a booster seat for 14-36 kg (30-80 lbs). The manufacturer further recommends using the top tether when the seat is used in the forward facing mode. In this crash, the seat was in the forward facing mode and the top tether was used. The use of the child seat in this mode was appropriate for this child's weight.

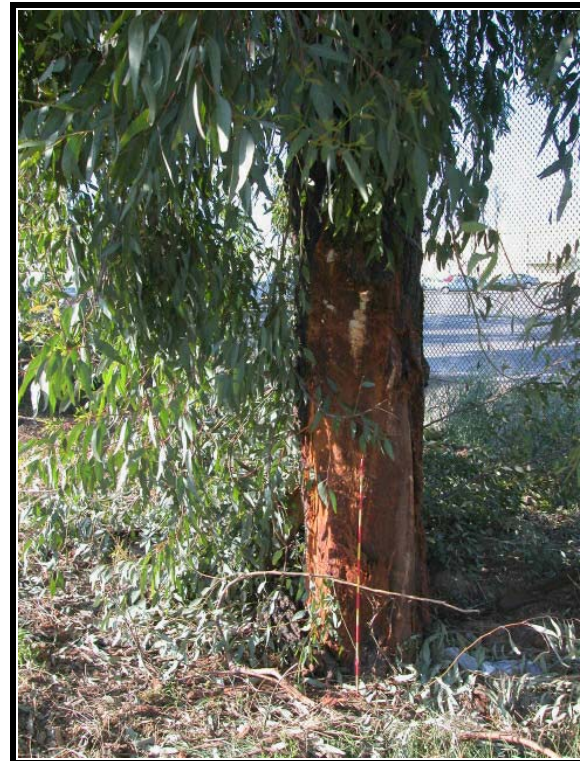
The Mazda Protégé was traveling northbound. For unknown reasons, the driver veered onto the left shoulder/ median area. The driver then steered back to the right and lost control of the vehicle. The vehicle crossed both northbound lanes and departed the roadway on the right. At the time of departure, the Protégé had a minimum travel speed of 58 km/h (36 mph)<sup>4</sup>. The driver steered to the left and began a counterclockwise rotation.

## Crash

The Protégé traveled approximately 27 m (89 ft) and had rotated 45 degrees prior to contacting the first of three eucalyptus trees. It struck the tree with the right rear tail light area. This initial impact was minor and did not alter the travel path of the case vehicle. The Protégé continued on



**Figure 2.** Approach to area of first and second tree impacts



**Figure 3.** Second tree impact (impact 2)

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<sup>1</sup>Based on projected due date

<sup>2</sup>Police report is incorrect

<sup>3</sup>Vehicle had not yet been inspected by the investigating agency and this contractor was instructed to leave the child seat in place and not remove it.

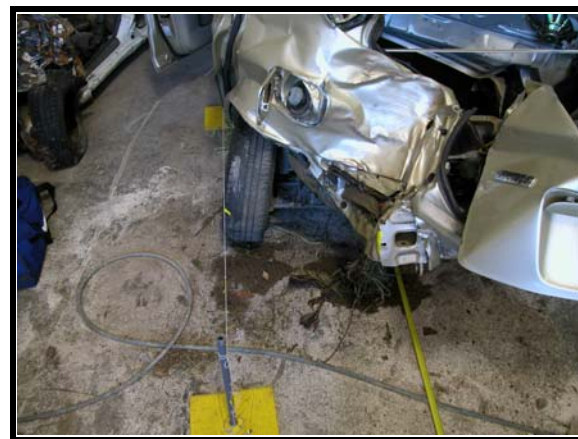
<sup>4</sup>See Attachment 2. Calculations



approximately 6 m (20 ft) and had rotated 90 degrees prior to striking a 58 cm (23 in) diameter eucalyptus tree with its right side (03RPAW4). The case vehicle sustained a total velocity change of 16.0 km/h (9.9 mph) as calculated using the barrier algorithm of the WinSmash program. The longitudinal and lateral components of the delta v were -2.8 km/h (-1.7 mph) and -15.8 km/h (-9.8 mph), respectively. The results appear to be low. This impact intruded significantly into the right rear passenger seating area. The right side C pillar/roof transition was forced into the head of the seated child occupant and she was killed instantly. The impact caused the case vehicle to rotate sharply 180 degree where it struck a 45 cm (18 in) in diameter eucalyptus tree with its left rear (09LBEN4). The case vehicle sustained a total velocity change of 26.0 km/h (16.2 mph) as calculated using the barrier algorithm of the WinSmash program. The longitudinal and lateral components of the delta v were 0 km/h (0 mph) and 26.0 km/h (16.2 mph), respectively.



**Figure 4.** Right side impact (impact 2)



**Figure 5.** Left side impact with third tree

## Post-Crash

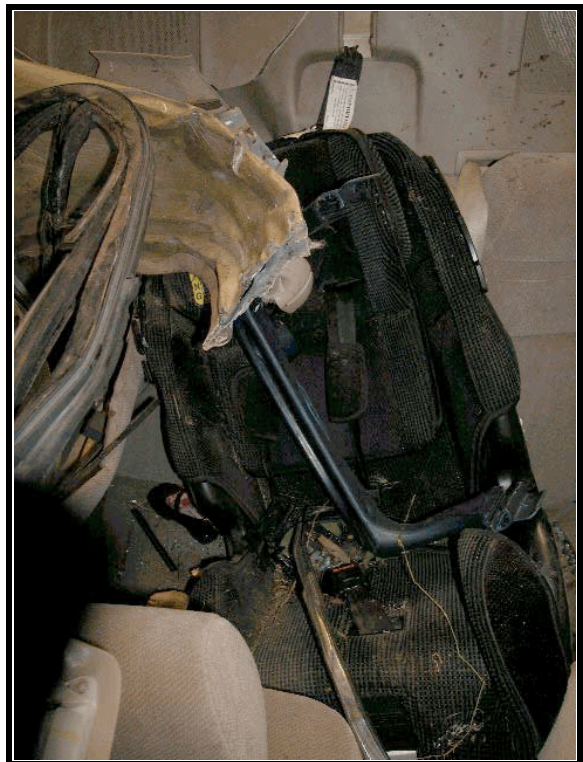
The vehicle came to rest facing generally southeast. The B and C pillars were cut by EMS personnel and the roof was folded forward over the hood to facilitate extrication efforts.

The pregnant driver sustained serious injuries and was flown by helicopter to a local hospital where she was initially listed in critical condition. She sustained a head trauma of unknown nature that resulted in a semi-comatose state and amnesia. She also sustained a left scapula fracture and contusions to the chest wall and abdomen. She lost the baby due to her injuries.

The right rear child occupant was fatally injured with major head injuries. She was removed from the vehicle by the medical examiner.



**Figure 6.** Driver's seated position



**Figure 7.** Rear middle seat occupant position



**VEHICLE DATA - 2001 Mazda Protégé four door sedan**

The 2001 Mazda Protégé was equipped with a 5-speed transmission, power brakes, power steering, a tilt steering wheel, front wheel drive.

The Protégé was originally a fleet vehicle that was being used in the northwest part of the country. In June, 2002 it was sold to a private party in California with 20,404 km (12,679 miles) on the odometer.

VIN:	JM1BJ222210XXXXXX
Odometer:	Unknown. Digital display with no power available.
Engine:	1.6L I4 DOHC 16V
Reported Defects:	There was a recall for 2000-01 model year vehicles for brake-fluid leakage that could cause brake performance to be degraded.
Cargo:	Child seat

The 2001 Mazda Protégé was equipped with Firestone FR680 P185/65R14 tires. The specific tire data is as follows:

<b>Tire</b>	<b>Tread</b>	<b>Pressure</b>	<b>Recommended pressure</b>
LF	3 mm (4/32 in)	200 kPa (29 psi)	241 kPa (35 psi)
LR	4 mm (5/32 in)	207 kPa (30 psi)	241 kPa (35 psi)
RF	2 mm (4/32 in)	Flat	241 kPa (35 psi)
RR	4 mm (3/32 in)	Flat	241 kPa (35 psi)

The two front seating positions in the 2001 Mazda Protégé were fabric covered bucket seats that were equipped with adjustable head restraints. The seats were adjusted to the full back track position. The three second row seating positions were configured with a fabric covered bench seat with integral head restraints for the two outboard positions.

## VEHICLE DAMAGE

### Exterior Damage - 2001 Mazda Protégé

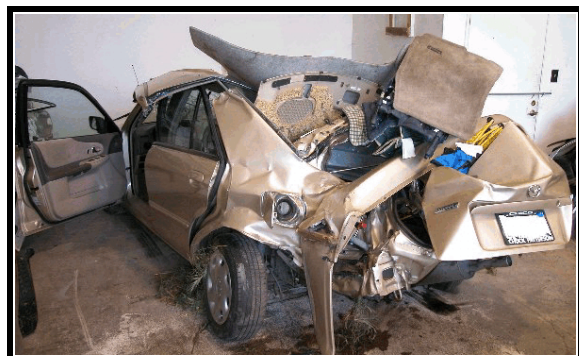
Damage Description: Major lateral damage through the right rear door with intrusion into the passenger compartment. Major left rear quarter panel damage. Vehicle towed due to damage.

CDC: Impact 1: Unknown  
Impact 2: 03RPAW4  
Impact 3: 09LBEN4

Delta V (impact 2):	Total	15.8 km/h (9.8 mph)
	Longitudinal	-2.8 km/h (-1.7 mph)
	Latitudinal	-15.6 km/h (-9.7 mph)
	Energy	16,887 joules (12,455ft lbs)

Delta V (impact 3):	Total	26.3 km/h (16.4 mph)
	Longitudinal	0 km/h (0 mph)
	Latitudinal	26.3 km/h (16.4 mph)
	Energy	35,877 joules (26,461 ft lbs)

The case vehicle sustained 85.0 cm (33.4 in) of direct contact to the right side from the impact with the second tree. The damage began 10.0 cm (3.9 in) forward of the right rear axle and extended forward. The residual crush as measured above the sill was as follows: C1=3.0 cm (1.2 in), C2=16.0 cm (6.3 in), C3=26.0 cm (10.2 in), C4=12.0 cm (4.7 in). The maximum crush fell between C2/C3 and measured 27.0 cm (10.6 in). The principle direction of force was within the 3 o'clock sector and was an estimated 80 degrees.



**Figure 8.** Left side impact (impact 3)

The vehicle sustained 39.0 cm (15.4 in) of direct contact to the left side from the impact with the third tree. The damage began 25.0 cm (9.8 in) rear of the left rear axle and extended forward. The residual crush as measured above the sill was as follows: C1=47.0 cm (18.5 in), C2=45.0 cm (17.7 in), C3=2.0 cm (0.8 in), C4=0 cm (0 in). The maximum crush fell at C1.

The damaged components included the right side door area and the left rear quarter panel. The rear bumper was knocked off during the impact with the second tree. The wheelbase was lengthened by 2.0 cm (0.8 in) on the right side and shortened by 10.0 cm (3.9 in) on the left.



**Figure 9.** Right side impact (impact 2)

### Interior Damage - 2001 Mazda Protégé

The Protégé sustained substantial interior damage from both intrusion and occupants contacts. There was intrusion primarily through the right rear that included the C pillar, roof, B pillar, sill, and door side panel. The C pillar and roof transition came into direct contact with the head of the rear seat child occupant. Blood and tissue was found at this location. A blood and tissue spray pattern from the rear seat occupant traversed the top of the rear deck as a result of the final tree impact. A substantial amount of tissue came to rest on the shoulder harness at the left rear seat location. There were loading contacts to the center console and the left side of the right front seat. Both rear doors were jammed shut. Passenger compartment integrity was lost through the backlight and the right rear window.



Figure 10. Overview of right side intrusion

### MANUAL RESTRAINT SYSTEMS - 2001 Mazda Protégé

The Protégé was configured with manual 3-point lap and shoulder belts for both front positions and all three rear seat positions. The front seat restraints were configured with adjustable shoulder belt upper anchorages that had been adjusted to the full down position. All the seat belts were equipped with sliding latch plates. The driver's seat belt was equipped with an emergency locking retractor. The front right passenger's seat belt and all three rear seat belts were equipped with switchable retractors (retractors that can be changed from an emergency locking retractor to an automatic locking retractor to assist in securing child seats). The driver's seat belt was in use at the time of the crash. The second row middle seat belt was being used with a child safety seat at the time of the crash.

## FRONTAL AIR BAG SYSTEM - 2001 Mazda Protégé

The driver's air bag was mounted in the steering column. It measured 46.0 cm (18.1 in) in diameter in its deflated state. It was equipped with two vent ports at the 11 and 1 o'clock positions. It was equipped with a single tether. There were eight horizontal folds on the air bag face. The air bag module cover had an H configuration and measured 17.0 cm (6.7 in) wide by 6.0 cm (2.4 in) high on the top and 17.0 cm (6.7 in) wide by 7.0 cm (2.8 in) high on the bottom. There was no damage to the air bag or the module cover.



Figure 11. Driver's air bag

The front right passenger air bag had a top mount installation. It measured 65.0 cm (25.6 in) wide seam to seam and 63.0 cm (24.8 in) high. There were two circular vent ports at the 3 and 9 o'clock positions. The module cover was generally rectangular in shape and measured 33.0 cm (12.9 in) wide by 11.0 cm (4.3 in) high. There were no indications of any damage or contact to either the air bag or the module cover.



Figure 12. Front right passenger air bag



**CHILD SAFETY SEAT - 2001 Mazda Protégé**

The Cosco Alpha Omega convertible child seat was found in the case vehicle during the vehicle inspection. It was anchored to the vehicle using the available lap and shoulder belt in the middle seat position. This seat position was equipped with a switchable retractor that appears to have been switched to the automatic locking retractor (ALR) mode. The child seat was further secured by a top tether. The harness was threaded through the top slots. A chest clip was available but its location is not known. The right side of the seat was fractured during the crash. The left side of the seat was rotated upward and to the right 17.0 cm (6.7 in) from the seat bottom.



**Figure 13.** Cosco Alpha Omega convertible child safety seat (C-pillar to left side of image)



**OCCUPANT DEMOGRAPHICS - 2001 Mazda Protégé**

	Driver	Occupant 2
Age/Sex:	34/Female	22 month/Female
Seated Position:	Front left	Rear middle
Seat Type:	Fabric covered bucket seat. Seat adjusted to rear most track position at time of inspection.	Fabric covered bench seat.
Height:	170 cm (67 in)	76 cm (30 in)
Weight:	82 kg (180 lbs)	11 kg (25 lbs)
Occupation:	Unknown	NA
Pre-existing Medical Condition:	No	None noted
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Presumed to be greater than 10 years	NA
Body Posture:	Normal, upright	Normal, seated in child seat
Hand Position:	Unknown	Unknown
Foot Position:	Right foot on brake, left on floorboard	Unknown
Restraint Usage:	Lap and shoulder belt available and used.	Lap and shoulder belt used with child seat
Air bag:	Steering wheel mounted air bag available, deployed.	NA

**OCCUPANT INJURIES -2001 Mazda Protégé**

Driver: Injuries obtained from trauma clinic follow up records and the police report.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Concussion, with dizziness	161000.2,0	Unknown	Unknown
Left scapula fracture	753000.2,2	Door side panel	Certain
Contusion, chest wall	490402.1,9	Center console	Probable
Contusion, abdomen	590402.1,9	Center console	Probable

Middle rear occupant: Injuries obtained from autopsy report.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Skull fracture with extruded brain matter	150406.4,1	C pillar	Certain
Brain laceration	140688.4,1	C pillar	Certain
Bilateral lung contusions	441410.4,3	Side panel	Probable
Mandible fracture	250600.1,9	C pillar	Certain
Maxilla fracture	250800.2,9	C pillar	Certain
Multiple abrasions	990200.1,9	Unknown	Unknown

## OCCUPANT KINEMATICS - 2001 Mazda Protégé

The 34-year-old female driver of the Mazda was seated in a normal, forward facing fashion. She was wearing the available lap and shoulder belt. The shoulder belt anchorage was in the full down position. The belt buckle was bent at an almost 90 degree angle to the left, but this was likely an artifact from rescue efforts. The fabric covered bucket seat was adjusted to rear most track position at time of inspection. The seat back was slightly reclined. Prior to impact, the driver was engaged in active steering maneuvers that had placed the vehicle into a counterclockwise rotation. Both hands were likely on the steering wheel. She was braking at this point and her right foot would have been on the brake. The counterclockwise rotation would have caused the driver to begin moving to the right. The impact with the first tree was negligible and there would have been little movement. At impact with the second tree, this occupant moved sharply to the right in response to the 3 o'clock direction of force. She engaged the center console with her lower legs at the bottom and with her hip at the higher end. She also engaged the right seat back with her upper torso as she came out of the shoulder harness. The case vehicle rotated sharply in a clockwise direction before striking the third tree with its left side. At impact with the third tree the driver pitched to the left and loaded the driver's door—likely causing the clavicle fracture.



**Figure 14.** Driver contact to upper center console and right seat back



**Figure 15.** Driver contact to lower center console

The 22-month-old female rear seat occupant was seated in a Cosco Alpha Omega BSS/CSS child seat that was in the forward facing mode. The seat was anchored to the vehicle using the available lap and shoulder belt in the middle seat position. This seat position was equipped with a switchable retractor that appears to have been switched to the ALR mode. The child seat was further secured by a top tether. The harness was threaded through the top slots. A chest clip was available but its location is not known.

This occupant reacted first to the counterclockwise rotation by moving slightly to the right. She was being held in place by the child seat harness and the seat was anchored in place to the vehicle. The impact with the first tree was negligible and there would have been little movement. At impact with the second tree, this occupant moved sharply to the right in response to the 3 o'clock direction of force. She engaged the right side of the child seat shell to some degree. At the same time the right side of the vehicle was penetrated and the C pillar and right rear door intruded into the passenger compartment. The C pillar and roof transition area struck the right

side of the child occupant's head causing the fatal head injuries. The case vehicle rotated sharply in a clockwise direction before striking the third tree with its left side. At impact with the third tree the child and child seat pitched to the left to some degree. Body fluid and tissue formed a splatter pattern along the top of the rear seat and onto the left side of the vehicle. The right side of the seat was fractured during the impact with the second tree. The left side of the seat was rotated upward and to the right 17.0 cm (6.7 in) from the seat bottom.

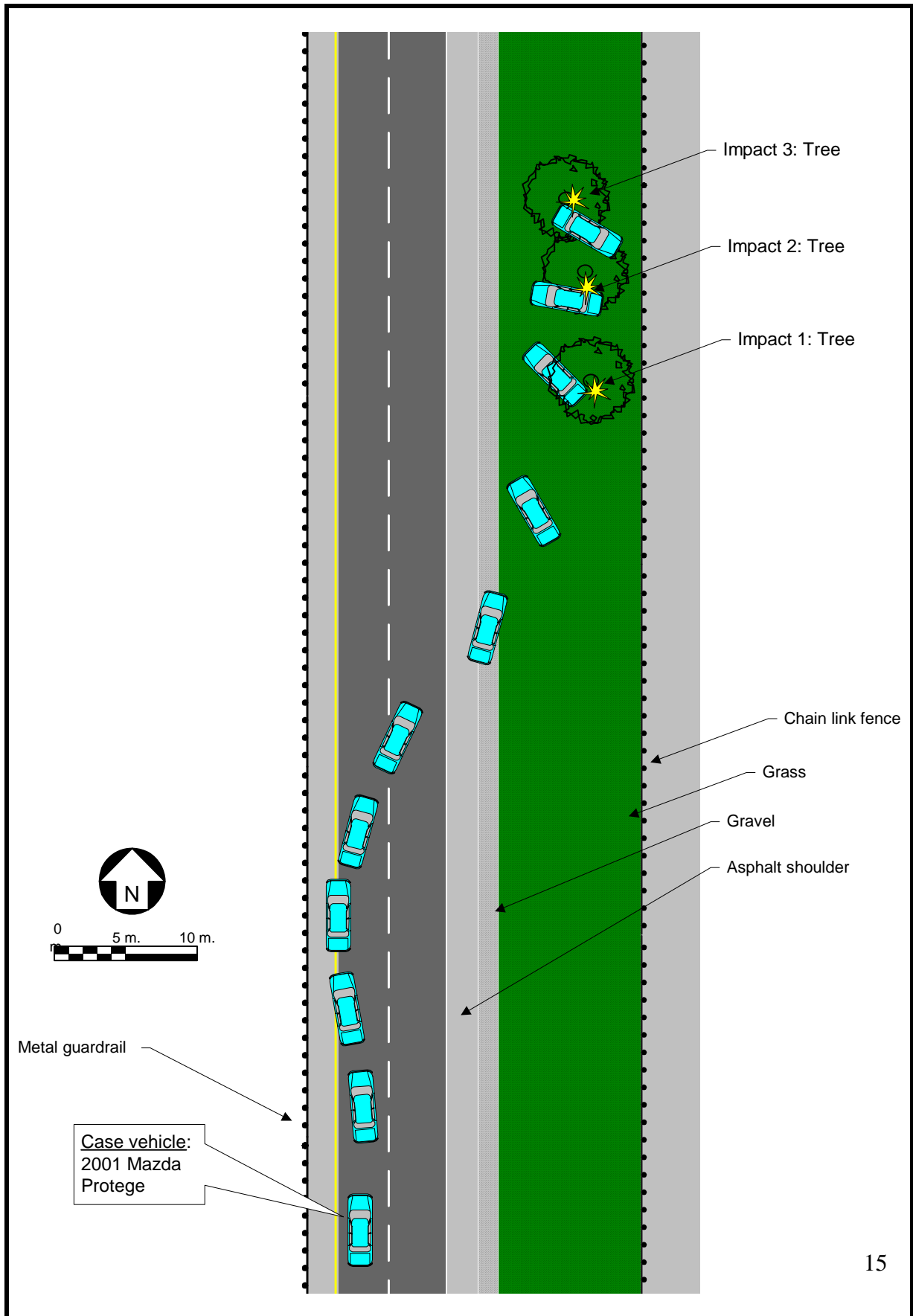


**Figure 16.** Head contact to right C pillar/roof transition



**Figure 17.** Child seat with view of intruding C pillar and splatter pattern to right of image

Attachment 1. Scene Diagram



**Attachment 2. Calculations**

**CASE NUMBER: DS04005**

Comments: Minimum skid speed, across grass, prior to tree impact

**\*\* MINIMUM SPEED W/ KNOWN DRAG FACTOR \*\***

$$S = \sqrt{30 \times D \times f}$$

$$S = \sqrt{30 \times 89.00 \times 0.35}$$

$$S = \sqrt{934.50}$$

$$S = 30.56$$

S = The Speed in MPH

30 = A Constant.

D = The Distance in Feet.

f = The Adjusted Accel/ Drag Factor.

INPUTS:		RESULTS:	
The Acceleration/ Drag Factor is:	0.35	The Speed in MPH is:	30.56
The Distance in Feet is:	89.00	The Velocity in FPS is:	44.80



**CASE NUMBER: DS04005**

Comments: combined skid speed, delta v impact 2, delta v impact 3

**\* \* COMBINED MINIMUM SPEEDS W/ KNOWN SPEEDS \* \***

$$S = \sqrt{S^2(1) + S^2(2) + \dots S^2(n)}$$

$$S = \sqrt{(30.56)^2 + (9.90)^2 + (16.20)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2}$$

$$S = \sqrt{933.91 + 98.01 + 262.44 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00}$$

$$S = \sqrt{1294.36}$$

$$S = 35.97$$

S = The Speed in MPH.  
 S<sup>2</sup> = The Individual Min. Speed.  
 (1), (2), (n) = The # of the individual speed.

INPUTS:	
Speed # 1 in MPH is:	30.56
Speed # 2 in MPH is:	9.90
Speed # 3 in MPH is:	16.20

RESULTS:	
The Speed in MPH is:	35.97
The Velocity in FPS is:	52.73

Minimum right side departure speed, using kinetic energy. Where  $w$  = vehicle weight in pound,  $E$  = energy,  $f$  = drag factor,  $d$  = skid distance in feet,  $v$  = velocity in fps,  $s$  = speed in mph.

Energy dissipated by case vehicle while skidding, before impact:

$$\begin{aligned} E1 &= wfd \\ E1 &= (2632)(0.35)(89) \\ E1 &= 81,986 \text{ ft-lbs} \end{aligned}$$

Energy from impact with tree 2:

$$E2 = 12,455 \text{ ft-lbs}$$

Energy from impact with tree 3:

$$E3 = 26,461 \text{ ft-lbs}$$

Total energy possessed by case vehicle when it first began its off-road skid:

$$\begin{aligned} ET &= E1 + E2 + E3 \\ ET &= 120,902 \end{aligned}$$

Determination of velocity based on energy:

$$\begin{aligned} v &= \sqrt{2gET/w} \\ v &= 54.38 \text{ fps} \end{aligned}$$

Determination of speed:

$$\begin{aligned} s &= v/1.466 \\ s &= 37.09 \text{ mph} \end{aligned}$$