On-scene Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS02005
1996 Mazda Protege 4-door
Colorado
March, 2002

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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.

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16. Abstract

This collision occurred in Colorado in March, 2002 at 1536 hours. The crash occurred within the confines of a four leg intersection. There are tri-color traffic signals for all directions of travel. The weather was clear and dry. The case vehicle is an air bag equipped 1996 Mazda Protege driven by an unrestrained 66-year-old female (the grandmother of the front right occupant) that was traveling northbound at a minimum pre-braking travel speed of 52.4 km/h (32.6 mph). The front right seat was occupied by an unrestrained 3-year-old female. There are fabric-covered bucket seats at the front outboard seating positions. The driver's seat was adjusted to the full rear track position. The front right seat was adjusted to the full forward track position. The other vehicle is a 1996 Honda Accord that had stopped southbound at the intersection in preparation to turn left to the east.

The collision occurred as the other vehicle turned in front of the case vehicle. The driver of the case vehicle saw the other vehicle and began braking. The front of the case vehicle (11FDEW1) struck the right side of the other vehicle (02RPEW2). The case vehicle sustained a total delta v of 21.0 km/h (13.0 mph), a longitudinal delta v of -19.7 km/h (-12.3 mph) and a lateral delta v of 7.2 km/h (4.5 mph). Both front air bags in the case vehicle deployed at impact. The other vehicle sustained a total delta v of 18.0 km/h (11.2 mph), and a longitudinal delta v of -11.6 km/h (-7.2 mph) and a lateral delta v of -13.8 km/h (-8.6 mph). The case vehicle was diverted to the right and came to rest in the intersection. The driver of the other vehicle moved his vehicle to the eastern leg of the intersection and parked it at that location.

The driver of the case vehicle sustained minor facial injuries from the deployed air bag. The front right occupant was removed from the vehicle due to serious injuries. It is unclear exactly who removed the child. First responders indicate that she was being held by the driver outside of the vehicle. The child was taken by ground ambulance to a local hospital where she was declared dead at 1620 hours.

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Dynamic Science, Inc.
Accident Investigation
Case Number: DS02005

TABLE OF CONTENTS

BACKGROUND:

Description:	This air bag related child fatality was generated in response to a news article regarding the child's death. DSI was assigned the case on March 26, 2002. The field investigation was completed on April 5, 2002. The investigating officer was present during the vehicle inspections.
Investigation Type:	On-scene
Crash Location:	Colorado
Crash Date:	March, 2002
Notification Date:	March 26, 2002
Field Work Completed:	April 5, 2002

SUMMARY:

This collision occurred in Colorado in March, 2002 at 1536 hours. The crash occurred within the confines of a four leg intersection. There are tri-color traffic signals for all directions of travel. The weather was clear and dry. There was a +3% grade for northbound traffic and a -3% grade for southbound traffic. The speed limit is 56 km/h (35 mph) for both northbound and southbound traffic.

The case vehicle is an air bag equipped 1996 Mazda Protege driven by an unrestrained 66-year-old female (the grandmother of the front right occupant) that was traveling northbound at a minimum pre-braking travel speed of 52.4 km/h (32.6 mph)[1]. The front right seat was occupied by an unrestrained 3-year-old female (116 cm/45.5 in, 19 kg/42 lbs). There are fabric-covered bucket seats at the front outboard seating positions. The driver's seat was adjusted to the full rear track position. The front right seat was adjusted to the full forward track position. There

Figure 1. Approach to area of impact (south)

[1]Calculated using speed to slide to stop combined with the velocity change

was a Century child safety seat present in the rear seat. It was not attached to the vehicle and seat belt straps were not connected. The child seat did not play a role in this case.

Figure 2. Front right, case vehicle (Mazda)

The other vehicle is a 1996 Honda Accord that had stopped southbound at the intersection in preparation to turn left to the east.

The collision occurred as the other vehicle turned in front of the case vehicle. The driver of the case vehicle saw the other vehicle and began braking. The case vehicle deposited 13.6 m (44.5 ft) of front right locked wheel skid and 3.9 m (12.9 ft) of front left locked wheel skid. The front of the case vehicle (11FDEW1) struck the right side of the other vehicle (02RPEW2). The case vehicle had 106 cm (41.7 in) of direct contact beginning at the front right bumper corner and had a maximum crush of 3 cm (1.2 in) at C6. The other vehicle had 123 cm (48.4 in) of direct contact beginning 29 cm (11.4 in) forward of the rear axle and had a maximum crush of 27 cm (10.6 in) at the C3. The case vehicle sustained a total delta v of 21.0 km/h (13.0 mph), a longitudinal delta v of -19.7 km/h (-12.3 mph) and a lateral delta v of 7.2 km/h (4.5 mph)[2]. Both front air bags in the case vehicle deployed at impact. The other vehicle sustained a total delta v of 18.0 km/h (11.2 mph), and a longitudinal delta v of -11.6 km/h (-7.2 mph) and a lateral delta v of -13.8 km/h (-8.6 mph). The case vehicle was diverted to the right and came to rest in the intersection. The driver of the other vehicle moved his vehicle to the eastern leg of the intersection and parked it at that location.

Figure 3. Right side, other vehicle (Honda)

[2]Calculated using WinSmash version 2.1.2

The driver of the case vehicle sustained minor facial injuries from the deployed air bag.

The front right occupant was removed from the vehicle due to serious injuries. It is unclear exactly who removed the child. First responders indicate that she was being held by the driver outside of the vehicle. The child was taken by ground ambulance to a local hospital where she was declared dead at 1620 hours.

According to the autopsy report, the child sustained the following injuries: complete atlanto-occipital dislocation, focal subarchnoid hemorrhage, spinal cord avulsion and contusion, extensive crush injury of larynx, liver laceration, and pulmonary and diaphragmatic contusions. There was an extensive abrasion extending in a band from the left side of the neck anteriorly to the right side of the neck. The abrasion extended from ear line to ear line. The abrasion extended to below the vermilion border[3] of the lip, and then wraps around the face along the lower cheeks. There was also an abrasion to left side of upper lip, an abrasion/contusion to back of left hand, a contusion to back of left thumb, a contusion/abrasion to back of right thumb and hand, and an abrasion to back right forearm. There was an abrasion to top of her head and a brush abrasion to right side of parietal scalp.

Death was reported as "due to complications of multiple blunt force injuries."

It is this investigator's opinion that the front right occupant was not using the available lap and shoulder belt. There were no indications of usage in this crash and very little indication of any usage in the past. Both front seat belt latch plates were jammed into the space between the seats and the center console.

[3]The exposed pink or redish margin of a lip.

Scene Diagram

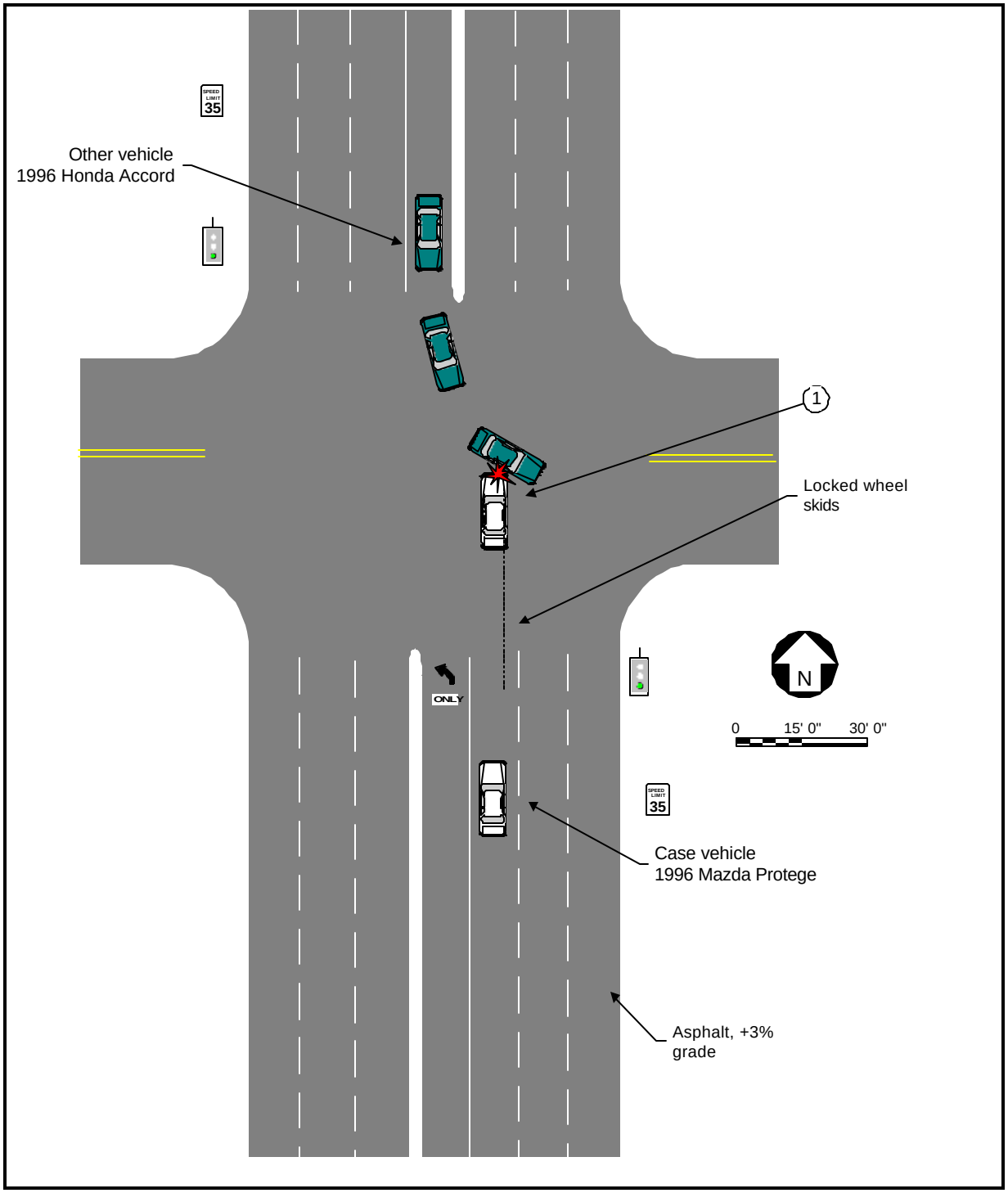

Figure 4. Scene diagram

DETAILED INFORMATION

Vehicles

Case vehicle

Description:	1996 Mazda Protege 4-door	
VIN:	JM1BB14171T0xxxxxx	
Odometer:	155,317 km (96,512 miles)	
Engine:	91 CID, 4 cylinder	
Reported Defects:	None noted	
Cargo:	Child safety seat	
Damage Description:	Minor bumper contact beginning at front right bumper corner. Right side of windshield damaged from occupant contact.	
CDC:	11FDEW1	
Delta V:	Total	21 km/h (13 mph)
	Longitudinal	-19.7 km/h (-12.3 mph)
	Latitudinal	7.2 km/h (4.5 mph)
	Energy	6,911 joules (5,097 ft-lbs)

Figure 5. Front, case vehicle

The driver's air bag is 54 cm wide. There were no tethers. There were two vent holes (11 and 1 o'clock positions). There was no damage to the air bag or the module cover.

The front right passenger air bag is 43 cm (16.9 in) wide, 50 cm (19.6 in) tall, and had a maximum post-crash excursion of 77 cm (30.3 in). There were no tether straps. There were two vent holes (3 and 9 o'clock positions). There was no damage to the air bag or the module cover.

Other vehicle

Description:	1996 Honda Accord four-door	
VIN:	1HGCD5637TAxxxxxx	
Odometer:	Unknown	
Engine:	2.1 L (132 CID), 4 cylinder	
Reported Defects:	None	
Cargo:	None	
Damage Description:	Moderate lateral crush to right side beginning 29 cm (11.4 in) forward of rear axle. Both right side doors were jammed shut.	
CDC:	02RPEW2	
Delta V:	Total	18.0 km/h (11.2 mph)
	Longitudinal	-11.6 km/h (-7.2 mph)
	Latitudinal	-13.8 km/h (-8.6 mph)
	Energy	41,615 joules (30,684 ft-lbs)

Figure 6. Right side, other vehicle

Occupants

Case vehicle	Occupant 1	Occupant 2
Age/Sex:	66/Female	3/Female
Seated Position:	Front right	Front left
Seat Type:	Fabric coverd bucket seat. Seat adjusted to rear-most track position.	Fabric covered bucket seat. Seat adjusted to forward most track position.
Height:	Unknown	116 cm (45.5 in)
Weight:	Unknown	19 kg (42 lbs)
Occupation:	None	NA
Pre-existing Medical Condition:	None noted	None
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Unknown	NA
Body Posture:	Normal, upright	Normal, upright
Hand Position:	Unknown, both hands presumed to be on steering wheel	Unknown
Foot Position:	Right foot on brake, left likely on floor	Unknown
Restraint Usage:	Lap and shoulder belt available, not used	Lap and shoulder belt available, not used (see photo below)
Air bag:	Driver's air bag available, deployed	Passenger's frontal air bag available, deployed

Figure 7. Location of front right passenger seat belt latch

Other vehicle	Occupant 1
Age/Sex:	42/Male
Seated Position:	Front left
Seat Type:	Fabric coverd bucket seat. Seat was adjusted to rear most track position
Height:	Unknown
Weight:	Unknown
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Presumed to be greater than 10 years
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Right foot presumed to be on accelerator
Restraint Usage:	Lap and shoulder belt available, used

Injuries and Injury Mechanisms

Case vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Minor facial injuries	215099.7,9	Unknown	Air bag
RF Occupant:	Complete atlanto-occipital dislocation, with cord transection	640274.6,6	Unknown	Air bag
	Basilar artery transection	121602.4,9	900.82	Air bag
	Vertebral artery torn from brain stem	122802.5[4], 9	900.82	Air bag
	Multiple brain contusions, right side	140612.3,1	851.49	Windshield
	Focal subarachnoid hemorrhage	140684.3,9	852.09	Windshield.
	Extensive crush injury of larynx	340212.5,5	925.0	Air bag
	Liver laceration	541820.2,1	864.09	Air bag
	Bilateral pulmonary contusions	441402.3,3	861.21	Air bag
	Diaphragm contusions	440602.2,8	862.0	Air bag
	Extensive abrasion extending in a band from the left side of the neck anteriorly to the right side of the neck. The abrasion extended from ear line to ear line. The abrasion extended to below the vermilion border of the lip, and then wraps around the face along the lower cheeks	290202.1,0 390202.1,5	910.0 910.0	Air bag
	Abrasion, left side of upper lip	290202.1,8	910.0	Air bag

[4]Coded as laceration

Abrasion/contusion to back of left hand	790202.1,2 790402.1,2	913.0 923.0	Unknown
Contusion, back of left thumb	790402.1,2	923.3	Unknown
Contusion/abrasion to back of right thumb and hand, just above wrist	790202.1,1 790402.1,1	913.0 923.0	Unknown
Abrasion, back right forearm	790202.1,1	913.0	Unknown
Abrasion, top of head	190202.1,5	910.0	Windshield
Abrasion, right side of parietal scalp	190202.1,1	910.0	Windshield

Other vehicle

	INJURY	OIC CODE	ICD-9	SOURCE
Driver:	Not injured, per police report			

Occupant Kinematics

The 66-year-old driver of the case vehicle was seated in a forward facing position. She was not wearing the available lap and shoulder belt. There are fabric-covered bucket seats at the front outboard seating positions. The front left seat was adjusted to the rear most track position. The driver of the case vehicle saw the other vehicle begin the turn and began braking with her right foot. Her left foot was on the floor board. It is presumed that both hands were on the steering wheel at this time. At impact, the steering wheel mounted air bag deployed. The unrestrained occupant pitched forward and engaged the deployed air bag causing some minor facial injuries.

The front right seat was occupied by an unrestrained 3-year-old female (116 cm/45.5 in, 19 kg/42 lbs). The front right seat was adjusted to the full forward track position. This occupant was seated in an upright fashion, facing the front. Prior to impact, the driver braked hard. The unrestrained front right occupant pitched straight forward and struck the windshield with the crown of her head[5] and the right instrument panel with her torso. There was hair and skin evidence found in the windshield fracture and scuffing to the face of the right instrument panel. As she rebounded from this contact the front of the case vehicle struck the right side of the other vehicle and passenger air bag deployed. There was no contact to the air bag module cover. As the air bag continued to deploy the top and face of the air bag engaged this occupant's neck. There was a significant amount of skin transfer found on the air bag–extending 29 cm (11.4 in) longitudinally on the top of the bag and 37 cm (14.6 in) vertically on the face of the air bag. The width of the contact was approximately 10 cm (3.9 in). This contact hyperflexed the occupant's neck–causing the atlanto-occipital dislocation and the resultant spinal cord transection. The air bag also struck this occupant's chest–causing the diaphragm and lung contusions.

Figure 8. Driver's air bag

Figure 9. Exterior view of occupant contact to windshield

[5]See Figure13

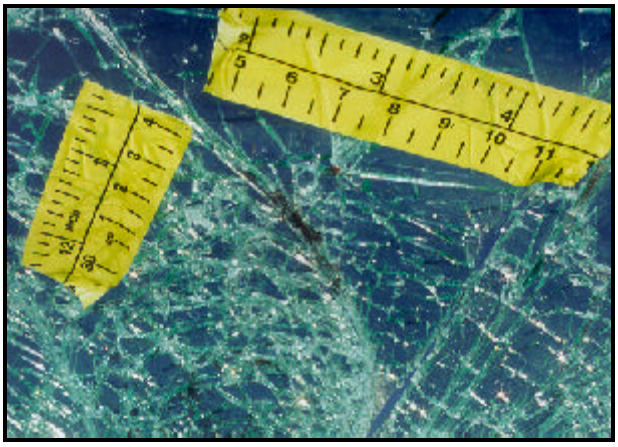

Figure 10. Hair embedded in windshield

Figure 11. Front right passenger air bag

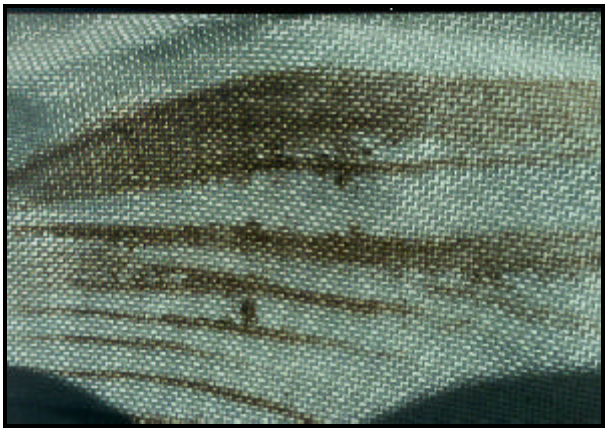

Figure 12. Skin transfer to face of air bag

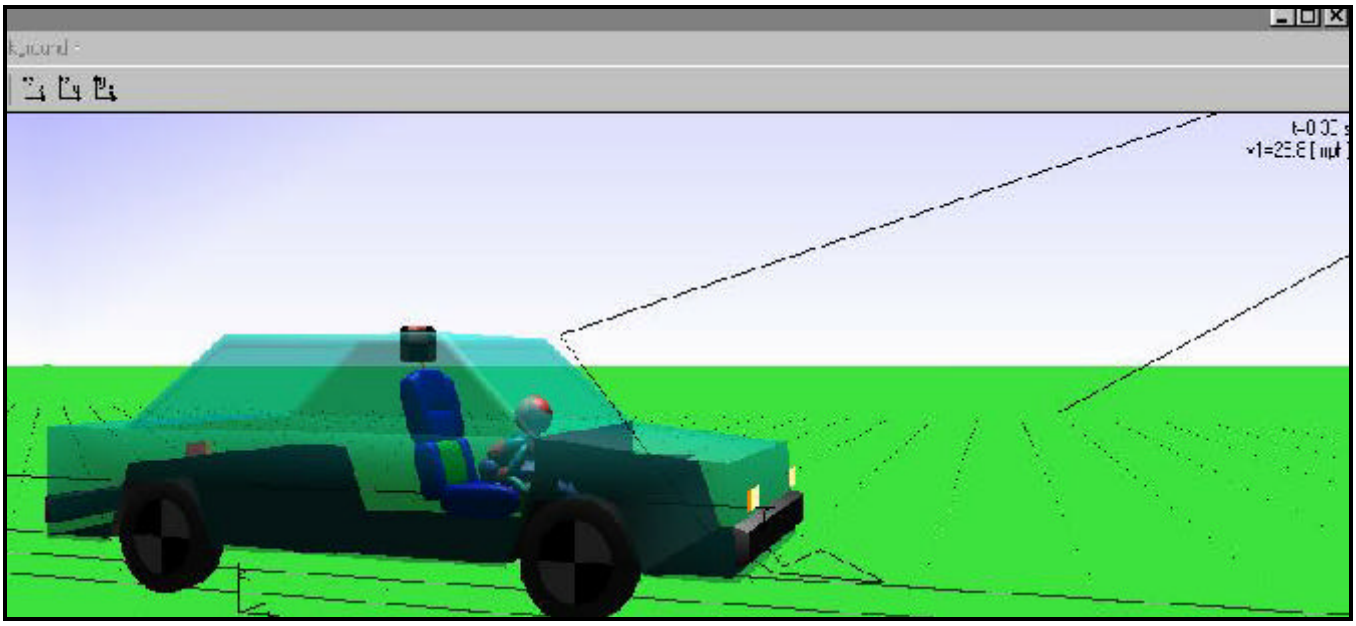

Figure 13. Position of front right occupant early into braking sequence

Attachment 1. Calculations

CASE NUMBER: ds02005

*** * COEFFICIENT OF FRICTION * ***

$f = \mu \pm m$

$f = 0.70 - 0.03$

$f = 0.67$

f = The Adjusted Accel/Drag Factor.
μ = The Coeff. of Friction, Level Surface.
m = The Grade Percentage.

INPUTS:	
The Level Surface Coeff. of Friction is:	0.70
The Percentage of Grade is:	0.03

RESULTS:	
The Acceleration/Drag Factor is:	0.67

CASE NUMBER: ds02005

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

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

$S = \sqrt{30 \times 44.50 \times 0.67}$

$S = \sqrt{894.45}$

$S = 29.90$

S = The Speed in MPH.
30 = A Constant.
D = The Distance in Feet.
f = The Adjusted Accel/Drag Factor.

INPUTS:	
The Acceleration/Drag Factor is:	0.67
The Distance in Feet is:	44.50

RESULTS:	
The Speed in MPH is:	29.90
The Velocity in FPS is:	43.83

CASE NUMBER: ds02005

Comments: Combined speed (pre-braking travel speed and delta v)

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

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

$S = \sqrt{(29.90)^2 + (13.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2}$

$S = \sqrt{894.01 + 169.00 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00 + 0.00}$

$S = \sqrt{1063.01}$

$S = 32.60$

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

INPUTS:	
Speed #1 in MPH is:	29.90
Speed #2 in MPH is:	13.00

RESULTS:	
The Speed in MPH is:	32.60
The Velocity in FPS is:	47.79