

Remote Investigation / Rollover, 15 Passenger Van
Dynamic Science, Inc. / Case Number: DS04011
2003 Ford Econoline E350 van
Washington
December, 2003

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no responsibility for the contents or use thereof.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Highway Traffic Safety Administration.

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.

1. Report No. DS04011	2. Government Accession No.		3. Recipient Catalog No.	
4. Title and Subtitle Remote Investigation / 15 Passenger Van			5. Report Date July 11, 2006	
			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. (TRAVIS)	
			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 <p>This remote investigation focused on a 2003 Ford Econoline 15 Passenger Van that was involved in a single vehicle rollover. The vehicle was in the left lane of state highway. It was being followed by a second van which was in the right lane and was several hundred feet distant. This was one of two rental vehicles that were transporting high school students on a high school sponsored program. The driver had picked up the students and began the 201 km (125 mile) trip. The crash occurred approximately 84 km (52 miles) into the journey. There were eight students and the driver on board at the time of the crash. The case vehicle crossed into a shadowed area on the roadway and struck a patch of ice/frost. The vehicle began to fishtail and eventually overturned three times. During the rollover one occupant was ejected and one occupant was partially ejected. Both of these occupants were fatally injured. This case was identified by a local state patrol officer. The National Highway Traffic Safety Administration (NHTSA) was notified by the officer on May 28, 2004. DSI was assigned the case on June 1, 2004.</p>				
17. Key Words 15 passenger van, rollover, fatality, ejection, partial ejection			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: DS04011

TABLE OF CONTENTS

Background	1
Summary	1
Crash Site	1
Pre-crash	1
Crash	4
Post-crash	4
Vehicle Data - 2003 Ford Econoline E350 Super Duty 4x2 Van .	6
Vehicle Damage	7
Exterior Damage	7
Interior Damage	8
Manual Restraint Systems	9
Occupant Demographics	11
Occupant Injuries	15
Occupant Kinematics	17
Attachment 1. Scene Diagram	22
Attachment 2. Calculations	23

BACKGROUND

This remote investigation focused on a 2003 Ford Econoline 15 Passenger¹ Van that was involved in a single vehicle rollover. There were eight students and the driver on board the van at the time of the crash. During the rollover one occupant was ejected and another occupant was partially ejected. Both of these occupants were fatally injured.

This case was identified by a local state patrol officer. The National Highway Traffic Safety Administration (NHTSA) was notified by the officer on May 28, 2004. DSI was assigned the case on June 1, 2004. The investigating agency was contacted on June 1, 2004 and materials related to the case were received on August 21, 2004.



Figure 1. Right side, Ford Econline van

SUMMARY

Crash Site

This single vehicle crash occurred in December, 2003 at 0920 hours in the state of Washington. The crash occurred on a straight section of a four-lane state highway. The north and southbound lanes were separated by a grassy median. The northbound travel lanes were of concrete construction and had a positive grade of between 2.7 and 3.2%. The cross slope is generally level. There are paved asphalt shoulders on both sides of the roadway. This part of the road was in shadows from a hill to the east. The road was ice/frost covered at the time of the crash. The speed limit is 113 k/h (70 mph). The weather was clear and the approximate temperature was 16 C (29 F).



Figure 2. Path of travel, road departure, and final rest. Looking north.

Pre-Crash

The case vehicle is a 2003 Ford Econoline E350 Super Duty 4x2 van (VIN: 1FBSS31S73Hxxxxxx).

¹Vehicle actually has seating positions for a driver plus 14 passengers but is referred to as a 15 passenger van. Classified as a bus under 49 CFR 571.3.

The van was traveling at minimum speed of 98 km/h (61 mph)². The vehicle was in the left lane. It was being followed by a second van which was in the right lane and was several hundred feet distant. This was one of two rental vehicles that were transporting high school students on a high school sponsored, community college approved activity known as “Upward Bound” which prepares low income students to become first-generation graduates of post-secondary programs. The vehicle was picked up at 0614 hours on the morning of the crash. The driver picked up the students and began the 201 km (125 mile) trip. The crash occurred approximately 84 km (52 miles) into the journey.

There were eight students and the driver on board at the time of the crash. An overview of occupant seating positions, ages, restraint usage, and injuries are shown on the following page. The driver was a 35-year-old male. This driver indicated that he had 20 years of driving experience. He had been at this job for three years and had made the same trip in excess of 50 times. The driver had received training in the operation of 15-passenger vans. The training was basically a review of 15-passenger van safety materials from the NHTSA and the state of Washington.

²See Attachment 2. Speed Calculations

Table 1. Injuries and Restraint Use

Occupant No.	Seat No.	Age/Sex	Restraint use	Injury
1	1	35/Male	Restrained	Lumbar strain
2	2	16/Female	Restrained	Abrasion to the left shoulder, a cervical strain, and a contusion to the right parietal area.
3	3	16/Female	Unrestrained	Lacerations to left leg, right knee, multiple abrasions
4	4	16/Male	Unrestrained	Contusion to left lower leg
5	5	15/Female	Restrained, improper	Fatal. Partially ejected. Head trauma.
6	6	17/Female	Unrestrained	Fatal. Ejected. Head trauma
7	8	15/Female	Unrestrained	Disabling injury.
8	9	15/Male	Unrestrained	Abrasion to left knee and shoulder. Laceration to left hand.
9	11	15/Female	Restrained, improper	Cervical strain, multiple lacerations and contusions

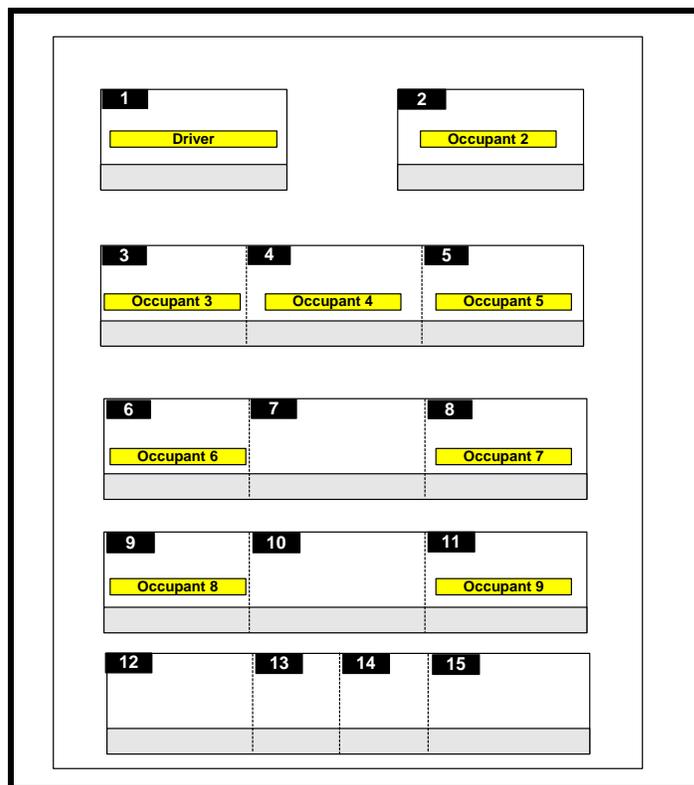


Figure 3. Overview of seat positions

Crash

The case vehicle crossed into the shadowed area and struck a patch of ice/frost. The vehicle began to fishtail to the right. The driver overcorrected to the right and the vehicle went into a clockwise yaw. The yaw continued for 56 m (183 ft) until the vehicle had reached approximately a 45 degree angle and the rear tires had entered the left side shoulder. The vehicle tripped at this point with its left side leading. The vehicle overturned three times as it continued on for an additional 46 m (152 ft) before coming to rest on its wheels facing generally east.



Figure 4. Final rest. Looking north.

Post-Crash

The E350 sustained major damage from the rollover (00TDDO3). There was vertical crush along the entire length of the roof. There was lateral crush to both the left and right roof rails. All the windows, with the exception of the windshield, disintegrated during the crash. The windshield was shattered. The left front and left rear tires were flattened. Smearred blood was located on the right passenger door from Occupant 5.

Investigators recommended that the driver of the van be cited for negligent driving and failure to restrain passengers under the age of 16.

The driver sustained a lumbar strain. He was transported to a local hospital where he was treated and released. An alcohol and drug tests were conducted, all of which came up negative.

The first row right seat occupant (02) an abrasion to the left shoulder, a cervical strain, and a contusion to the right parietal area. She arrived with a Glasgow Coma Scale (GCS) score of 15. She was treated and then released.

The second row left seat occupant (03) sustained an 8.0 cm (3.1 in) laceration to the left lower leg, a laceration to the left ankle, bilateral lacerations to both knees, and abrasions to the left wrist and leg. She arrived at the hospital with a GCS score of 15. She denied any loss of consciousness. She was treated and then released.

The second row middle occupant (04) sustained a contusion to his lower left leg. He arrived at



Figure 5. Final rest, Econoline, Occupant 6. Facing south.

the hospital with a GCS score of 15. He was treated and then released.

The second row right seat occupant (05) was partially ejected through the right side window and was fatally injured. She remained outside of the window as the vehicle came to rest but was pulled inside by other occupants shortly after the vehicle came to rest. According to the certificate of death, she sustained a blunt head trauma and neck injuries. She had been partially ejected. The interval between the crash and the time of death was listed as instantaneous.

The third row left seat occupant (06) was completely ejected and came to rest on the roadway 11 m (35 ft) north of the van's final rest. She had been ejected through the left side window and was fatally injured.. According to the certificate of death, she sustained a blunt head trauma, and neck and thoracic injuries. She had been fully ejected. The interval between the crash and the time of death was listed as instantaneous.

The third row right occupant (7) sustained non-disabling injuries of an unknown nature. No medical records were found. It appears that she was transported and released.

The fourth row left occupant (08) sustained an abrasion to the left knee, abrasion to the left shoulder, abrasion to the left hand, swelling to the left wrist and left elbow, and a small laceration to the left hand. He was transported to a local hospital where he was treated and released. He arrived with a GCS score of 15. X-rays were obtained of the left hand, left wrist, left knee and left elbow, all of which were interpreted as negative.

The fourth row right occupant (09) sustained a cervical strain, a 1.5 cm (0.6 in) laceration to the right hand, 2.5 cm (1.0 in) lacerations to the 4th and 5th fingers of the right hand, 0.5 cm (0.2 in) laceration to the right wrist, and a contusion to the right knee. She was transported to a local hospital where he was treated and released. He arrived with a GCS score of 15. She denied any loss of consciousness.

VEHICLE DATA - 2003 Ford Econoline E350 Super Duty 4x2 van

The 2003 Ford Econoline E350 Super Duty 4x2 van was identified by the Vehicle Identification Number (VIN): 1FBSS31S73Hxxxxxx. This vehicle is equipped with 6.8 liter V10 engine, automatic transmission, dual front air bags, power steering, and 4-wheel anti-lock brakes. This vehicle model has a reported static stability factor (SSF) of 1.11. Measurements on a lightly loaded and fully loaded E350 showed SSF ranges from 1.07 to 0.95³. The mileage at the time of the crash was 34,222 km (21,265 miles). A post-crash inspection of the vehicle by police investigators did not reveal any vehicle defects that might have contributed to the crash.

The 2003 Ford Econoline E350 van was equipped with Goodyear Wrangler HT LT245/75R16 tires that were mounted on stock steel wheels. The specific tire data is as follows:

Tire	Tread	Pressure	Recommended pressure
LF	9 mm (11/32 in)	Flat	Unknown
LR	8 mm (10/32 in)	Flat	Unknown
RF	8 mm (10/32 in)	359 kPa (52 psi) ⁴	Unknown
RR	8 mm (10/32 in)	303 kPa (44 psi)	Unknown

The front seating positions in the 2003 Ford Econoline E350 van included two front bucket seats followed by three rows with seating for three passengers each, and a fourth row with seating for four passengers.

³The Rollover Propensity of Fifteen-Passenger Van, NHTSA Research Note, April, 2001.

⁴Pressure for right front and right rear were taken on scene

VEHICLE DAMAGE

Exterior Damage - 2003 Ford Econoline E350 van

Damage Description: Moderate roof and side damage consistent with a rollover crash. Left side tires were both off the rims.

CDC: 00TDDO3

Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown



Figure 6. Left side, Ford Econoline van



Figure 7. Right side, Ford Econoline van

Interior Damage - 2003 Ford Econoline E350 van

Interior showed large quantities of blood, concentrated primarily on the interior right passenger door. The police indicate that there was hair and blood behind the driver's seat in between the first and second bench seats that most likely came from the occupant who was ejected forward through the left front side window. There was intrusion along both roof rails, particularly on the right. The roof was bowed upwards in the center. All the side glazing and the rear door glazing was disintegrated. The windshield was fractured, holed, and displaced.



Figure 8. Overview of vehicle interior



Figure 9. Area of partial ejection of Occupant 5

MANUAL RESTRAINT SYSTEMS - 2003 Ford Econoline E350 van
Seat belt usage discussion

The driver of the E350 was wearing the available lap and shoulder belt. Belt usage was based on the driver's statement and loading evidence found on the belt during the police examination.



Figure 10. Loading to driver's seat belt webbing

Occupant 2 (seated in position 2) was wearing the available lap and shoulder belt. Belt usage was based on loading and blood evidence found during the police examination.

Occupant 3 (seated in position 3) was not restrained. Belt usage was based on the post crash location of the belt. The police found it jammed between the left side of the vehicle and seat back.

Occupant 4 (seated in position 4) was not restrained. Belt usage was based on the police examination of the seat belt and this occupant's statement to the police.



Figure 11. Digital photo taken during trip by front seat occupant

Occupant 5 (seated in position 5) was wearing the lap and shoulder belt in an improper fashion. It appears that the shoulder harness was not being used. The shoulder harness had been wrapped around the right side coat hook. See Figure 13 on the following page.

Occupant 6 (seated in position 6) was not restrained. Belt usage was based on the seat belt post crash location of the belt, her ejection, and a photo taken by a front seat occupant showing the belt in the stowed position⁵.

Occupant 7 (seated in position 8) was not restrained. Belt usage was based on a photo taken by a front seat occupant showing the belt in the stowed position.

⁵Image was date stamped for the day of the crash and time stamped 0905 hours—approximately 15 minutes prior to the crash

Occupant 8 (seated in position 9) was not restrained. Belt usage was based on the police examination of the seat belt and a photo taken by a front seat occupant showing the belt in the stowed position.

Occupant 9 (seated in position 11) was wearing the available lap and shoulder belt incorrectly. Belt usage was based on a photo taken by a front seat occupant showing the belt worn under the occupant's arm.



Figure 12. Seat belt in seat position 5, belt wrapped around coat hook

OCCUPANT DEMOGRAPHICS - 2003 Ford Econoline E350 van

	Occupant 1	Occupant 2
Age/Sex:	35/Male	16/Female
Seated Position:	Front left	Front right
Seat Type:	Van style box	Van style box
Height:	165 cm (65 in)	Unknown
Weight:	64 kg (140 lbs)	Unknown
Occupation:	Driver	Unknown
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	None	N/A
Driving Experience:	>10 years	N/A
Body Posture:	Normal, upright	Unknown
Hand Position:	Hands on steering wheel, actively steering	Unknown
Foot Position:	Right foot likely on brake	Unknown
Restraint Usage:	Lap and shoulder belt available, used	Lap and shoulder belt available, used

	Occupant 3	Occupant 4	Occupant 5
Age/Sex:	16/Female	16/Male	15/Female
Seated Position:	Second row, left	Second row, middle	Second row, right
Seat Type:	Bench	Bench	Bench
Height:	Unknown	Unknown	Unknown
Weight:	Unknown	Unknown	Unknown
Occupation:	N/A	N/A	N/A
Pre-existing Medical Condition:	None noted	None noted	None noted
Alcohol/Drug Involvement:	N/A	N/A	N/A
Driving Experience:	N/A	N/A	N/A
Body Posture:	Presumed upright	Presumed upright	Presumed upright
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, not used	Lap belt available, not used	Lap and shoulder belt available, used improperly

	Occupant 6	Occupant 7
Age/Sex:	17/Female	15/Female
Seated Position:	Third row, left	Third row, right
Seat Type:	Bench	Bench
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	N/A	N/A
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	N/A	N/A
Driving Experience:	N/A	N/A
Body Posture:	Presumed upright	Presumed upright
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, not used	Lap and shoulder belt available, not used

	Occupant 8	Occupant 9
Age/Sex:	15/Male	15/Female
Seated Position:	Fourth row, left	Fourth row, right
Seat Type:	Bench	Bench
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Occupation:	N/A	N/A
Pre-existing Medical Condition:	None noted	None noted
Alcohol/Drug Involvement:	N/A	N/A
Driving Experience:	N/A	N/A
Body Posture:	Presumed upright	Presumed upright
Hand Position:	Unknown	Unknown
Foot Position:	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt available, not used	Lap and shoulder belt, used improperly

OCCUPANT INJURIES -2003 Ford Econoline E350 van

Driver: Injuries obtained from emergency room records and radiology reports.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Lumbar strain	640678.1,8	Impact forces	Probable

Occupant 2: Injuries obtained from emergency room records and radiology reports.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Abrasion, left shoulder	790202.1,2	Unknown	Unknown
Cervical strain	640278.1,6	Impact forces	Probable
Contusion, right parietal scalp	190402.1,1	Right window frame	Possible

Occupant 3: Injuries obtained from emergency room records and radiology reports.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
8.0 cm (3.1 in) laceration to the left lower leg	890600.1,2	Seat back	Possible
Laceration, left ankle	890600.1,2	Seat back	Possible
Bilateral lacerations, both knees	890600.1,3	Seat back	Possible
Abrasion, left wrist	790202.1,2	Unknown	Unknown
Abrasion, left leg	890202.1,2	Seat back	Possible

Occupant 4: Injuries obtained from emergency room records.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Contusion, left lower leg	890402.1,2	Seat back	Possible

Occupant 5: Injuries obtained from death certificate. No autopsy was conducted.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Blunt head trauma	115099.7,0	Ground/Exterior of case vehicle	Probable
Neck injuries	315099.7,0	Ground/Exterior of case vehicle	Probable

Occupant 6: Injuries obtained from death certificate. No autopsy was conducted.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Blunt head trauma	115099.7,0	Ground/Exterior of case vehicle	Probable
Neck and thoracic injuries	315099.7,0 415099.7,0	Ground/Exterior of case vehicle	Probable

Occupant 7: Hospital could not find any records.

Occupant 8: Injuries obtained from emergency room records and radiology reports.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Abrasion, left knee	890202.1,2	Unknown	Unknown
Abrasion, left shoulder	790202.1,2	Unknown	Unknown
Swelling, left wrist and elbow	Not codeable	Unknown	Unknown
Laceration, left hand	790600.1,2	Flying glass	Possible

Occupant 9: Injuries obtained from emergency room records and radiology reports.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
1.5 cm (0.6 in) laceration, right hand	790602.1,1	Flying glass	Possible
Cervical strain	640278.1,6	Impact forces	Probable
2.5 cm (1.0 in) lacerations to the 4 th and 5 th fingers, right hand	790602.1,1	Flying glass	Probable
0.5 cm (0.2 in) laceration, right wrist	790602.1,1	Flying glass	Possible
Contusion, right knee	890402.1,1	Unknown	Unknown

OCCUPANT KINEMATICS - 2003 Ford Econoline E350 van

Driver Kinematics

The 35-year-old driver of the case vehicle was seated in an upright fashion. He was wearing the manual 3-point lap and shoulder belt. The seat belt shoulder adjustment was in the full down position. As the vehicle encountered the frost/ice, the driver began to make sharp steering movements. As he lost control of the vehicle, the vehicle began a clockwise rotation. As the vehicle rotated approximately 90 degrees from its initial path of travel, the vehicle tripped and began to rollover about its longitudinal axis with its left side leading. The vehicle overturned three times as it continued on for an additional 46 m (152 ft) before coming to rest on its wheels facing generally east. The driver likely shifted from right to left during the steering maneuver, and then shifted sharply to the right as the vehicle rolled to the left. He remained in his seat, with the seat belt fastened, throughout the rollover sequence. He sustained a lumbar strain. He was transported to a local hospital where he was treated and released.



Figure 13. Driver's seated position

Front Right Seat Occupant Kinematics

The 16-year-old female front right occupant was seated in an upright fashion. She was wearing the manual 3-point lap and shoulder belt. The seat belt shoulder adjustment was an unknown position. As the vehicle encountered the frost/ice, the driver began to make sharp steering movements. As he lost control of the vehicle, the vehicle began a clockwise rotation. As the vehicle rotated approximately 90 degrees from its initial path of travel, the vehicle tripped and began to rollover about its longitudinal axis with its left side leading. The vehicle overturned three times. This occupant likely shifted from right to left during the steering maneuver, and then shifted sharply to the right as the vehicle rolled to the left. This occupant likely struck the

right side of her head at this point, causing a contusion to the right parietal area. She remained in her seat, with the seat belt fastened, throughout the rollover sequence. As the vehicle rolled, she also sustained a cervical strain and an abrasion to the left shoulder. She was transported to a local hospital where she was treated and released.

Second Row Left Seat Occupant Kinematics

The 16-year-old female second row left occupant was seated in an upright fashion. She was not wearing the manual 3-point lap and shoulder belt. As the vehicle encountered the frost/ice, the driver began to make sharp steering movements. As he lost control of the vehicle, the vehicle began a clockwise rotation. As the vehicle rotated approximately 90 degrees from its initial path of travel, the vehicle tripped and began to rollover about its longitudinal axis with its left side leading. The vehicle overturned three times. This occupant likely shifted from right to left during the steering maneuver, and then shifted sharply to the right as the vehicle rolled to the left. She was likely pitched out of her seat at various times throughout the rollover sequence. She sustained an 8.0 cm (3.1 in) laceration to the left lower leg, a laceration to the left ankle, bilateral lacerations to both knees, and abrasions to the left wrist and leg. She was transported to a local hospital where she was treated and then released.

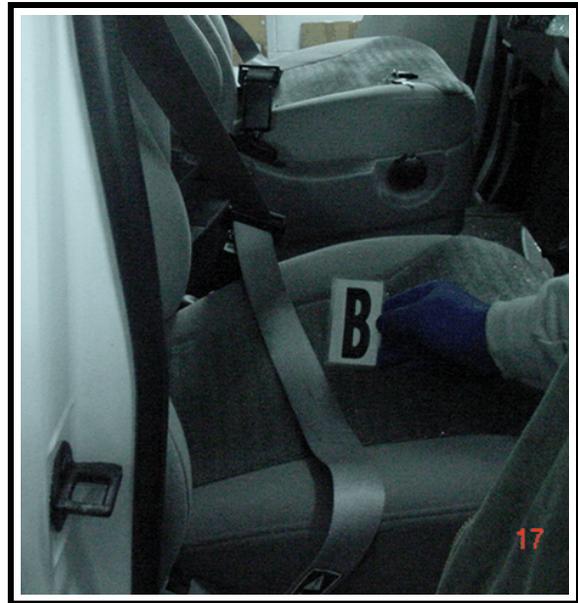


Figure 14. Front right seat occupant seated area



Figure 15. Second row left occupant seated position

Second Row Middle Seat Occupant Kinematics

The 15-year-old male second row middle occupant was seated in an upright fashion. He was not wearing the manual lap belt. As the vehicle encountered the frost/ice, the driver began to make sharp steering movements. As he lost control of the vehicle, the vehicle began a clockwise rotation. As the vehicle rotated approximately 90 degrees from its initial path of travel, the vehicle tripped and began to rollover about its longitudinal axis with its left side leading. The vehicle overturned three times. This occupant likely shifted from right to left during the steering maneuver, and then shifted sharply to the right as the vehicle rolled to the left. He was likely pitched out of his seat at various times throughout the rollover sequence. He sustained a contusion to the left lower leg, possibly from the seat back.



Figure 16. Second row right and middle seat positions

Second Row Right Seat Occupant Kinematics

The 16-year-old female second row right occupant was seated in an upright fashion. She was wearing the manual 3-point lap and shoulder belt improperly. It appears that the shoulder harness was not being used. The shoulder harness had been wrapped around the right side coat hook. As the vehicle encountered the frost/ice, the driver began to make sharp steering movements. As he lost control of the vehicle, the vehicle began a clockwise rotation. As the vehicle rotated approximately 90 degrees from its initial path of travel, the vehicle tripped and began to rollover about its longitudinal axis with its left side leading. The vehicle overturned three times. This occupant likely shifted from right to left during the steering maneuver, and then shifted sharply to the right as the vehicle rolled to the left. She was likely pitched out of her seat at various times throughout the rollover sequence. She was partially ejected through the right side window and was fatally injured. She remained outside of the window as the vehicle came to rest but was pulled inside by other occupants shortly after the vehicle came to rest. According to the certificate of death, she sustained a blunt head trauma and neck injuries. She had been partially ejected. The interval between the crash and the time of death was listed as instantaneously.

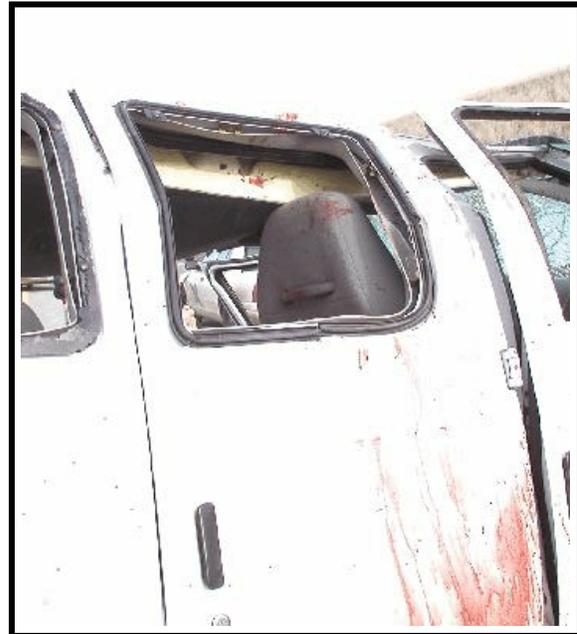


Figure 17. Second row right seat occupant partial ejection medium

Third Row Left Seat Occupant Kinematics

The 17-year-old female third row left occupant was seated in an upright fashion. She was not wearing the manual 3-point lap and shoulder belt. As the vehicle encountered the frost/ice, the driver began to make sharp steering movements. As he lost control of the vehicle, the vehicle began a clockwise rotation. As the vehicle rotated approximately 90 degrees from its initial path of travel, the vehicle tripped and began to rollover about its longitudinal axis with its left side leading. The vehicle overturned three times. This occupant likely shifted from right to left during the steering maneuver, and then shifted sharply to the right as the vehicle rolled to the left. She was likely pitched out of her seat at various times throughout the rollover sequence. She was completely ejected and came to rest on the roadway 11 m (35 ft) north of the van's final rest. She had been ejected through the left side window and was fatally injured. It appears likely that she was partially ejected at some point and contacted the road surface. According to the certificate of death, she sustained a blunt head trauma, and neck and thoracic injuries. The interval between the crash and the time of death was listed as instantaneous.



Figure 18. Third row, left occupant seated position and ejection path



Figure 19. Final rest position, third row left occupant

Third Row Right Seat Occupant Kinematics

The 15-year-old female third row right occupant was seated in an upright fashion. She was not wearing the manual lap belt. As the vehicle encountered the frost/ice, the driver began to make sharp steering movements. As he lost control of the vehicle, the vehicle began a clockwise rotation. As the vehicle rotated approximately 90 degrees from its initial path of travel, the vehicle tripped and began to rollover about its longitudinal axis with its left side leading. The vehicle overturned three times. This occupant likely shifted from right to left during the steering maneuver, and then shifted sharply to the right as the vehicle rolled to the left. She was likely pitched out of her seat at various times throughout the rollover sequence. She sustained non-disabling injuries of an unknown nature. She was likely transported, treated and released.

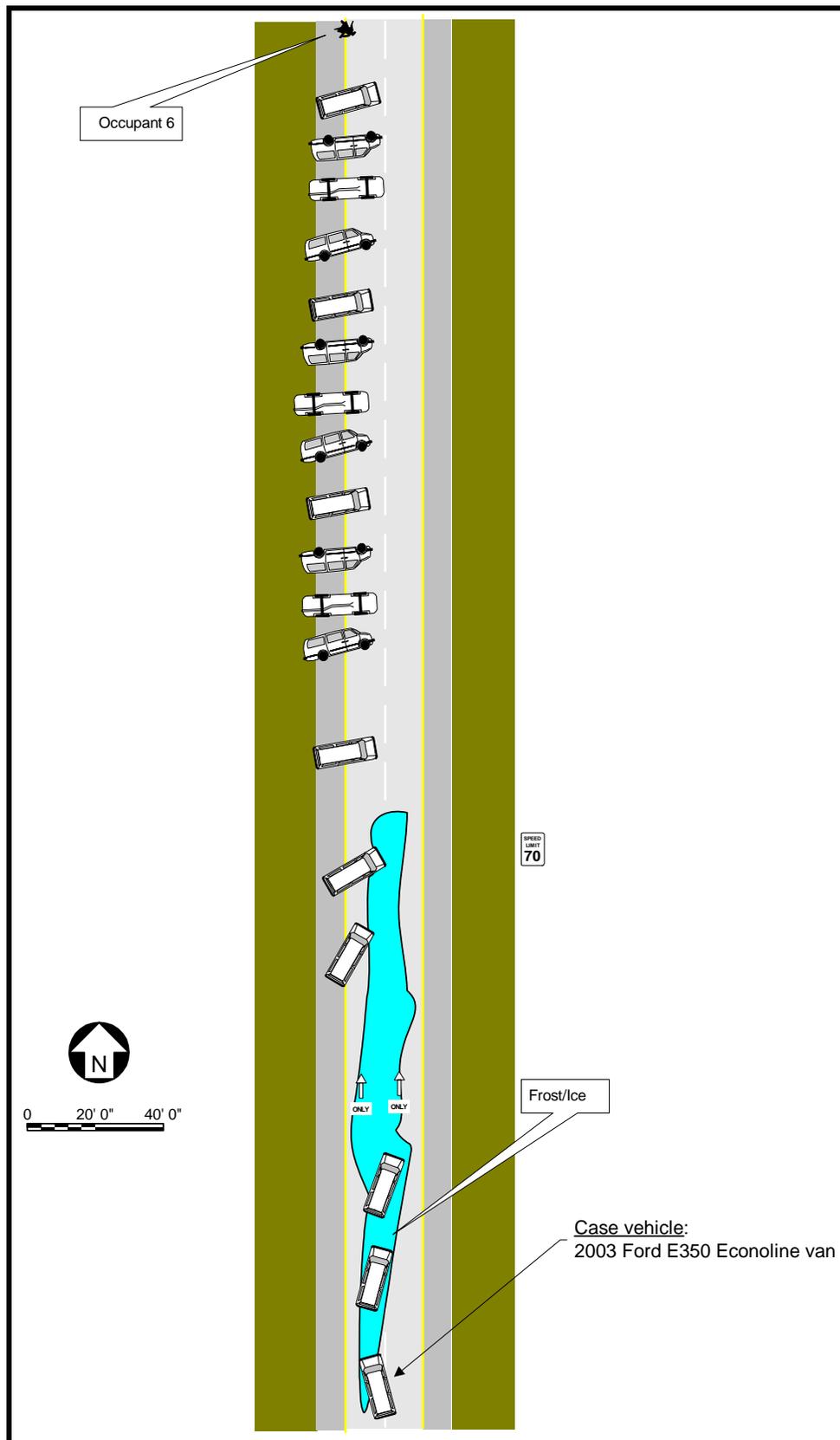
Fourth Row Left Seat Occupant Kinematics

The 15-year-old male fourth row left occupant was seated in an upright fashion. He was not wearing the manual lap belt. As the vehicle encountered the frost/ice, the driver began to make sharp steering movements. As he lost control of the vehicle, the vehicle began a clockwise rotation. As the vehicle rotated approximately 90 degrees from its initial path of travel, the vehicle tripped and began to rollover about its longitudinal axis with its left side leading. The vehicle overturned three times. This occupant likely shifted from right to left during the steering maneuver, and then shifted sharply to the right as the vehicle rolled to the left. He was likely pitched out of his seat at various times throughout the rollover sequence. He sustained an abrasion to the left knee, abrasion to the left shoulder, abrasion to the left hand, swelling to the left wrist and left elbow, and a small laceration to the left hand. He was transported to a local hospital where he was treated and released.

Fourth Row Right Seat Occupant Kinematics

The 15-year-old female fourth row right occupant was seated in an upright fashion. She was wearing the available 3-point lap and shoulder belt improperly. The shoulder harness was under her right arm. As the vehicle encountered the frost/ice, the driver began to make sharp steering movements. As he lost control of the vehicle, the vehicle began a clockwise rotation. As the vehicle rotated approximately 90 degrees from its initial path of travel, the vehicle tripped and began to rollover about its longitudinal axis with its left side leading. The vehicle overturned three times. This occupant likely shifted from right to left during the steering maneuver, and then shifted sharply to the right as the vehicle rolled to the left. She was likely pitched from side to side at various times throughout the rollover sequence. She sustained a cervical strain, a 1.5 cm (0.6 in) laceration to the right hand, 2.5 cm (1.0 in) lacerations to the 4th and 5th fingers of the right hand, 0.5 cm (0.2 in) laceration to the right wrist, and a contusion to the right knee. The strain is likely due to impact forces, while the lacerations to the hand and wrist were from the sideglass. She was transported to a local hospital where he was treated and released.

Attachment 1. Scene Diagram



Attachment 2. Calculations

CASE NUMBER: DS04011

Comments: s1 = van sliding on ice/frost

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

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

$$S = \sqrt{30 \times 68.05 \times 0.32}$$

$$S = \sqrt{653.28}$$

$$S = 25.55$$

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:	0.32
The Distance in Feet is:	68.05

RESULTS:	
The Speed in MPH is:	25.55
The Velocity in FPS is:	37.45

Drag F	Speed
0.32	25.55
0.33	25.95
0.34	26.34
0.35	26.73
0.36	27.10
0.37	27.48
0.38	27.85
0.39	28.21

INCREMENTATION CALCs:

Drag F	Speed

CASE NUMBER: DS04011

Comments: s2 = van sliding on ice/frost - shoulder

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

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

$$S = \sqrt{30 \times 29.91 \times 0.32}$$

$$S = \sqrt{287.13}$$

$$S = 16.94$$

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:	0.32	The Speed in MPH is:	16.94
The Distance in Feet is:	29.91	The Velocity in FPS is:	24.83

Drag F	Speed
0.32	16.94
0.33	17.20
0.34	17.46
0.35	17.72
0.36	17.97
0.37	18.22
0.38	18.46
0.39	18.70

INCREMENTATION CALCs:

Drag F	Speed

CASE NUMBER: DS04011

Comments: s3 = van sliding in gravel shoulder

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

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

$$S = \sqrt{30 \times 85.26 \times 0.37}$$

$$S = \sqrt{946.38}$$

$$S = 30.76$$

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:	0.37
The Distance in Feet is:	85.26

RESULTS:	
The Speed in MPH is:	30.76
The Velocity in FPS is:	45.09

Drag F	Speed
0.37	30.76
0.38	31.17
0.39	31.58
0.40	31.98
0.41	32.38
0.42	32.77
0.43	33.16
0.44	33.54

INCREMENTATION CALCs:

Drag F	Speed

CASE NUMBER: DS04011

Comments: s4 = rollover to rest

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

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

$$S = \sqrt{30 \times 153.13 \times 0.40}$$

$$S = \sqrt{1837.56}$$

$$S = 42.86$$

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:	0.40	The Speed in MPH is:	42.86
The Distance in Feet is:	153.13	The Velocity in FPS is:	62.83

Drag F	Speed
0.40	42.86
0.41	43.39
0.42	43.92
0.43	44.44
0.44	44.95
0.45	45.46
0.46	45.96
0.47	46.46
0.48	46.95
0.49	47.44

INCREMENTATION CALCs:

Drag F	Speed
0.50	47.92

CASE NUMBER: DS04011

Comments: Minimum pre-crash travel speed

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

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

$$S = \sqrt{(25.55)^2 + (16.94)^2 + (30.76)^2 + (42.86)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2 + (0.00)^2}$$

$$S = \sqrt{652.80 + 286.96 + 946.17 + 1836.97 + 0.00 + 0.00 + 0.00 + 0.00}$$

$$S = \sqrt{3722.90}$$

$$S = 61.01$$

S = The Speed in MPH
 S² = The Individual Min. Speed.
 (1), (2), (n) = The # of the individual speed.

INPUTS:	
Speed # 1 in MPH is:	25.55
Speed # 2 in MPH is:	16.94
Speed # 3 in MPH is:	30.76
Speed # 4 in MPH is:	42.86

RESULTS:	
The Speed in MPH is:	61.01
The Velocity in FPS is:	89.44