

On Site Tour Bus Crash Investigation - Office of Defects Investigation
Dynamic Science, Inc. (DSI), Case Number DS08028
2001 Prevost Marathon Tour Bus Class A Recreational Vehicle
Nevada
August 2008

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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 on-site tour bus crash investigation focused on the tires that were installed on a 2001 Prevost Marathon Tour Bus Class A Recreational Vehicle. The Prevost was being driven southbound on an interstate highway by an unrestrained 67-year-old male and was towing a 2008 GMC Yukon sport utility vehicle. The driver's 63-year-old wife was probably seated in the front right position. The Prevost's left front tire tread separated from the tire. The Prevost traveled to the left, departed the roadway, and entered a depressed dirt covered median. The median area contained a series of undulating embankments. As the vehicle traveled south, the front of the Prevost impacted three dirt embankments. As the vehicle impacted the third embankment, the front right passenger was ejected through the front windshield area. She contacted the ground in front of the bus, was run over, and was fatally injured. The Prevost came to rest facing south; the right front passenger came to rest underneath the front axle of the vehicle.				
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Dynamic Science, Inc.
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Background

This on-site tour bus crash investigation was identified by the National Highway Traffic Safety Administration (NHTSA) Office of Defects Investigation (ODI) in response to a report of a crash that was possibly caused by a tire tread separation. The subject vehicle was a 2001 Prevost Marathon Tour Bus Class A Recreational Vehicle (**Figure 1**). The Prevost was towing a 2008 GMC Yukon sport utility vehicle. The Prevost was being driven southbound on an interstate highway by an unrestrained 67-year-old male. The driver's 63-year-old wife was probably seated in the front right position; the driver did not have an exact recollection where she was positioned prior to the crash. The Prevost's left front tire tread separated from the tire. The Prevost traveled to the left, departed the roadway, and entered a depressed dirt covered median. The median area contained a series of undulating embankments. As the vehicle traveled south, the front of the Prevost impacted three dirt embankments. As the vehicle impacted the third embankment, the front right passenger was ejected through the front windshield area. She contacted the ground in front of the bus, was run over, and was fatally injured. The Prevost came to rest facing south; the right front passenger came to rest underneath the front axle of the vehicle.



Figure 1. Subject vehicle, 2001 Prevost Marathon

DSI contacted the investigating law enforcement agency and obtained permission to inspect the vehicle. The scene and vehicle inspections took place on September 6, 2008. Present at the vehicle inspection was the investigating police officer. A completed police report was obtained on January 29, 2009. An autopsy report was obtained on February 3, 2009 and on-scene photos were obtained on March 9, 2009.

Summary

Crash Site

This single vehicle crash occurred off road, adjacent to the southbound lanes of a divided interstate highway (**Figure 2**). The roadway was configured with two lanes that were separated by dashed white lines. The roadway was bordered on the right by a solid white fog line and an asphalt shoulder with a rumble strip. The roadway was bordered on the left by a solid yellow line and an asphalt shoulder with a rumble strip. The roadway was of asphalt construction and had a negative 1% grade. Adjacent to the paved shoulder was a descending 2.9 m (9.5 ft) wide gravel covered shoulder. A wide uneven dirt-covered median separated the northbound and southbound lanes. The median was approximately 1.8 m (6 ft) lower in elevation than the roadway surface. The weather was clear with scattered clouds. The temperature was 41 degrees C (106 degrees F) at the nearest reporting station, and the winds were blowing 14.4 km/h (9 mph) from the northeast. The crash occurred at 1625 hours. The speed limit at this location was 121 km/h (75 mph).

Pre Crash

The 2001 PrevoSt was traveling southbound in the right travel lane at an unknown speed. The bus was towing a 2008 GMC Yukon sport utility vehicle. The GMC was connected to the bus by a tow bar and safety chains. Both occupants of the bus were unrestrained. The driver and his wife were traveling with another couple who were in a second recreational vehicle. The group left Wyoming at approximately 0603 hours and traveled 307 km (191 miles) before stopping for fuel. After taking a short break, they continued the trip south and did not stop again until crossing the Utah/Nevada border where they pulled off the road for a second break. The distance traveled from the fuel stop to the area of the crash was 769 km (478 miles). The total mileage traveled that day was approximately 1076 km (669 miles). Prior to the crash, the other recreational vehicle was traveling 0.8 km (0.5 miles) in front of the subject vehicle.

Crash

The left front tire sustained a complete tread separation due to unknown reasons (**Figure 3**). The damaged tire was located on a steer axle and caused the driver to lose control of the vehicle. The PrevoSt initiated a left trajectory, crossed the adjacent travel lane and departed the roadway on the left roadway edge (**Figure 4**). The police identified a point where both front tires began marking, and then identified an area in the inboard lane where the left front tire began depositing flat tire scuffs. It appears that the driver may have braked initially, and then taken his foot off the brake. Based on the tire marks, the bus traveled 69 m (225 ft) before departing the roadway and entering the median. At a point just beyond where the bus left the roadway, the police located a portion of the left front tire tread. As the PrevoSt continued southbound in the median, the vehicle generated a set of tire furrows in the soil. Along the path of the vehicle were three distinct undulating dirt embankments that were perpendicular to the path of the vehicle. The PrevoSt traveled off road for 105 m (345 ft) before impacting the first embankment (Event 1) and then traveled 4 m (13 ft) before impacting the second (Event 2). During the embankment impacts, the



Figure 2. Southbound roadway



Figure 3. Tread separation marking (police photo)



Figure 4. Left side roadway departure (police photo)

front right tire became restricted. When this tire became restricted, the tread was cut and peeled away from the casing by the wheel well's metal structure. After impacting the third embankment (Event 3), the occupant was ejected through the front windshield area. It is not known if the windshield had been damaged or dislodged prior to the ejection. Portions of the windshield were located just south of the second embankment. The occupant was ejected forward and to the front of the bus and was subsequently run over.



Figure 5. Area of impact with last embankment and final rest (police photo)

At some point during the crash sequence, the tow bar connecting the two vehicles was fractured and displaced. The vehicles were still connected by the safety chains. As the bus came to rest, the GMC continued forward and struck the rear of the bus, causing damage to both vehicles.

Post Crash

The Prevost came to rest facing south 192 m (630 ft) from the roadway departure point with the GMC still in-tow. The right front passenger came to rest underneath the front axle of the vehicle.

The driver sustained musculoskeletal strains to his left shoulder and lower back. He was removed from the vehicle by emergency personnel and transported to a local trauma center where he arrived with a Glasgow Coma Score (GCS) of 15. CAT scans were negative for any fractures or acute injuries and he was subsequently treated and released.

The ejected occupant sustained fatal injuries. The autopsy report stated that the body was “severely fragmented with the head and part of the torso separate, the right forearm, wrist and hand separate, the right lower extremity and part of the pelvis separate, the left foot and ankle area, spine, ribs, and viscera co-mingled with the parts unidentifiable”. The cause of death was due to multiple blunt force trauma with severe fragmentation of the body. She was pronounced dead at the scene at 1950 hours.

Vehicle Data - 2001 Prevost Marathon Tour Bus

The 2001 Prevost Marathon Tour Bus Class A Recreational Vehicle was identified by the Vehicle Identification Number (VIN): 2PCW3349811xxxxxx. The bus was 13.7 m (45 ft) in length. The Prevost's date of manufacture was October 2000; the Marathon's date of manufacture was June 2001. The mileage was not known due an absence of power. The bus was equipped with a Detroit Diesel Series 60 12.7-liter 6-cylinder engine, a diesel fuel tank with 787 liter (208 gal) capacity, and an automatic transmission, and was configured as a recreational vehicle. The vehicle was configured on the left side with three storage compartments and a compartment used to house water tank controls; it was configured on the right side with compartments that housed pump controls, a generator, and storage areas. The auxiliary generator was located aft of the front axle. The gray and black water tank levels were not known. The interior of vehicle was equipped with sinks, a stove,

a microwave oven, a refrigerator, a dishwasher, a shower, a bathroom, cabinetry, and a full bed.

The bus had a Gross Vehicle Weight Rating (GVWR) rating of 23,225 kg (51,200 lbs). The GVWR by axle is shown below:

- Front: 7800 kg (17,200 lbs)
- Drive: 9725 kg (21,400 lbs)
- Tag: 5725 kg (12,600 lbs)

The vehicle manufacturer's recommended tire pressure by axle was is shown below:

- Front 861 kPa (125 psi)
- Drive 620 kPa (90 psi)
- Tag 620 kPa (90 psi).

All eight tires on the bus were Michelin X radial regroovable 315/80 R22.5 Pilote XZA1 tires with a maximum load rating of 4123 kg (9090 lbs) at 896 kPa (130 psi) cold. The treads had 4 steel plies and the side wall had 1 steel ply.

According to the interviewee, the tires were replaced when the vehicle was purchased in 2004.

The specific tire information was as follows:

Left Front Tire

Tire Identification Number (TIN): HAD7 BENX 4203

Tread depth: 13 mm (17/32 in)

Measured pressure: 0 psi

Rim type: Aluminum, 10 lugs, 57.1 x 22.8 cm (22.5 x 9 in)

Rim damage: The rim was gouged and scratched on the perimeter.

Valve stem: The valve stem was recessed in a port in the rim and exhibited no evidence of damage.

Tire damage: The tread separated from the carcass (**Figure 6**). Four sections of tread were recovered. The largest section of separated tread measured 145 cm (57.0 in) in length by 19 cm (7.4 in) in width. This section was rubber tread with belts still partially attached. The belts were frayed at the ends. The section consisted of three center ribs and was separated from the tire lengthwise along the grooves. The ribs measured 4 cm (1.6 in) in width and the grooves measured 1 cm (0.4 in) in width. There were small holes observed in the tread grooves which measured 5 mm (0.2 in) in diameter and were located at 30 mm (1.2 in) intervals lengthwise along the tread. The next largest section



Figure 6. Left front tire

was 97 cm (38.1 in) in length by 5 cm (2.0 in) in width. This section consisted of a single rib which separated evenly along the grooves, and had no ply material attached. The next largest section was 43 cm (16.9 in) in length by 11 cm (4.3 in) in width. This section consisted of two ribs across its width, which separated evenly along the grooves, and had no ply material attached. The last section of tread was 42 cm (16.5 in) in length by 13 cm (5.1 in) in width. This section consisted of one rib from the tire shoulder and had a section of sidewall attached. There was no foreign debris present in the separated tread or carcass. There were no indications of punctures or cuts.

The tire carcass was deboned. The belts were partially detached and frayed and the sidewalls were cracked and deformed. The carcass was damaged and attempts to identify evidence of punctures was unsuccessful. The air valve was recessed in a port in the rim and was undamaged.

Middle Left Outboard Tire

TIN: HED7 BENX 2102

Tread depth: 10 mm (12/32 in)

Measured pressure: 620 kPa (90 psi)

Rim type: Aluminum, recessed, 10 lugs, 57.1 x 22.8 cm (22.5 x 9 in)

Rim damage: None

Tire damage: None

Valve stem: The valve stem was constructed of metal and designed with a bend in the shaft. The stem pointed toward the inboard aspect of the rim. There was no evidence of damage.

Middle Left Inboard Tire

TIN: HAD7 BENX 4203

Tread depth: 9 mm (11/32 in)

Measured pressure: 662 kPa (96 psi)

Rim type: Aluminum, 10 lugs, 57.1 x 20.9 cm (22.5 x 8.25 in)

Rim damage: None

Tire damage: None

Valve stem: The valve stem protruded through a port in the outboard rim, was contained in a rubber grommet and exhibited no evidence of damage

Left Rear Tire

TIN: HED7 BENX 2102

Tread depth: 12 mm (15/32 in)

Measured pressure: 620 kPa (90 psi)

Rim type: Aluminum, 10 lugs, 57.1 x 22.8 cm (22.5 x 9 in)

Rim damage: None

Tire damage: None

Valve stem: The valve stem was recessed in a port in the rim and exhibited no evidence of damage.

Right Rear Tire

TIN: HED7 BENX 1802

Tread depth: 10 mm (13/32 in)

Measured pressure: 607 kPa (88 psi)

Rim type: Aluminum, 10 lugs, 57.1 x 22.8 cm (22.5 x 9 in)

Rim damage: None

Tire damage: None

Valve stem: The valve stem was recessed in a port in the rim and exhibited no evidence of damage.

Middle Right Outboard Tire

TIN: HED7 BENX 1802

Tread depth: 10 mm (13/32 in)

Measured pressure: 641 kPa (93 psi)

Rim type: Aluminum, recessed, 10 lugs, 57.1 x 22.8 cm (22.5 x 9 in)

Rim damage: None

Tire damage: None

Valve stem: The valve stem was constructed of metal and designed with a bend in the shaft. The stem pointed toward the inboard aspect of the rim. There was no evidence of damage.

Middle Right Inboard Tire

TIN: HAD7 BENX 0603

Tread depth: 9 mm (11/32 in)

Measured pressure: 662 kPa (96 psi)

Rim type: Aluminum, 10 lugs, 57.1 x 20.9 cm (22.5 x 8.25 in)

Rim damage: None

Tire damage: None

Valve stem: The valve stem protruded through a port in the outboard rim, was contained in a rubber grommet and exhibited no evidence of damage

Right Front Tire

TIN: HED7 BENX 2102

Tread depth: 10 mm (12/32 in)

Measured pressure: 0 psi

Rim type: Aluminum, 10 lugs, 60 x 26 cm (23.6 x 10.2 in)

Rim damage: The rim was gouged and scratched on the perimeter.

Valve stem: The valve stem was recessed in a port in the rim and exhibited no evidence of damage.

Tire damage: The tire sustained partial tread separation in two areas (**Figure 7**). The longer section of separated tread measured 210 cm (82.7 in) in length and measured 30 cm (11.8 in) from shoulder to shoulder. The tread section remained attached at one end and acted as a flap. The width of this section consisted of the entire ribbed section and the shoulders, and was separated at the inner and

outer sidewalls. The shorter section of separated tread measured 32 cm (12.6 in) in length and also was attached at one end as a flap. The separated tread consisted of rubber tread as well as belts. There was damage to the bead and the sidewalls. The tread exhibited some gouges; however, there were no punctures or debris in the tire. There was a section of intact tread which was located between the two flaps that measured 87 cm (34.2 in) in length. The tire casing sustained cuts or tears which ran laterally across the width. There were tears in the sidewalls which began at the shoulder and ran radially toward the bead. Inspection of the subject vehicle revealed that the source of damage to this tire was probably due to longitudinal crush to the wheel well which resulted in tire restriction (**Figure 8**). The tire had been cut through laterally so that it could be removed from the rim at the crash scene.

Vehicle Damage

Exterior Damage - 2001 Prevost Marathon Tour Bus Class A Recreational Vehicle

The vehicle sustained moderate frontal and undercarriage damage due to impacts with embankments and ground (**Figure 9**). The direct damage began at the front right bumper corner and measured 263 cm (103.5 in) to the left. Six crush measurements were documented at the bumper level as follows: C1 = 20 cm (7.8 in), C2 = 22 cm (8.7 in), C3 = 23 cm (9.0 in), C4 = 26 cm (10.2 in), C5 = 45 cm (17.7 in), C6 = 42 cm (16.5 in). There was longitudinal crush to the structural cross members between the frame rails. The frame rails were 145 cm (57 in) apart. The maximum crush measured 99 cm (38.9 in) at the center point between the frame rails.

The left side panel below the driver's position was deformed rearward 28 cm (11.0 in). There was 9 cm (3.5 in) of vertical crush to the left side rail below the first compartment panel (**Figure 10**). There was 7 cm (2.8 in) of vertical crush to the left side rail below the fourth compartment panel, as well as vertical crush to the wood flooring within the compartment (**Figure 11**). On the back end of the vehicle, there was a slight deformation due to intra-unit contact with the towed GMC. Also, the trailer hitch was deformed and the tail pipe



Figure 7. Right front tire



Figure 8. Right front wheel/wheel well



Figure 9. Front bumper damage

bent. On the right side, the lower B-pillar/forward wheel well was deformed rearward .



Figure 10. Left side rail/floor vertical crush



Figure 11. Damage to area below storage compartment

Interior Damage - 2001 Prevost Marathon Tour Bus Class A Recreational Vehicle

The interior of the Prevost sustained moderate damage due to intrusion, occupant loading, and movement of non-fixed objects within the vehicle. There was vertical and longitudinal intrusion to the floor on the right side of the vehicle and longitudinal intrusion to the left toe pan. The specific passenger compartment intrusions were documented as follows:

Position	Intruded Component	Magnitude of Intrusion	Direction
Left front	Toe pan	8 cm (3.1 in)	Longitudinal
Right front	Floor	15 cm (5.9 in)	Longitudinal
Right front	Floor	18 cm (7.0 in)	Vertical

The steering column was cracked on the right side due to occupant loading . The right front door had been pried open. The lower step at the door entrance was deformed rearward and the marble steps were fractured. The glass above the right door was missing from the vehicle. The outer glass above the driver's side window had disintegrated.

The windshield was configured in two sections and both sections of glazing were displaced during the crash (**Figures 12-13**). Glass from the windshield was located at the scene in the traveled path of bus. The glass had been displaced and then run over by the bus. The glazing probably was dislodged while the vehicle was traveling across the median and then fully displaced upon impact with the second embankment. Since both sides were displaced, it was not clear if occupant loading was related to the windshield displacements.



Figure 12. Front view of windshield



Figure 13. Exemplar view of windshield

The Prevost bus interior sustained moderate damage to the forward and aft sections due to the off-road travel and the impacts with the dirt embankments (**Figures 14-15**). Numerous loose objects were strewn throughout the vehicle. Prior to the vehicle inspection, relatives of the driver had gone through the vehicle to remove personal and high value items.



Figure 14. Overview of forward area (living room/kitchen)



Figure 15. Overview of aft section (bedroom)

Manual Restraints - 2001 Prevost Marathon Tour Bus

The driver and right front passenger seats were equipped with lap belts. Neither restraint was used in the crash. There were no indications of loading to the latch plates or any stretch markings to the belt webbing.

OCCUPANT DEMOGRAPHICS - 2001 Prevost Marathon Tour Bus

	Driver	Front Row Right Occupant
Age/Sex:	67/Male	63/Female
Seated Position:	Front left	Front right
Seat Type:	Bucket seat	Bucket seat with foot rest
Height:	Unknown	Unknown
Weight:	Unknown	Unknown
Alcohol/Drug Involvement:	None	None
Body Posture:	Upright	Unknown
Hand Position:	Both hands on steering wheel, actively steering	Unknown
Foot Position:	Right foot on brake	Unknown
Restraint Usage:	Lap belt not used	Lap belt not used

Occupant Kinematics

Driver Kinematics

The 67-year-old driver of the Prevost was sitting upright in the leather bucket seat and was not using the manual lap belt (**Figure 16**). As the left front tire tread separated, the driver began braking and then appeared to take his foot off the brake. The driver probably pitched forward slightly as he braked. The bus veered to the left and departed the roadway. As the vehicle departed the roadway, there was a change in elevation and the driver likely was displaced in an upward direction. As the vehicle struck the first embankment, the driver was displaced in a forward direction. The driver moved in a similar fashion as the vehicle struck the third embankment, and probably deformed the steering column at this point. According to the interviewee, the driver remained in his seated position after the crash. The driver sustained musculoskeletal strains to his left shoulder and lower back that were probably a result of impact forces. He was removed from the vehicle by emergency personnel and transported to a local trauma center he was treated and released.



Figure 16. Overview of driver's seat position

Front Right Occupant Kinematics

The unrestrained 63-year-old female front right occupant was probably either sitting in the front right seat or was in the proximity of the front right seat as the vehicle left the roadway (**Figure 17**). She was probably displaced forward to some degree as the driver initially braked. As the vehicle left the roadway, there was a change of elevation and this occupant was probably displaced in an upward direction. During the impact with the first embankment, she may have come into contact with the right instrument panel or the base of the windshield. As the vehicle struck the third embankment, both the windshield and this occupant were displaced forward and were ejected into the path of the bus. As the bus ran over this occupant, her body became entrapped just forward of the front axle. The body stayed in this location and traveled with the bus until the bus came to rest. She sustained fatal injuries and was pronounced deceased at the scene.



Figure 17. Area of front right windshield ejection

Occupant Injuries

Driver: Injuries obtained from discharge summary.

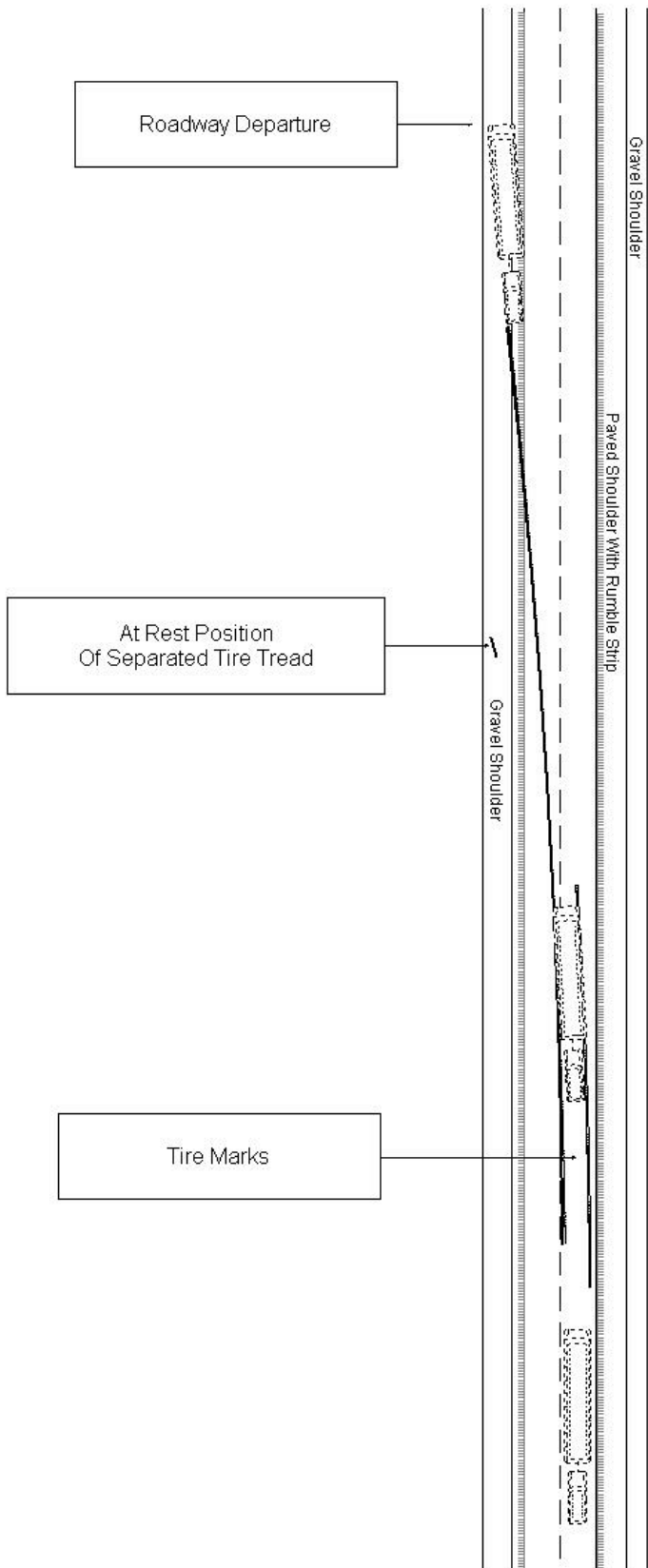
<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Strain, left shoulder	751020.1,2	Impact forces	Probable
Strain, lower back	640678.1,8	Impact forces	Probable

Front Row Right Occupant: Injuries obtained from autopsy report

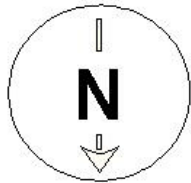
<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Fragmented with the head and part of the torso separate. Coded as decapitation.	311000.6,0	Vehicle undercarriage	Certain
Crush type injury to spine, ribs, and viscera.	413000.6,0	Vehicle undercarriage	Certain
Right forearm, wrist, and hand separate. Coded as traumatic amputation.	711000.3,1	Vehicle undercarriage	Certain

Right lower extremity and part of the pelvis separate. Coded as traumatic amputation.	811000.3,1	Vehicle undercarriage	Certain
Crush type injuries to left foot and ankle	8130002.2	Vehicle undercarriage	Certain

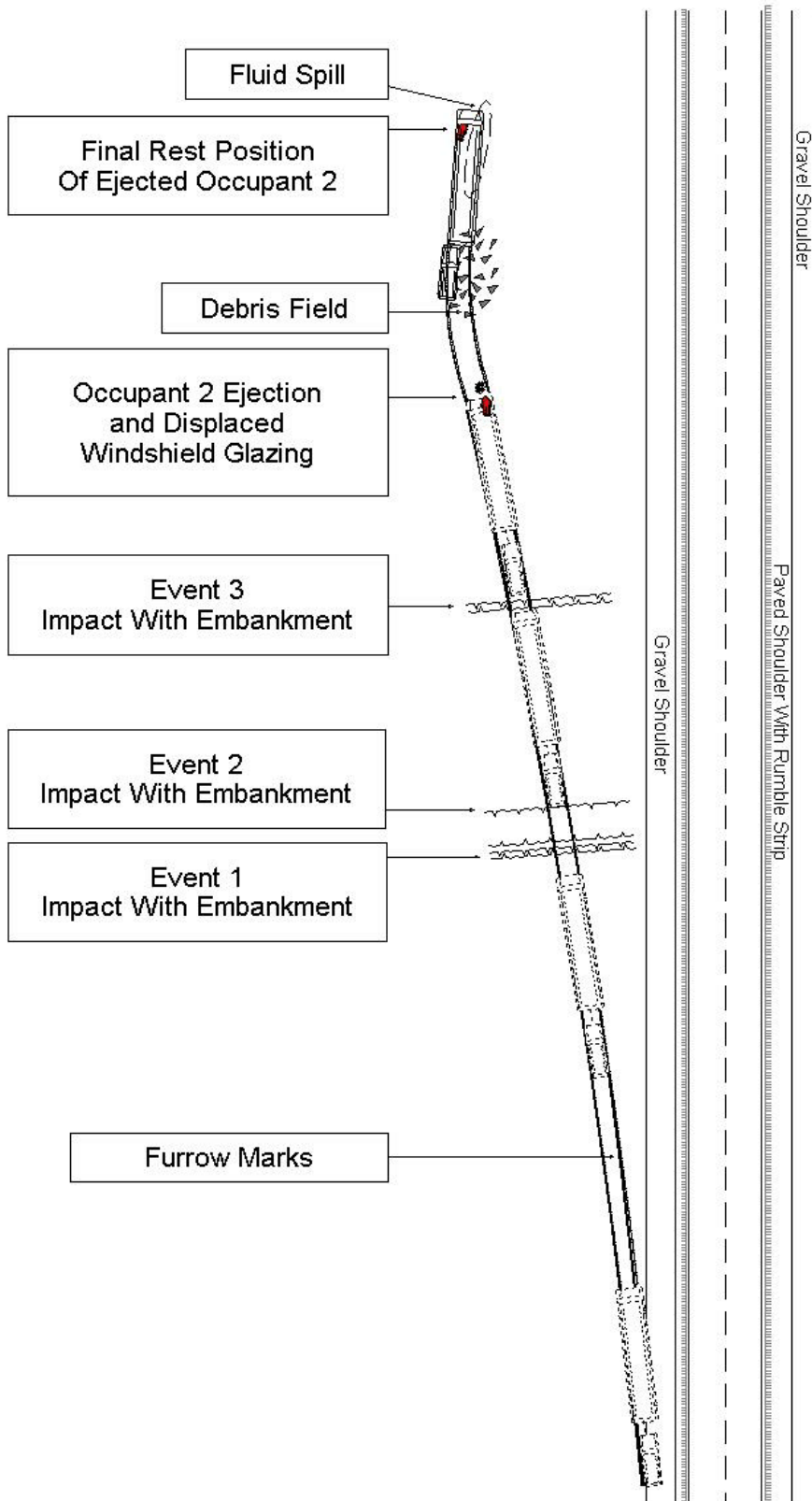
Scene Diagram



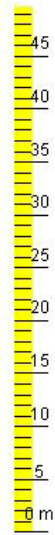
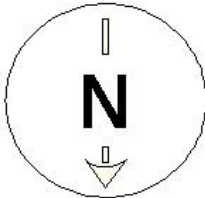
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