

CRASH DATA RESEARCH CENTER

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**CALSPAN ON-SITE MOTORCOACH ROLLOVER CRASH INVESTIGATION
SCI CASE NO.: CA10020**

VEHICLE: 1997 MCI MODEL 102-DL3 MOTORCOACH

LOCATION: NEW JERSEY

CRASH DATE: JUNE 2010

Contract No. DTNH22-07-C-00043

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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 are 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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<i>16. Abstract</i> <p>This on-site investigation focused on the rollover of a 1997 MCI Model 102-DL3 motorcoach. The motorcoach was occupied by a 35-year-old male driver and 20 passengers. It was traveling southbound at highway speeds on an interstate when it departed the right side of the roadway onto the grass roadside. The vehicle initiated a counterclockwise (CCW) yaw on the grassy slope, impacted three small-diameter trees, and tripped into a one-quarter turn rollover onto its right side. As a result of the crash, six passengers were transported by ground ambulance to local area hospitals for treatment of their injuries.</p> <p>Notification of this crash was provided to the Calspan Special Crash Investigations (SCI) team on June 2, 2010 by the Crash Investigations Division (CID) of the National Highway Traffic Safety Administration (NHTSA). Telephone contact was initiated by the SCI team to the investigating law enforcement agency, and cooperation was gained to conduct an on-site inspection of the motorcoach on June 3, 2010. The motorcoach had been towed from the scene and was on-hold in police impound. The on-site investigation involved the inspection and documentation of the motorcoach, with primary emphasis focused on the lateral and vertical intrusion of the side structures and roof, and the status of the side glazing. The crash site was also documented and the investigating officer was interviewed.</p>			
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BACKGROUND

This on-site investigation focused on the rollover of a 1997 MCI Model 102-DL3 motorcoach (**Figure 1**). The motorcoach was occupied by a 35-year-old male driver and 20 adolescent to adult age passengers. It was traveling southbound at highway speeds on an interstate when it departed the right side of the roadway onto the grass roadside. The vehicle initiated a counterclockwise (CCW) yaw on the grassy slope, impacted three small-diameter trees, and tripped into a one-quarter turn rollover onto its right side. As a result of the crash, six passengers were transported by ground ambulance to local area hospitals for treatment of their injuries.



Figure 1: Left front oblique view of the involved motorcoach.

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SUMMARY

Crash Site

The motorcoach crash occurred on a divided interstate highway with a posted speed limit of 105 km/h (65 mph). The interstate consisted of three lanes in both directions, divided by a depressed grass median. Paved shoulders bordered the travel lanes with rumbles strips cut into the shoulders adjacent to the edge lines. In the area of the crash, the southbound travel lanes curved to the left and were level. To the west of the roadway, outboard of the shoulder, was a grass swale area with negative 9.8 percent grade that transitioned into a ditch bordered by a line of deciduous trees. The daytime weather conditions were clear with a temperature of 30 Celsius (86 Fahrenheit) degrees, 37 percent relative humidity, and west-southwest wind of 10 km/h (6 mph). **Figure 2** depicts the southbound trajectory view of the motorcoach. The crash schematic is attached as **Figure 18**.



Figure 2: Southbound trajectory view of the motorcoach.

Vehicle Data - 1997 MCI Model 102-DL3

The 1997 MCI Model 102-DL3 motorcoach was manufactured by Motor Coach Industries, Inc. in March 1997. This motorcoach had a 55-passenger capacity, exclusive of the driver. Depicted in **Figure 3**, the motorcoach was identified by the Vehicle Identification Number (VIN): 1M8PDMTA7VP (production sequence deleted). The instrument panel-mounted odometer reading was 365,858.4 km (227,333.9 mi). A Veeder-Root Series 7777 Hubodometer manufactured by Danaher was installed on the right drive axle and displayed a reading of 353,445.6 km (219,620.9 mi) at the time of SCI inspection.



Figure 3: Left rear oblique view of the involved motorcoach.

The motorcoach was powered by a Detroit Diesel Series 60 rear-mounted engine with a displacement of 12.7 liters, linked to an Allison B-500R automatic transmission. The service brakes were air-activated drum with DD3 brake chambers on the drive axle. Engine cooling was achieved by a rear-mounted radiator positioned above the engine compartment. The exhaust system consisted of a single muffler and tailpipe located on the left rear undercarriage. The front of the vehicle was equipped with a compressed air-driven kneeling front suspension, enabling the front suspension of the motorcoach to lower to facilitate boarding through the right front door.

The motorcoach was purchased used by the motorcoach company and was placed in service in January 2008. Recent service records provided by the motorcoach company indicated that the motorcoach received routine service and repairs to its rear brakes on March 11, 2010, an issue identified during a semi-annual state inspection. The specific repair was not identified.

Fuel System

The motorcoach was equipped with a single fuel tank mounted within the undercarriage of the vehicle. The filler tube was located on the right side of the motorcoach, near the midpoint of the wheelbase. At the time of SCI inspection, the filler cap was in place and intact. A placard declared that although the tank had a rated capacity of 727 L (192 US gallons), per Section 393.67 of the Federal Motor Carrier Safety Administration (FMCSA) regulations, the tank may not contain more than 689 L (182 US gallons). The level of Low-Sulfur Diesel fuel in the tank at time of SCI inspection was unknown.

Axles /Tires / Wheels

The motorcoach had three axles, including a front steer axle, dual-wheel drive axle, and a rear tag axle. The manufacturer’s placard declared a Gross Vehicle Weight Rating (GVWR) of 20,410 kg (44,400 lb), distributed 6,532 kg (14,400 lb) front, 10,206 kg (22,500 lb) intermediate, and 5,443 kg (12,000 lb) rear. The manufacturer recommended 12.75-22.5 H tires at all axle positions, with corresponding cold pressures of 793 kPa (115 PSI) in front and 655 kPa (95 PSI) in the rear. The motorcoach was equipped with 315/80R22.5 size tires mounted on OEM-style 8.25x22.50 steel wheels at all three axle positions. Specific data of the tires at the time of SCI inspection was as follows:

Position	Make / Model	TIN	Pressure	Tread Depth	Damage
LF	Firestone FS400	Unknown	Unable to access valve	9 mm (11/32 in)	None
RF	Firestone FS400	Unknown	840 kPa (122 PSI)	9 mm (11/32 in)	None
L Drive Inner	UNABLE TO ACCESS				
L Drive Outer	Continental HSL	Unknown	Unable to access valve	11 mm (14/32 in)	None
R Drive Inner	UNABLE TO ACCESS				
R Drive Outer	Continental HSL	A372 1WB 1707	Unable to access valve	9 mm (11/32 in)	None
L Tag	Goodyear Intercity Cruiser	MC72 TRMW 0308	800 kPa (116 PSI)	6 mm (7/32 in)	None
R Tag	Goodyear G409 MBA	MJ72 MBAW 4603	Unable to access valve	9 mm (11/32 in)	None

Exterior

The motorcoach was a monocoque body/frame design. The front, side, and rear body panels were of fiberglass composite, with trim and fascia consisting of plastic, aluminum, and rubber components. The frame that encompassed the passenger compartment was constructed of square stock with gusset plate reinforcement, while the frame of the roof was constructed of similar square stock aligned in a grid pattern with aluminum panels riveted to the exterior.

The side body panels incorporated three wide underbody luggage compartments within the wheelbase. There were also several equipment and mechanical maintenance access doors positioned on both sides of the motorcoach, providing access to the vehicle's batteries and electrical systems, engine compartment, engine cooling system, fuel filler receptacle, fluid reservoirs, and the Heating, Ventilation, and Air Conditioning (HVAC) system. The overall width of the motorcoach was 244 cm (96 in) at the A-pillars and flared to 259 cm (102 in) at the B-pillars, maintaining this width to the back of the vehicle.

Interior

The interior of the motorcoach was configured for a driver and 55 passengers. The driver's seat and the forward controls were conventionally mounted to the left side of the unit, left of the center aisle, directly opposite of the loading door and entrance staircase. The driver's fully adjustable seat was equipped with a manual lap belt restraint. Typical vehicle controls and gauges were mounted within the vinyl and polymer instrument panel, as depicted in **Figure 4**. The brake air pressure gauge measured 690 kPa (100 PSI) at the time of the SCI inspection. Based on the gauge reading, there were no air leaks in the system.



Figure 4: Driver's location and instrument panel/controls of the motorcoach.

Passenger seating consisted of 14 rows of seats. The forward 13 rows consisted of four seats each, laterally offset in groups of two on each side of the center aisle as seen in **Figure 5**. The rear row consisted of a three-passenger bench seat with separate cushions and seatbacks.

All seats were of tubular steel construction with foam padding, and covered with a synthetic blend fabric. Each seat was also equipped with a reclining seatback, adjustable head restraint, and a metal footrest. Armrests were mounted to the outboard aspects of the seatbacks. Adjacent to the rear row was a typical small lavatory, constructed of plywood walls incorporated into the right rear corner of the motorcoach. These walls, as well as the ceiling structure and all other similar areas of the motorcoach, were covered in a synthetic carpet material similar to the fabric covering the seats.



Figure 5: Interior of the motorcoach looking rearward.

Aircraft-style overhead storage compartments extended the length of the ceiling area on both sides of the motorcoach. These compartments were configured with top-hinged rigid plastic doors, and were designed to facilitate the storage of carry-on luggage and personal belongings. On the underside of these compartments and directly above the passenger seats were courtesy reading spotlights, accompanied by several staggered video screens used for passenger entertainment.

Driver Data

The driver of the motorcoach was a 35-year old male. His height was 180 cm (71 in) with a weight of 88 kg (195 lb). He held a valid Commercial Driver's License (CDL) with passenger endorsement and a corrective lenses restriction. The police reported that the driver had no prior history on his driving record. The driver's medical certification was current and was issued on 10/26/2009. The motorcoach driver was hired as a part-time driver in July 2005 and served as a mechanic for the motorcoach company. His previous employment was as a motorcoach driver for another company.

Crash Sequence

Pre-Crash

The motorcoach and the 35-year-old male driver were hired to transport the 20 passengers to a family function from a city in New Jersey to a city in New York, a distance of approximately 105 km (65 mi) each way. The function required an evening departure to the destination with a scheduled early morning return trip. The driver stated to the investigating officer that he did not work during the day, prior to the departure for this trip. The driver did state that he drove a daytrip two days prior to this departure. He further stated that he dislikes nighttime driving.

The driver reported to the motorcoach company in the late afternoon hours on the day of the departure. He drove the motorcoach to the predetermined departure point and loaded the 20

passengers and their belongings for the family function. The motorcoach arrived at its destination in the evening hours and the driver off-loaded the passengers. He was to stay in the area of the function for the return trip that was scheduled for nine hours after the drop-off time. The driver drove the motorcoach several blocks from the function location and parked the vehicle at curbside. It is unknown if he left the motorcoach running during this time period. He stated that he slept in the motorcoach and awoke in the early morning hours for the return trip. He drove to the function location and boarded the 20 passengers for the return trip.

As he exited the city area at approximately 0430 hours, the driver entered the interstate and traveled in a southerly direction during the nighttime conditions. He traveled a distance of approximately 48-56 km (30-35 mi) from the function location, which involved a travel time of approximately one hour. On the approach to the impending crash site, the driver was traveling in the outboard lane of the interstate highway at an estimated speed of 105 km/h (65 mph). As the driver was attempting to negotiate the left curve, the motorcoach drifted to the right and departed the travel onto the west shoulder. The right side tires overrode the rumble strip. The motorcoach continued on a straight line trajectory as it traversed the asphalt shoulder. The driver responded to the road departure by steering left and applying the brakes in an attempt to regain control of the motorcoach and maneuver to the outboard travel lane. The driver later reported to the investigating officer that he was fatigued at the time of the crash.

The left side tires began to mark on the asphalt road surface approximately 50 m (164 ft) south of the initial point of departure from the travel lane (**Figure 6**). The vehicle traveled another 25 m (82 ft) prior to exiting the outboard edge of the shoulder onto the grass roadside. The combination of the steering input, brake application, and negative slope of the roadside induced a counterclockwise (CCW) yaw to the motorcoach approximately 37 m (121 ft) from the point of departure from the shoulder. The vehicle's trajectory and travel distance was evidenced by deep tire marks in the soft grass surface. The motorcoach's center of gravity (CG) continued in a southerly direction as it yawed approximately 30 degrees CCW over a distance of 54 m (177 ft) to impact with the small diameter trees. **Figure 7** is an off-road view of the motorcoach's trajectory across the roadside.



Figure 6: Departure of the motorcoach onto the west shoulder.



Figure 7: Trajectory and CCW yaw of the motorcoach across the roadside slope.

Crash

The right rear area of the motorcoach impacted, fractured, and uprooted the three trees (**Figure 8**) that were located at the bottom of the slope over a longitudinal distance of (5.5 m (18 ft)). The tree impacts did not alter the trajectory of the motorcoach as it continued to yaw approximately 10 degrees CCW. The right side tires furrowed deep into the soft dirt of the roadside which tripped the vehicle into a right side leading rollover event. The motorcoach yawed approximately 40 degrees CCW and traveled 171.5 m (563 ft) from the point of lane departure to the trip point. The motorcoach overturned into tall cattails and vegetation, which resulted in a soft rollover event (**Figure 9**). The vehicle completed one-quarter turn onto its right side and slid approximately 8 m (26 ft) to final rest.



Figure 8: Motorcoach crash site.



Figure 9: Rollover and final rest position of the motorcoach.

Post-Crash

Local police, fire, and emergency medical services (EMS) personnel responded to the location of the crash on the limited access interstate. Most of the occupants of the motorcoach were able to exit through the two emergency roof exits. The firefighters placed ladders against the left side and assisted the remaining occupants from the vehicle through the left side emergency window exits. The side emergency exits were also used by the firefighters to gain access to the interior to conduct a search for additional occupants. The EMS personnel provided treatment at the scene and transported six of the 20 passengers to local hospitals for the treatment of minor severity injuries. The motorcoach was up-righted by two tow trucks and removed from scene by the local recovery service to their lot. The vehicle was impounded by the investigating officer for a safety inspection and retained for this SCI inspection.

Vehicle Damage

Exterior

The exterior of the motorcoach sustained damage to its right, front, and back planes as a result of the side impacts and subsequent rollover. Minor severity damage was located on the right side (**Figure 10**) from the initial small diameter tree impacts. The damage consisted of isolated minor crush and inward buckling of the lower body-panel fascia, sill, and rear-axle area polymer fender flare. The tree impact damage was overlapped by the subsequent rollover; however, based on scene evidence and vehicle damage patterns, the three tree impacts were located as follows: (Event 1) immediately aft of the rear tag axle area with corresponding damage to the sill; (Event 2) immediately forward of the right drive axle with corresponding sill and lower body-paneling damage; (Event 3) within the right rear axle area with corresponding polymer fender flare damage above the tag axle location. The rollover damage was distributed across the entire right side of the motorcoach, with induced damage to the front and back planes.



Figure 10: View of right side plane rollover damage.



Figure 11: Right rear oblique view of the motorcoach.

Front

The frontal damage was limited to the windshield glazing and the separation of the upper body panel between the top of the windshield glazing and the roofline. This damage was attributed to lateral displacement of the right A-pillar. The top of the right A-pillar was displaced 3 cm (1.25 in) laterally left. The pillar at the beltline elevation was displaced 0.6 cm (0.25 in). The right outside mirrors were mounted on a stalk that was attached to the right A-pillar. The mirrors and stalk were displaced laterally left, forward of the windshield, pivoting on the adjustment point.

The windshields were gasket-mounted to the frame. The right windshield glazing was cracked vertically along the full-height of the A-pillar. The right glazing panel was separated from the gasket at the full-width across the top, approximately 80 percent along the center divider, 40 percent of the inboard bottom aspect, and approximately 10 percent along the upper right A-

pillar area. The left windshield was cracked diagonally from the lower left corner to the upper right area with separation from the gasket at the left A-pillar, top and center post. The body panel located above the windshields was completely separated from the vehicle.

Left Side

There was no damage to the left side of the motorcoach. Post-crash, six of the eight side glazing push-out emergency exits were opened. The left side glazing was not damaged.

Back

Damage to the back plane was limited to the separation of the bumper fascia at the right corner and lateral buckling of the fiberglass paneling at the upper right corner, near the roofline, as seen in **Figure 8**. The engine compartment doors and the access door to the top-mounted radiators and air conditioning condenser remained closed and operational post-crash.

Right Side

The right side body damage consisted of isolated dents with mud and grass embedded into the body panels and glazing frames (**Figure 11**). The forward-hinged right front door remained closed, intact and operational, although the laminated upper glazing was fractured and partially separated from its gasket mount. The right A-pillar was displaced laterally 3 cm (1.25 in) at the juncture with the side rail. The luggage compartment doors and the doors to the mechanical compartments remained closed and operational post-crash. The side glazing panels at pillars B through I remained closed and intact, and were not fractured. The eighth glazing panel was fractured by a tree impact or recovery efforts. The integrity of the right side structure remained as there was no separation or displacement of the body panels. The lateral crush to the right roof side rail area between the right H and I pillar locations was due to tree and recovery efforts. The lateral crush was approximately 7 cm (3 in) based on interior intrusion dimensions.

Roof

The roof of the motorcoach was constructed of aluminum body panels riveted to the lateral and vertical members of the roof structure. **Figure 12** is a view of the roof looking aft from the rear roof exit area. The roof panels remained intact with no separation or crash related damage. The roof at the back of the motorcoach was compressed laterally on each side from tow straps used during the recovery efforts of the vehicle. The tow straps were attached to the right sill area and extended over the roof of the motorcoach. A diagonally oriented crease from a tow strap began at the midline of the roof aft of the rear



Figure 12: Roof damage from towing activities.

roof exit at the H-pillar area, and extended to the back right corner. The second tow strap was attached to the same sill location and routed laterally across the roof resulting in damage to both roof side rail areas. The right rear roof area was crushed laterally and the composite body panel was fractured.

Interior

The interior damage to the motorcoach was limited to the lateral intrusions of the right side components. The following table provides a listing of the lateral intrusions at the specific pillar location and the vertical position of the intrusion as documented during the SCI inspection. **Figures 13 and 14** are longitudinal views of the lateral intrusions on the right side interior.

Interior Intrusion			
Pillar/ Position	Vertical Position of the Intruded Pillar/ Component	Intrusion Extent	Direction
A	Roofline	2.5 cm (1 in)	Lateral
A	Beltline	1 cm (0.5 in)	Lateral
B	Roofline	0 cm (0 in)	Lateral
C	Below overhead storage compartments	1 cm (0.5 in)	Lateral
C	Beltline	4 cm (1.5 in)	Lateral
D	Below overhead storage compartments	1 cm (0.5 in)	Lateral
D	Beltline	5 cm (2 in)	Lateral
D	Floor	2.5 cm (1 in)	Lateral
E	Below overhead storage compartments	0 cm (0 in)	Lateral
E	Beltline	1 cm (0.5 in)	Lateral
F	Below overhead storage compartments	0 cm (0 in)	Lateral
G	Below overhead storage compartments	2 cm (0.75 in)	Lateral
H	Below overhead storage compartments	4 cm (1.5 in)	Lateral
I	Below overhead storage compartments	7.5 cm (3 in)	Lateral

The interior remained intact without damage other than the minor intrusions noted above. All of the overhead storage compartments remained intact and the compartment doors were operational. The status of the doors at the time of the crash was unknown as the compartments were opened and closed during a post-crash inspection by the police. There was no contact evidence attributable to the occupants.



Figure 13: Rear view of the lateral intrusions along the right side of the interior.



Figure 14: Interior view of the right lateral intrusions looking forward.

Glazing

The motorcoach was equipped with large glazing panels on its front and side planes. The split front windshield glazing consisted of two large Guardian Safety Float fixed windshields, constructed of laminated AS1 glass and labeled with the alphanumeric sequence GG-M65L1, DOT 22, 3L-27-398. The windshields were gasket-mounted to the frame. The left windshield glazing panel was cracked diagonally from the lower left corner to the top right aspect, and was partially separated from the gasket as previously noted. The right windshield glazing panel was fractured full-height along the right A-pillar on its right aspect, and was partially separated from its gasket mount across the top, center, and bottom edge.

The right side glazing consisted of two right front door panels, eight large rectangular passenger compartment panels, and one narrow vented glazing panel for the restroom area. The forward seven rectangular passenger compartment panels measured 81 cm (32 in) in height by 132 cm (52 in) in width. The side glazing panels were manufactured by Laird Plastics in September 1996, were constructed of AS5 Almacoat 2000 single pane glass, and labeled DOT 393, M-505 AS5. The eighth (rear) glazing panel was 81 cm (32 in) in height by 102 cm (40 in) in width and was of the same material and construction as the forward seven panels. The vented restroom glazing was 81 cm (32 in) in height by 25 cm (10 in) in width. All of the large side glazing panels remained intact and were not damaged. The narrow restroom panel was disintegrated. **Figures 15 and 16** are views of the right side glazing status.

The left side glazing consisted of two small driver's panels and eight large rectangular passenger compartment panels. Both of the driver's glazing panels were intact and undamaged. The eight large rectangular passenger compartment glazing panels were manufactured of the same glazing material and construction as the aforementioned right side panels, and were the same size. All eight left side panels remained intact and were undamaged.



Figure 15: Rear view of the right side glazing status.



Figure 16: Forward view of the right glazing status.

Emergency Exits

The motorcoach was equipped with emergency exits at all side window locations and two roof exits. The eight large glazing panels on the left and seven on the right were configured with push-out frames, creating a path for egress from the passenger compartment. Five of the eight left side panels had been utilized as emergency exits following the arrival of the fire department. The utilized exit locations were between pillar locations: (1) B-C, (2) D-E, (3) E-F, (4) H-I, and (5) I-J. All five remained released and were operational at the time of SCI inspection. The remaining emergency exits on the left side remained closed and undamaged.

The top plane of the motorcoach was equipped with two emergency exits. These were incorporated into the roof structure and located on vehicle centerline, between the B-C and G-H pillars. Their dimensions measured 51 cm (20 in) wide by 74 cm (29 in) long. At the time of SCI inspection, both exits were released, though they remained operational and were not damaged.

Occupant Data

The motorcoach was occupied by the 35-year-old male driver and the 20 passengers. At the time of the crash, the driver stated to the investigating officer that he was restrained by the available lap belt system. There were no safety belt systems for the passengers. The passengers consisted of 12 males and 8 females, ranging in age from adolescent to adult.

The local law enforcement agency investigating the crash reported that six occupants of the motorcoach were transported to local area hospitals for the treatment of minor injuries. The investigating officer provided a seating chart and the police reported injury severity for the passenger compartment. The injuries were listed using the standardized KABCO injury scale that rates injury severity by K= Killed to O = No Injury. The chart listed fourteen of the occupants as not injured. Three did not have an accompanying description of injury, and were subsequently coded with “C” to designate possible injury. The remaining four received the non-incapacitating injury code “B”. These four individuals included a 12-year-old male, a 17-year-old male, a 36-year-old female, and an unknown-aged female. The seating chart and injury classification is provided in **Figure 17**.

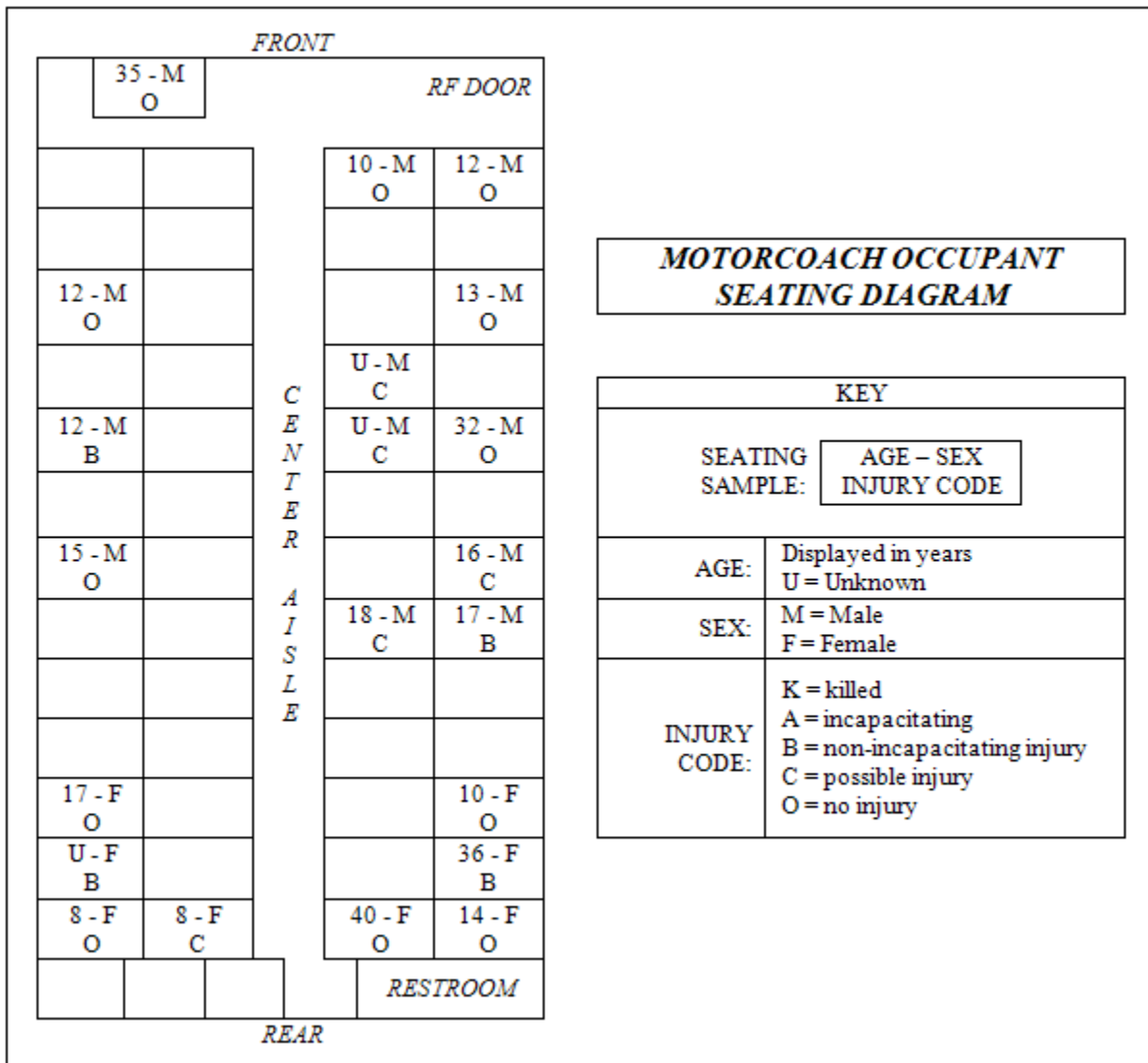


Figure 17: Motorcoach occupant seating diagram.

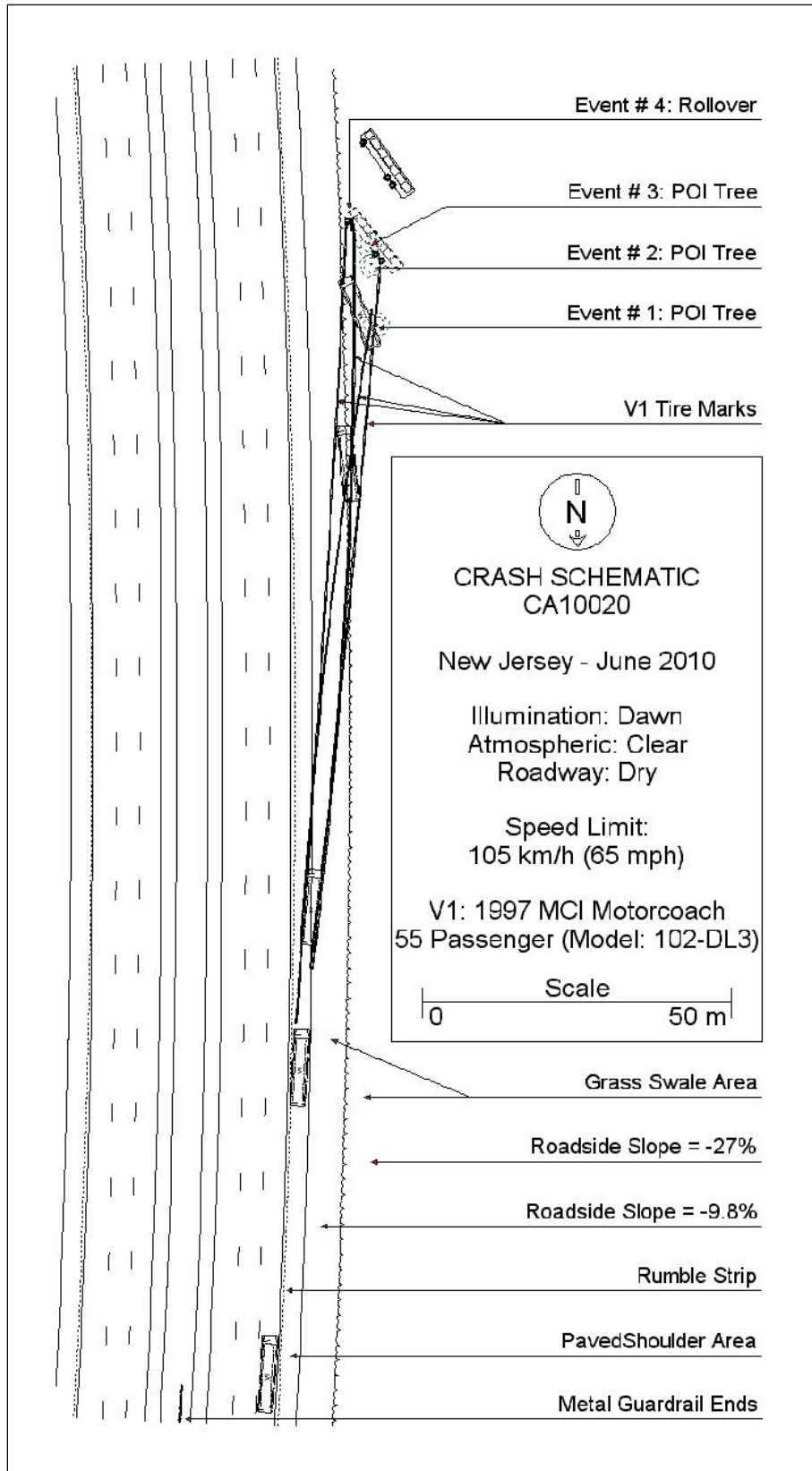


Figure 18: Crash schematic.