On-Site Motor Coach Rollover Investigation
Dynamic Science, Inc. (DSI), Case Number DS10007
1992 Dina Marcopolo Paradiso Motor Coach
Arizona
March 2010

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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 investigation focused on a 1992 Dina Marcopolo Paradiso motor coach that was involved in a rollover crash. This crash occurred in March 2010 at 0527 hours in a rural area of Arizona. The crash scene was an east/west two-lane divided interstate highway. The bus was being driven by a 67-year-old male and was traveling westbound. There were 22 persons on board the bus, including the driver. A 1997 Ford F-150 pickup was traveling in front of the Dina. The pickup was traveling slower than the Dina and was impacted by the front end of the bus. The Dina veered to the left onto the median, overcorrected to the right, crossed both westbound travel lanes, departed the roadway on the right side, overturned, and came to rest off the right side of the roadway. A total of nine occupants were ejected from the bus. Six of the ejected occupants, two males and four females, were fatally injured. One occupant did not report any injuries but was transported to a local hospital with a relative. The remaining 15 occupants were all injured and transported from the scene to local hospitals.

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BACKGROUND

This on-site investigation focused on a 1992 Dina Marcopolo Paradiso motor coach that was involved in a rollover crash. This crash occurred in March 2010 at 0527 hours in a rural area of Arizona. The crash scene was an east/west two-lane divided interstate highway. The bus was being driven by a 67-year-old male and was traveling westbound. There were 22 occupants on board the bus, including the driver. A 1997 Ford F-150 pickup was traveling in front of the Dina. The pickup was traveling slower than the Dina and was impacted by the front end of the bus. The Dina veered to the left onto the median, overcorrected to the right, crossed both westbound travel lanes, departed the roadway on the right side, overturned, and came to rest off the right side of the roadway (**Figure 1**). A total of nine occupants were ejected from the bus. Six of the ejected occupants, two males and four females, were fatally injured. One occupant did not report any injuries but was transported to a local hospital with a relative. The remaining 15 occupants were all injured and transported from the scene to local hospitals.

Figure 1. Final rest location of bus - looking west (police photo)

This rollover crash investigation was initiated by the National Highway Traffic Safety Administration in response to an internet news article. DSI was instructed on March 9, 2010 to contact police authorities and establish cooperation. On March 10, 2010, DSI obtained permission to inspect the vehicle and was assigned the case. Field work was completed on March 18, 2010. The investigating police officer was present during the vehicle inspection.

Figure 2. Westbound approach for both vehicles

SUMMARY

Crash Site

The crash occurred within the westbound lanes of an east/west interstate highway (**Figure 2**). The highway was configured with two lanes that were separated by dashed white lines. The asphalt roadway was straight, level, and dry at the time of the crash. It was dark and there were no streetlights. The roadway was bordered on the north by a 3.0 m (10.0 ft) asphalt shoulder with a 1.2 m (4.0 ft) rumble strip, and a 21 percent gravel-covered

descending embankment that leveled out after 11.2 m (37.0 ft). Beyond this there was a dirt area which was bordered by a barbed wire right-of-way fence. The roadway was bordered on the south by an asphalt shoulder and depressed dirt median with sparse desert vegetation. A solid yellow line separated the rumble strip shoulder from the inboard travel lane and a solid white line separated the outboard travel lane from the right shoulder. The weather was clear , the winds calm, and the temperature 5 degrees C (41 degrees F) at the nearest reporting station. The posted speed limit was 121 km/h (75 mph).

Pre-Crash

The Dina was traveling westbound in the inboard lane at a driver-estimated speed of 113-121 km/h (70-75 mph). The driver reported to the police that the bus was governed at 121 kmh (75 mph) but would go up to 129 km/h (80 mph). The driver took over driving responsibilities at approximately 0000 hours after the bus had crossed the Mexican border into Texas. The bus stopped in New Mexico at approximately 1300-1330 hours where local authorities at the port of entry verified the driver's travel permission. The bus stopped again at 1400 hours at a border patrol check point. The bus did not stop again before the crash. The bus co-driver was asleep on a cot at the back of the bus. He had been sleeping for approximately 6 hours before the crash. Approximately half of the bus occupants were asleep. The Ford was being driven by 38-year-old male and was traveling in front of the Dina at a driver-reported speed of 105 km/h (65 mph). The driver of the Dina steered to the left prior to the impact to avoid striking the back of the slower moving Ford.

Figure 3. Path through median (police photo)

Figure 4. Right side roadway departure for the bus

Crash

The right front of the Dina impacted the left rear of the Ford. The Ford was displaced forward but the driver remained in control of the vehicle and brought the vehicle to a controlled stop.

The Dina departed the roadway on the left side and entered the median (**Figure 3**). The driver of the Dina steered to the right, reentered the roadway, and crossed the two travel lanes. The vehicle departed the roadway on the right, the driver steered left to return to the roadway, and the vehicle began a counterclockwise rotation. The rear tires crossed the shoulder onto the embankment (**Figure 4**). The vehicle traveled approximately 51.8 m (170.0 ft) before the tires impacted the embankment surface and the vehicle tripped (**Figure 5**). The bus began a right side leading rollover, rolled 4 quarter-turns, and traveled 34.1 m (112.0 ft) before coming to rest.

Figure 5. Rear bus tire trip points. Right side road departure.

Figure 6. Look back view of bus from beyond final rest

Post-Crash

The bus came to rest on its wheels facing southwest (**Figure 6**). All but two of the bus occupants were known to be injured. A total of nine occupants were ejected from the bus. Six of the ejected occupants were fatally injured. The remaining occupants were transported to a variety of trauma centers and hospitals. The police did not list seating positions for all the occupants. An overview of the occupants and their injury status is illustrated in Table 1. A seating diagram for occupants in known seating positions is included as Attachment 2 to this report.

Table 1. Overview of Occupant Injuries

The first digit of the seat position represents the seat row going from the front of the bus to the back beginning with the driver's row. The remaining digits represent the seat position left to right. For each row there were a total of four seats, two on the left and two on the right. For example, seat location 23 would be in the second row and would be the third seat from the left.

Occupant No.	Seat Position	Age/Sex	Injuries
01	Driver	67/Male	Abrasions to arms and right side of head. Transported by ground to hospital where he was treated and released.
02	23	70/Male	Fractures to T10 and sternum and unspecified head trauma. Transported by ground to hospital and admitted.
03	24	67/Female	***Ejected and fatally injured***. Brain laceration, bilateral rib fractures, spleen laceration, liver laceration.

Occupant No.	Seat Position	Age/Sex	Injuries
04	31	43/Female	Fractures to C1 and multiple left ribs, punctured left lung. Transported by air to trauma center and admitted.
05	32	50/Male	Fractures to left wrist and ankle and unspecified head trauma. Transported to trauma center by air and admitted.
06	33	14/Female	Abrasions to face. Transported by ground to hospital where she was treated and released.
07	34	81/Female	***Ejected and fatally injured.*** Cardiac contusions, T6-T7 fracture, left side rib fractures; and pelvic, femur, clavicle fractures.
08	41	57/Female	***Ejected and fatally injured***. Transected descending aorta, multiple rib fractures, bilateral hemothoraces.
09	42	Unknown/ Female	Injury status not known.
10	44	73/Male	Left rib fractures with pneumothorax. Transported by ground to hospital where he was admitted.
11	51	46/Male	Fracture to cervical spine and near amputation of left thumb. Transported by ground ambulance to hospital and admitted.
12	53	12/Male	***Ejected.*** Multiple left rib fractures with pneumothorax. Transported by air to trauma center. Hospitalization status is not known.
13	61	24/Male	Multiple rib fractures. Transported to trauma center and admitted.
14	63-64	17/Female	Not injured. Transported in ground ambulance with father.
15	71	58/Female	***Ejected and fatally injured***. Liver lacerations, bilateral rib fractures, shoulder fracture and dislocation.
16	Unknown	85/Male	***Ejected and fatally injured***. Lung lacerations, bilateral rib fractures, atlanto-occipital joint dislocation, subdural hemorrhages.

Occupant No.	Seat Position	Age/Sex	Injuries
17	Unknown	69/Female	***Ejected and fatally injured***. Atlanto-occipital articulation dislocation and fracture with spinal cord transection, multiple rib fractures.
18	Unknown	52/Female	Left rib fracture and unspecified head trauma. Transported to trauma center and admitted.
19	Unknown	35/Male	Minor abrasions and contusions. Transported to hospital where he was treated and released.
20	Unknown	74/Male	Fractures to T10 and ribs and unspecified head trauma. Transported to hospital and admitted.
21	Unknown	55/Female	Fractures to right leg and wrist. Transported by air and admitted.
22	In cot, back of bus	24/Male	***Ejected.*** Contusions to arms, legs, and torso. Transported to hospital but unknown if admitted.

There was one additional non-fatal ejected occupant but the identification of this occupant could not be determined.

Both vehicles were towed from the scene and were placed into police evidence. The driver of the Ford did not sustain any injuries.

Vehicle Data - 1992 Dina Marcopolo Paradiso 1150 Motor Coach

The Dina Marcopolo Paradiso was identified by the Vehicle Identification Number (VIN): 9BPRLFAUNNBxxxxxx. The date of manufacture is unknown. A single identification tag was located in the vehicle and was attached to the left interior surface next to the driver. The mileage was not known due to an absence of power. The vehicle had a Gross Vehicle Weight Rating of 22,680 kg (50,000 lbs)[1] and a tare weight of 15,900 kg (35,052 lbs)[2]. The vehicle was equipped with seating for 41 passengers. The Dina was configured with a front axle, a drive axle, and a tag axle. There were dual tires on the drive axle.

The specific tire information was as follows:

Left Front Tire
Michelin XZE2 305/75R24.5
Tire Identification Number (TIN): Unknown

[1]Obtained from police report

[2]Obtained from VIN tag

Tread depth: 10 mm (13/32 in)
Measured pressure: Tire Flat
Rim type: Aluminum, 10 lugs
Rim damage: Fractured.
Valve stem: The valve stem was recessed in a port in the rim and exhibited no evidence of damage.
Tire Damage: Tire was debeaded and there was a 4.0 cm (1.6 in) area of scuffing/abrading along the outboard tread.

#2 Axle, Left Outboard Tire
Michelin XZE2 11R24.5
TIN: Unknown
Tread depth: 9 mm (11/32 in)
Measured pressure: Tire Flat
Rim type: Aluminum, 10 lugs
Rim damage: Gouged
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.
Tire Damage: Tire was debeaded and there was a small cut in sidewall.

#2 Axle, Left Inboard Tire
Michelin XZE2 11R24.5
TIN: Unknown
Tread depth: 5 mm (6/32 in)
Measured pressure: 662 kPa (96 psi)
Rim type: Aluminum, 10 lugs
Rim damage: Gouged
Valve stem: The valve stem protruded through a port in the outboard rim and exhibited no evidence of damage.
Tire Damage: None

#3 Axle, Left Tire
Michelin XZE2 305/75R24.5
TIN: Unknown
Tread depth: 10 mm (13/32 in)
Measured pressure: Tire Flat
Rim type: Aluminum, 10 lugs
Rim damage: Fractured
Valve stem: The valve stem was recessed in a port in the rim and did not exhibit any damage.
Tire Damage: Debeaded

Right Front Tire
Michelin Radial X 305/75R24.5
TIN: B6LT 5KAX 3109
Tread depth: 17 mm (21/32 in)
Measured pressure: 469 kPa (68 psi)
Rim type: Aluminum, 10 lugs
Rim damage: Gouged

Valve stem: The valve stem was recessed in a port in the rim and exhibited no evidence of damage.
Tire Damage: Scuffed along outer edge near tread

#2 Axle, Right Outboard Tire
Michelin XZE2 11R24.5
TIN: B64F 566X 3908
Tread depth: 14 mm (18/32 in)
Measured pressure: 641 kPa (93 psi)
Rim type: Aluminum, 10 lugs
Rim 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.
Tire Damage: The sidewall was scuffed. Grass was imbedded in the bead.

#2 Axle, Right Inboard Tire
Michelin XZE2 11R24.5
TIN: B64F 566X 4808
Tread depth: 12 mm (15/32 in)
Measured pressure: 414 kPa (60 psi)
Rim type: Aluminum, 10 lugs
Rim damage: None.
Valve stem: The valve stem protruded through a port in the outboard rim and exhibited no evidence of damage.
Tire Damage: None

#3 Axle, Right Tire
Bridgestone R250 ED 11R24.5
TIN: 2C4F 3K7 4407
Tread depth: Maximum inboard 6 mm (7/32 in), Minimum outboard 2 mm (3/32 in)
Measured pressure: Tire Flat
Rim type: Aluminum, 10 lugs
Rim damage: None.
Valve stem: The valve stem was recessed in a port in the rim and did not exhibit any damage.
Tire Damage: De-beaded

Figure 7. Driver's seat position

Figure 8. Overview of seating, view from front

The Dina motor coach was configured to carry one driver (**Figure 7**), one front right passenger, and 40 additional passengers (**Figure 8**). Including the front left and right seating positions, there were a total of 11 rows. Each row was configured with left and right 2-seat units. The inboard leg of each seat unit was anchored to a metal strip mounted to the floor and the outboard leg was anchored to a metal strip mounted to the side of the bus.

Mechanical Inspection Summary

Following the crash, the police conducted a Level 1 inspection. It was determined that the driver would have been out of service for not being capable of reading and speaking the English language sufficiently to converse with the general public and for not having a prior 7 days of log. The co-driver would have been out of service for not having a prior 7 days of log. The bus had no operating authority to transport passengers in interstate commerce. The bus was found to be operating in an out-of-service condition due to the brakes being contaminated and out of adjustment.

Vehicle Damage

Exterior Damage

The Dina sustained minor front end damage as a result of the impact with the Ford (**Figure 9**). The direct damage began at the right front bumper corner area and extended 55.0 cm (21.6 in) to the left. The damage extended vertically 131.0 cm (51.5 in) from the ground. Six crush measurements were taken at the bumper level as follows: C_1 = 0 cm, C_2 = 6.0 cm (2.3 in), C_3 = 9.0 cm (3.5 in) C_4 = 13.0 cm (5.1 in), C_5 = 19.0 cm (7.4 in), C_6 = 35.0 cm (13.7 in). The maximum crush was located at C_6. The bumper was torn away from the vehicle.

Figure 9. Frontal damage

The Dina sustained severe damage as a result of the rollover. There was direct damage to the right side, top, and left side. The damage to the right side began 240.0 cm (94.5 in) aft of the rear axle and extended 1256.0 cm (494.4 in) forward (**Figure 10**). The damage extended vertically from the roof rail downward 170.0 cm (66.9 in) and terminated along the belt line. The lateral crush was documented at three locations as follows:

Location	Crush
Right A-pillar/roof side rail	76.0 cm (29.9 in)
Right roof side rail, 170.0 cm (66.9 in) forward of #3 axle	61.0 cm (24.0 in)
Right roof side rail, 52.0 cm (21.6 in) rearward of #3 axle	52.0 cm (21.6 in)

There was scattered damage to the left side that began at the left rear bumper corner and extended forward along the entire length of the bus **(Figure 11**). There was 223.0 cm (87.8 in) of direct damage that extended from the left rear bumper forward to the #3 axle tire. Along this area there was 37.0 cm (14.6 in) of vertical crush along the lower edge of the body. There was direct damage that began at the left front bumper corner and extended 148.0 cm (58.2 in) and terminated 56.0 cm

(22.0 in) forward of the front axle. This area was dented and mud-covered. The maximum lateral crush was located at the left bumper corner and measured 25.0 cm (9.8 in). The greenhouse was shifted to the left by the right side impact with the ground. The shift was measured at two locations; 69.0 cm (27.1 in) at the left A-pillar and 43.0 cm (16.9 in) at the #3 axle.

The damage on the roof was distributed laterally from roof side rail to roof side rail and measured 252.0 cm (99.2 in) (**Figure 12**); it was distributed longitudinally along the entire bus length and measured 1141.0 cm (449.2 in). The maximum vertical damage was located at the right A-pillar/roof junction and measured 235.0 cm (92.5 in) from the ground.

The rear of the vehicle sustained remote buckling type damage due to the left and right impacts with the ground. The upper fascia was dislodged and there was a 70.0 x 67.0 cm (27.5 x 26.3 in) area of the fascia broken away at the top right. The rear bumper was displaced from the vehicle.

Interior Damage

The Dina sustained severe interior damage due to intrusion, seat movement, loss of integrity, and occupant contacts. The right and left windshield glazing was displaced. Based on police photos, the side windows on the right were displaced/disintegrated at all locations except the 4th and 7th windows. The windows on the left were all displaced/disintegrated. The side windows were all sealed with none of them configured to be used as exits. It is not known which, if any, of the windows were originally intended to be used as exits. The vehicle was configured with two roof exits; the exit covers were missing at the time of the vehicle inspection but were present and closed at the time of the crash according to police photos.

Figure 10. Right side damage

Figure 11. Left side damage

Figure 12. Roof damage (looking toward front of bus)

Details regarding survival space measurements, seat damage, and roof crush and intrusions are discussed in the sections that follow.

Survival Space Measurements

Survival space measurements were documented for each outboard seat. The measurements were defined as follows: A = vertical measurement from floor to top of seat, B = vertical measurement from floor to seat back at time of inspection, C = lateral measurement from seat cushion to interior side surface, and D = lateral measurement from seat back to interior side surface. The driver and right front seat were excluded from this listing. For C, a negative number indicates that the seat back was outboard the interior side surface.

Row	Position	A	B	C	D
2	21, 22	Seat unit not in vehicle.			
2	23, 24	44.0 cm (17.3 in)	63.0 cm (24.8in)	-7.0 cm (-2.8 in)	10.0 cm (3.9 in)
3	31, 32	Seat unit not in vehicle.			
3	33, 34	44.0 cm (17.3 in)	63.0 cm (24.8in)	-3.0 cm (-1.2 in)	3.0 cm (1.2 in)
4	41, 42	Seat unit not in vehicle.			
4	43, 44	44.0 cm (17.3 in)	64.0 cm (25.1 in)	0 cm	5.0 cm (1.9 in)
5	51, 52	44.0 cm (17.3 in)	65.0 cm (25.6 in)	24.0 cm (9.4 in)	13.0 cm (5.1 in)
5	53, 54	44.0 cm (17.3 in)	56.0 cm (22.0 in)	0 cm	6.0 cm (2.4 in)
6	61, 62	Seat unit displaced from anchorages.			
6	63, 64	44.0 cm (17.3 in)	66.0 cm (25.9 in)	-3.0 cm (-1.2 in)	0
7	71, 72	44.0 cm (17.3 in)	72.0 cm (28.3 in)	38.0 cm (14.9 in)	13.0 cm (5.1 in)
7	73, 74	44.0 cm (17.3 in)	49.0 cm (19.3 in)	-2.0 cm (-0.8 in)	0 cm
8	81, 82	44.0 cm (17.3 in)	65.0 cm (25.6 in)	20.0 cm (7.9 in)	14.0 cm (5.5 in)
8	83, 84	44.0 cm (17.3 in)	58.0 cm (22.8 in)	0 cm	0 cm
9	91, 92	44.0 cm (17.3 in)	66.0 cm (25.9 in)	22.0 cm (8.7 in)	14.0 cm (5.5 in)
9	93, 94	44.0 cm (17.3 in)	44.0 cm (17.3 in)	-2.0 cm (-0.8 in)	0 cm
10	101, 102	Seat unit displaced from anchorages.			
10	103, 104	44.0 cm (17.3 in)	61.0 cm (24.0 in)	-3.0 cm (-1.2 in)	0 cm
11	111, 112	44.0 cm (17.3 in)	66.0 cm (25.9 in)	22.0 cm (8.7 in)	13.0 cm (5.1 in)
11	113, 114	44.0 cm (17.3 in)	60.0 cm (23.6 in)	0 cm	0 cm

Seat Damage

The seats were examined for seat back, seat cushion, armrest, and anchor damage. There were numerous instances of seat shifting, particularly at the inboard legs (**Figure 13**). Outboard arm rests were deformed by intrusion on the right, as well as by occupant contact. The following table describes the damage at each seat position.

Figure 13. Exemplar shifting of inboard seat leg

Row	Position	Seat back damage	Seat cushion damage	Armrest	Anchors
2	21,22	Seat unit not in vehicle.			
2	23,24	23 deformed due to intrusion of 24	None	Outboard arm deformed inboard 13.0 cm (5.1 in)	Inboard leg deformed inboard 7.0 cm (2.7 in), outboard leg bent inboard 5.0 cm (1.9 in).
3	31,32	Seat unit not in vehicle.			Portion of inboard leg still anchored to vehicle. 7.0 cm (2.7 in) floor to fracture.
3	33, 34	None	None	Outboard arm deformed inboard 3.0 cm 1.2 in). Inboard arm deformed inboard 14.0 cm (5.5 in).	No damage
4	41, 42	Seat unit not in vehicle			

Row	Position	Seat back damage	Seat cushion damage	Armrest	Anchors
4	43, 44	44 deformed inboard 3.0 cm (1.2 in)	None	Outboard arm deformed inboard 7.0 cm (2.7 in)	Inboard leg deformed inboard 4.0 cm (1.6 in). Leg is separated from bus.
5	51, 52	51 deformed forward 86.0 cm (33.8 in). 52 broken, won't hold position.	None	Inboard arm deformed inboard 12.0 cm (4.7 in)	Inboard leg deformed outboard 7.0 cm (2.7 in). Top of leg has 4.0 cm (1.6 in) long fracture.
5	53, 54	None	None	None	Inboard leg deformed inboard 9.0 cm (3.5 in). Anchor strip unstable.
6	61, 62	Seat unit in vehicle but displaced from mounted position.			All anchors failed.
6	63, 64	None	None	None	None
7	71, 72	71 deformed forward 26.0 cm (10.2 in)	None	None	Outboard rear anchor bolt missing and there is a 4.0 cm (1.6 in) gap above runner. Inboard leg deformed outboard 4.0 cm (1.6 in).
7	73, 74	None	None	None	Inboard leg deformed inboard 1.0 cm (0.4 in).
8	81, 82	82 deformed forward 75.0 cm (29.5 in).	None	None	Outboard leg deformed outboard 4.0 cm (1.6 in).

Row	Position	Seat back damage	Seat cushion damage	Armrest	Anchors
8	83, 84	84 shifted inboard 4.0 cm (1.6 in), binding center arm rest against 83.	None	None	Inboard leg deformed inboard 1.0 cm (0.4 in).
9	91, 92	92 seat back loose, won't lock in place.	None	None	Outboard leg deformed outboard 2.0 cm (0.8 in).
9	93, 94	94 deformed inboard 4.0 cm (1.6 in)	None	None	Inboard leg deformed inboard 2.0 cm (0.8 in).
10	101, 102	Seat unit in vehicle but displaced from mounted position. Inboard arm rest deformed outboard 3.0 cm (1.2 in).			All anchors failed
10	103, 104	104 moved inboard 2.0 cm (0.8 in)	None	None	Inboard leg deformed inboard 3.0 cm (1.2 in).
11	111, 112	None	None	None	Inboard leg deformed outboard 3.0 cm (1.2 in). Outboard forward anchor bolt missing.
11	113, 114	114 deformed inboard 3.0 cm (1.2 in)	None	Outboard deformed inboard 4.0 cm (1.6 in) by side panel intrusion.	Inboard leg deformed inboard 2.0 cm (0.8 in).

Roof Crush and Intrusions

Row	Position	Intruded Component	Magnitude	Direction
1	11	Roof side rail Lower kick panel	Not yet known 12.0 cm (4.7 in)	Vertical Longitudinal

Row	Position	Intruded Component	Magnitude	Direction
2	21	Roof	Not yet known	Vertical
2	22	Roof	Not yet known	Vertical
2	23	Luggage compartment	43.0 cm (16.9 in)	Vertical
2	24	B-pillar Side panel	68.0 cm (26.7 in) 4.0 cm (1.6 in)	Lateral Lateral
3	31	Roof	Not yet known	Vertical
3	32	Roof	Not yet known	Vertical
3	33	Luggage compartment	40.0 cm (15.7 in)	Vertical
3	34	Side panel	11.0 cm (4.3 in)	Lateral
4	41	Roof Luggage compartment	28.0 cm (11.0 in)	Vertical Vertical
4	42	Roof	Not yet known	Vertical
4	43	Luggage compartment	30.0 cm (11.8 in)	Vertical
4	44	Luggage compartment C-pillar Side panel	27.0 cm (10.6 in) 56.0 cm (22.0 in) 9.0 cm (3.5 in)	Vertical Lateral Lateral
5	51	Luggage compartment	30.0 cm (11.8 in)	Vertical
5	52	Roof	Not yet known	Vertical
5	53	Luggage compartment	20.0 cm (7.9 in)	Vertical
5	54	Luggage compartment (wooden frame) Side panel	13.0 cm (5.1 in) 8.0 cm (3.1 in)	Vertical Lateral
6	61	Luggage compartment	14.0 cm (5.5 in)	Vertical
6	62	Roof	Not yet known	Vertical
6	63	Luggage compartment	11.0 cm (4.3 in)	Vertical
6	64	Side panel	14.0 cm (5.5in)	Lateral
7	71	Roof Luggage compartment	51.0 cm (20.0 in) 11.0 cm (4.3 in)	Lateral Vertical
7	72	None	N/A	N/A
7	73	Luggage compartment	14.0 cm (5.5 in)	Vertical

Row	Position	Intruded Component	Magnitude	Direction
7	74	Side panel E-pillar	14.0 cm (5.5 in) 40.0 cm (15.7 in)	Lateral Lateral
8	81	Luggage compartment	7.0 cm (2.8 in)	Vertical
8	82	None	N/A	N/A
8	83	Luggage compartment	13.0 cm (5.1 in)	Vertical
8	84	Side panel	14.0 cm (5.5 in)	Lateral
9	91	Luggage compartment	4.0 cm (1.6 in)	Vertical
9	92	None	N/A	N/A
9	93	Luggage compartment	6.0 cm (2.4 in)	Vertical
9	94	Side panel F-pillar	17.0 cm (6.7 in) 40.0 cm (15.7 in)	Lateral Lateral
10	102	None	N/A	N/A
10	103	Luggage compartment	5.0 cm (1.9 in)	Vertical
10	104	Side panel	to center line 14.0 using D	Lateral
11	111	Luggage compartment	3.0 cm (1.2 in)	Vertical
11	112	None	N/A	N/A
11	113	Luggage compartment	6.0 cm (2.4 in)	Vertical
11	114	Luggage compartment Side panel G-pillar	Unknown 33.0 cm (12.9 in)	Vertical Lateral Lateral

In addition to the intrusions listed earlier, the Heating, Ventilation and Air Conditioning (HVAC) strip above seats 53, 63, 83, 83, and 93 had separated from the luggage compartment and came to rest on the seats' head rests.

Manual Restraints

The driver's seat was configured with a lap belt. The belt exhibited indications of historical usage but there was no evidence of loading. There were no other safety belts in the vehicle.

Rollover Dynamics

After the impact with the Ford and the subsequent return to the roadway, the Dina crossed both westbound lanes and began a right side road departure. The driver began a left steering maneuver and the vehicle began a counterclockwise rotation as it entered the soft shoulder and embankment **(Figure 14**). The vehicle traveled approximately 51.8 m (170.0 ft) before the tires tripped on the embankment surface (**Figure 15**). The bus began a right side leading rollover, rolled 4 quarter-turns and came to rest on its wheels facing southwest. The distance between the trip point and final rest measured 37.2 m (122.0 ft)

Figure 14. Right side roadway departure. Arrows depict right rear tires trip point.

Figure 15. Rear tires trip points

Vehicle Data - 1997 Ford F-150

The 1997 Ford F-150 Super Cab pickup was identified by the VIN: 1FTDX1728VKxxxxxx. The vehicle's date of manufacture was February 1997. The Ford was equipped with a 4.2-liter, 6-cylinder engine, automatic transmission, rear wheel drive, rear wheel ABS, and power steering. The Ford was configured with Firestone Destination LE P245/70R16 tires.

The vehicle sustained moderate damage to the back end during the impact with the front of the Dina (**Figure 16**). The direct damage began at the left rear bumper corner and extended 28.0 cm (11.0 in) to the right. Two crush measurements were documented at the bumper level as follows: C1 = 0 cm, C2 = 31.0 cm (12.0 in). The left side of the bed was deformed 60.0 cm (23.6 in) longitudinally. The Collision Deformation Classification for this impact was 06BLEE2.

The driver was able to exit the vehicle under his own power. The vehicle was towed from the scene and placed into police evidence.

Figure 16. Back end damage, other vehicle (police photo)

Occupant Kinematics

According to the police report, the driver was restrained. There were no indications of loading located on the lap belt. The remaining occupants of the bus were unrestrained. Approximately one-half of the occupants were awake. Several of the occupants reported being awakened as the bus began the sharp steering motions. As the vehicle began the right side road departure and the driver steered sharply to the left, the occupants were displaced to the right. As the vehicle tripped and began a right side leading rollover, the occupants were further displaced to the right. Most of the right side glazing was disintegrated or displaced during the first quarter-turn.

Figure 17. Occupant 03 seating position, seat location 24

According to the police report, a total of nine occupants were ejected during the rollover. There is incomplete information regarding seat position and ejection areas. The information that is known about these ejections follows.

Figure 18. Occupant 07 seating position, seat location 34

Fatals

Occupant 03, a 67-year-old female, was seated in seat 24 (**Figure 17**). During the first quarter-turn, she was displaced against the side window adjacent to her seat position. The window was fractured/displaced during the initial right side roll. She was ejected from the vehicle through the forward most side window during the fourth quarter-turn and came to rest to the right of the bus.

Occupant 07, an 81-year-old female, was seated in seat position 34 (**Figure 18**). During initial right side roll, she was displaced from her seat forward and to the right against the adjacent side window. The window was displaced/fractured during the right side impact. She came out of her seat as the vehicle overturned and was then ejected through the side window during the fourth quarter-turn. She came to rest approximately 8.5 m (28.0 ft) to the right of the bus.

Occupant 08, a 57-year-old female, was seated in seat position 41 (**Figure 19**). During initial right side roll, she was displaced from her seat forward and to the right and was probably near the second set of windows. The seat unit was displaced from its anchorage during the rollover. This occupant was ejected from the vehicle during the fourth quarter- turn and came to rest approximately 1.0 m (3.3 ft) to the right of the bus near the right front axle.

Figure 19. Occupant 08 seating position, seat location 41

Occupant 15, a 58-year-old female was seated in seat position 71. During initial right side roll, she was displaced from her seat forward and to the right and was probably near the second set of windows. The seat unit in front of her seat position was displaced during the rollover. This occupant was ejected from the vehicle during the fourth quarter-turn and came to rest approximately 8.2 m (27.0 ft) to the right of the bus.

Occupant 16, an 85-year-old male, was seated in an unknown position. He was ejected from the right side of the vehicle during the fourth quarter-turn and came to rest approximately 7.9 m (26.0 ft) to the right of the bus.

Occupant 17, a 69-year-old female, was seated in an unknown position. She was ejected from the left side of the vehicle during the third quarter-turn and came to rest to the left of the bus near the rear tires.

Non-Fatals

Occupant 12, a 12-year-old male, was seated in seat position 53 (**Figure 20**). He was asleep before the crash. He was ejected at some point during the rollover sequence. The ejection area is not known.

Figure 20. Occupant 12 seating position, seat location 53

Occupant 22, a 24-year-old male, was lying down on a cot at the very rear of the bus. He was asleep as the steering maneuvers began but did wake up prior to the rollover. He was ejected at some point during the rollover sequence. The ejection area is not known.

There was one additional non-fatal ejected occupant but the identification of this occupant is not known.

Occupant Injuries

Driver: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Abrasions, bilateral arms	710202.1,3	Unknown	Unknown
Abrasions, right side of head	110202.1,1	Unknown	Unknown

Occupant 02: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Fracture, thoracic vertebra at T10	650416.2,7	Arm rest	Possible
Sternum fracture	450804.2,4	Unknown	Unknown
Head trauma	100099.9,0	Roof	Possible

Occupant 03: Injuries obtained from autopsy report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Horizontal brain laceration, inferior surface left occipital lobe, 4.0 cm (1.6 in)	140686.4,2	Ground	Possible
Multiple areas of subdural and subarachnoid hemorrhages	140650.3,3 140693.2,9	Ground	Possible
Pericardial laceration	441602.2,4	Side surface	Possible
Spleen, multiple lacerations	544220.2,2	Unknown	Unknown
Liver, multiple lacerations	541820.2,1	Side surface	Possible

Bilateral rib fractures (all), both anterior and posterior	450203.3,3	Side surface	Possible
Right pelvic fractures	856100.2,4	Side surface	Possible
Right forearm bone deformed and fractured	751800.2,1	Side surface	Possible
Hematoma, right clavicular area, 7.0 cm (2.7 in)	710402.1,1	Side surface	Possible
Multiple contusions, back of left hand	710402.1,2	Ground	Possible
Multiple lacerations, back of right hand	710600.1,1	Ground	Possible
Multiple punctated abrasions/lacerations, right lower extremity	810202.1,1 810600.1,1	Ground	Possible
Abrasion, front of left leg, 5.0 cm (1.9 in)	810202.1,2	Unknown	Unknown
Contusions, posterior parietal and occipital areas	110402.1,6	Ground	Possible
Contusions, right side of head and face	110402.1,1 210402.1,1	Side glass	Possible
Lacerations, right side of head and face	110600.1,1 210600.1,1	Side glass	Possible

Occupant 04: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Fracture, cervical spine at C1	650216.2,6	Roof	Possible
Multiple left rib fractures	450200.2,2	Unknown	Unknown
Left lung puncture	441413.3,2	Unknown	Unknown

Occupant 05: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Fracture, left wrist	751800.2,2	Unknown	Unknown
Fracture, left ankle	852002.2,2	Unknown	Unknown
Head trauma	100099.9,0	Roof	Possible

Occupant 06: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Facial abrasions	210202.1,0	Unknown	Unknown

Occupant 07: Injuries obtained from autopsy report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Pericardial laceration	441602.2,4	Side surface	Possible
Cardiac contusions, anterior surface involving upper half of anterior surface including left anterior descending artery	441002.1,1	Side surface	Possible
Displaced fracture, T6 and T7	650416.2,7	Ground	Possible
Fracture, left ribs (all)	450203.3,2	Side surface	Possible
Bilateral hemothoraces, 600 mL right, 425 mL left	442200.3,3	Unknown	Unknown
Liver lacerations	541820.2,1	Side surface	Possible
Multiple pelvic fractures, including pubic symphsis	856151.2,4	Side surface	Possible
Fracture, left femur	853000.3,2	Ground	Possible

Fracture, left clavicle	750500.2,2	Ground	Possible
Focal subarachnoid hemorrhages	140693.2,9	Unknown	Unknown
Left lower extremity dislocation with possible hip joint dislocation	870099.9,2	Unknown	Unknown
Laceration, frontal scalp and forehead, 12.5 x 4.0 cm (4.9 x 1.6 in)	110604.2,5 210604.2,7	Side glass	Possible
Multiple scalp contusions	110402.1,0	Unknown	Unknown
Contusions, left chest, 5.0 x 3.0 cm (1.9 x 1.2 in)	410402.1,2	Ground	Possible

Occupant 08: Injuries obtained from autopsy report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Transected descending aorta	420210.5,4	Seat back	Possible
Subarachnoid hemorrhages, left side	140693.2,2	Unknown	Unknown
Right side rib fractures, 1-10	450203.3,1	Seat back	Possible
Left hemidiaphragm laceration	440604.2,2	Unknown	Unknown
Multiple splenar lacerations, averaging 6.3 cm (2.5 in) in length	544220.2,2	Unknown	Unknown
Bilateral hemothoraces, 400 mL in left, 1200 mL in right	442201.4,3	Unknown	Unknown
Lacerations (5) to liver	541820.2,1	Seat back	Possible

Laceration/abrasion, lateral to left eye	210600.1,2	Unknown	Unknown
Multiple linear lacerations, left mid and upper abdomen	510600.1,2	Unknown	Unknown
Abrasion, left elbow	710202.1,2	Ground	Possible
Abrasion, right knee	810202.1,1	Ground	Possible
Linear abrasion, left pretibial area	810202.1,2	Unknown	Unknown
Focal contusions, left forehead and temporal scalp	210402.1,2 110402.1,2	Unknown	Unknown

Occupant 09: Injury status not known.

Occupant 10: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Left rib fractures with pneumothorax	450210.2,2 442220.2,2	Armrest	Possible

Occupant 11: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Cervical spine fracture	650216.2,6	Roof	Possible
Near amputation, left thumb	711005.2,2	Unknown	Unknown

Occupant 12: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Multiple left rib fractures with pneumothorax	450210.2,2 442202.2,2	Unknown	Unknown

Occupant 13: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Multiple rib fractures	450210.2,2	Unknown	Unknown

Occupant 14: Not injured.

Occupant 15: Injuries obtained from autopsy report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Liver lacerations, right lobe, deep parenchvmal laceration 5.0 x 3.0 cm (1.9 x 1.2 in)	541824.3,1	Seat	Possible
Bilateral rib fractures, left 5-7, right 8	450203.3,3	Seat	Possible
Fracture/dislocation, right shoulder	771030.2,1	Seat	Possible
Abrasion, right forehead, 2.0 x 2.5 cm (0.8 x 1.0 in)	210202.1,7	Unknown	Unknown
Lacerations, right ear	210600.1,1	Unknown	Unknown
Contusions, right side of head	210402.1,1	Unknown	Unknown
Contusion, left hip, 10.0 x 2.0 cm (3.9 x 0.8 in)	810402.1,2	Unknown	Unknown
Multiple contusions, lateral aspect of left leg, 9.0 x 2.0 cm (3.5 x 0.8 in)	810402.1,2	Unknown	Unknown

Occupant 16: Injuries obtained from autopsy report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Transverse dens fracture with atlanto-occipital joint dislocated and slightly displaced	650228.3,6	Unknown	Unknown
Subdural hemorrhages, left superior cerebral surface and bilateral base of brain	140650.3,2	Unknown	Unknown
Focal subarachnoid hemorrhages	140693.2,9	Unknown	Unknown
Petechial hemorrhages, left temporal pole, corpus callosum	140642.2,2	Unknown	Unknown
Contusion, right parietal cortex	140602.3,1	Unknown	Unknown
Spinal fracture with displacement, C6	650216.2,6	Unknown	Unknown
Hemorrhages, prevertebral muscles in neck areas	310402.1,6	Unknown	Unknown
Rib fracture, left 1-9 posterior, right 1-9 posterior	450203.3,3	Unknown	Unknown
Right displaced clavicle fracture	750500.2,1	Unknown	Unknown
Bilateral hemothoraces, 200 mL left, 300 mL right	442200.3,3	Unknown	Unknown
Multiple bilateral lung contusions	441410.3,3	Unknown	Unknown
Laceration, right middle lobe and right upper lobe	441432.4,1	Unknown	Unknown

Liver lacerations	541820.2,1	Unknown	Unknown
Right retroperitoneal hemorrhages	543800.2,6	Unknown	Unknown
Avulsion, left wrist and hand, 7.6 x 3.8 (3.0 x 1.5 in)	710800.1,2	Window frame	Possible
Avulsion, back of right lower leg, 15.2 x 12.7 (6.0 x 5.0 in)	810800.1,1	Window frame	Possible
Compound fracture, right tibia and fibula	854001.3,1 854442.2,1	Unknown	Unknown
Laceration, occipital scalp, 10.1 cm (4.0 in)	110600.1,6	Unknown	Unknown
Contusion, scalp, 10.1 cm (4.0 in)	110402.1,9	Unknown	Unknown

Occupant 17: Injuries obtained from autopsy report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Atlanto-occipital articulation dislocation and fracture with spinal cord transection	640250.5,6	Unknown	Unknown
Transverse dens fracture	650228.3,6	Unknown	Unknown
Displaced transverse thoracic spinal fracture	650420.2,7	Unknown	Unknown
Rib fractures, 1-4 right posterior, 1-8 left posterior	450203.3,3	Seat back	Possible
Muscle contusions, upper posterior chest wall	410402.1,9	Unknown	Unknown
Bilateral hemothoraces, 300 mL left, 200 mL right	442200.3,3	Unknown	Unknown

Bilateral pulmonary contusions	441410.3,3	Unknown	Unknown
Abrasion, left upper back, 5.0 x 2.5 (2.0 x 1.0 in)	410202.1,2	Ground	Possible
Abrasion, right buttock, 3.8 cm (1.5 in). Multiple short linear abrasions, right buttock	810202.1,1	Ground	Possible
Abrasions, right elbow	710202.1,1	Ground	Possible
Abrasions, left lower abdomen	510202.1,2	Ground	Possible
Scalp contusions (2), right parietal scalp	110402.1,1	Unknown	Unknown
Multiple focal subarachnoid hemorrhage	140693.2,9	Unknown	Unknown
Contusion, left parietal scalp, 5.0 cm (2.0 in)	110402.1,2	Unknown	Unknown

Occupant 18: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Left rib fracture	450200.1,2	Unknown	Unknown
Head trauma	100099.9,0	Unknown	Unknown

Occupant 19: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Minor abrasions and contusions	910200.1,0 910400.1,0	Unknown	Unknown

Occupant 20: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Thoracic spinal fracture at T10	650416.2,7	Unknown	Unknown
Rib fracture	450200.1,9	Unknown	Unknown
Head trauma	100099.9,0	Unknown	Unknown

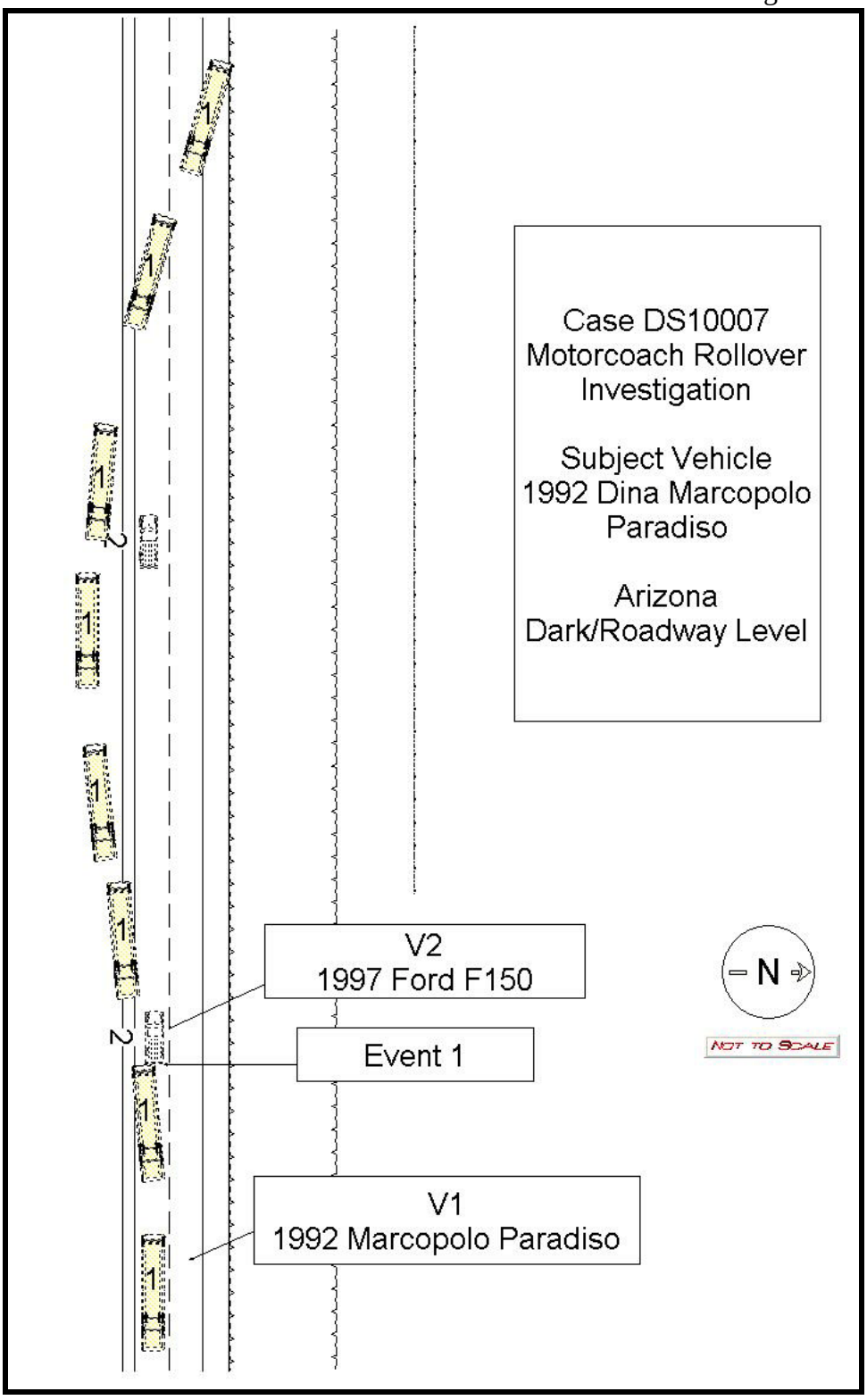
Occupant 21: Injuries obtained from police report.

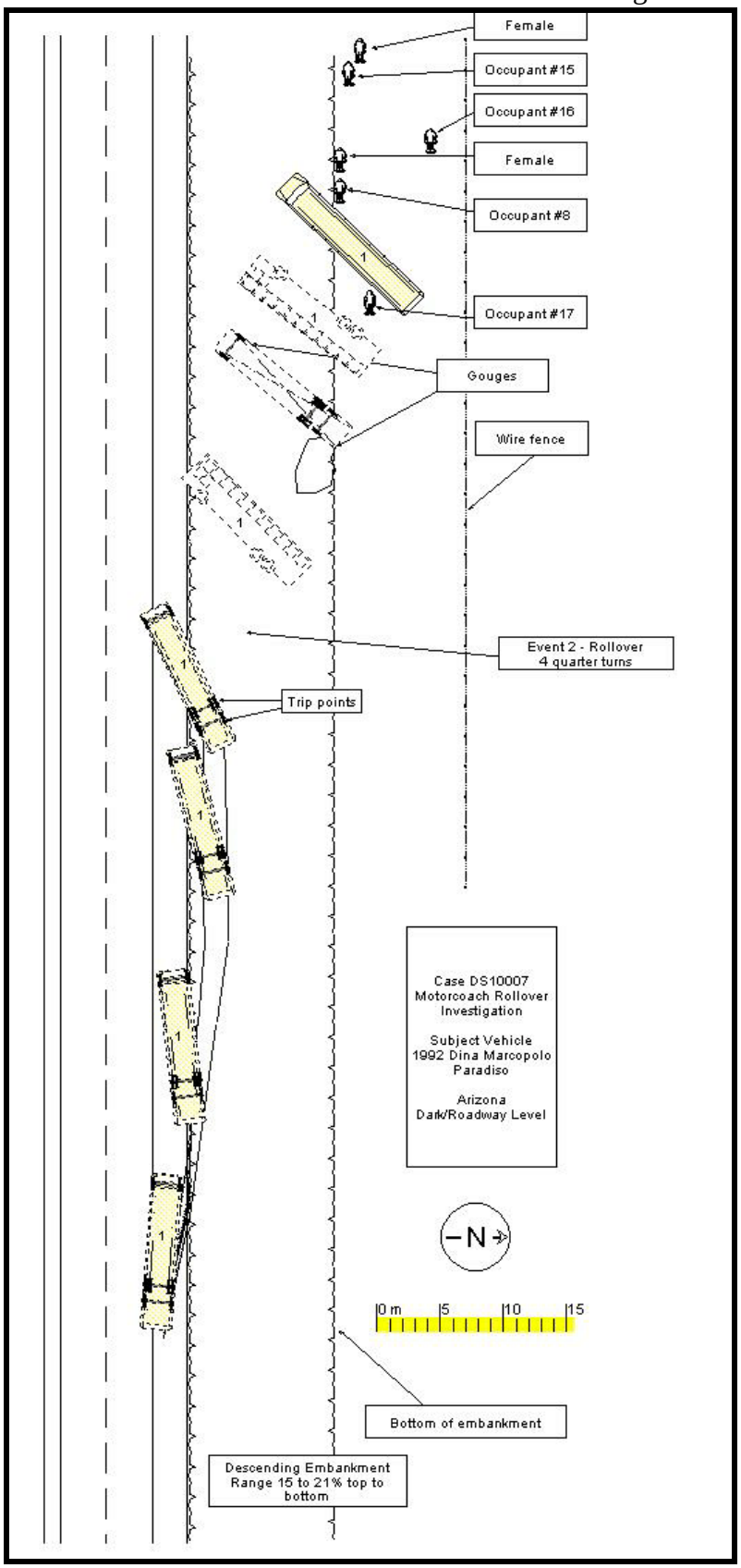
Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Right leg fracture	852002.2,1	Unknown	Unknown
Right wrist fracture	751800.2,1	Unknown	Unknown

Occupant 22: Injuries obtained from police report.

Injury	Injury Severity (AIS 2005)	Injury Mechanism	Confidence Level
Contusions, arms	710402.1,3	Ground	Possible
Contusions, leg	810402.1,9	Ground	Possible
Contusions, torso	410402.1,9	Ground	Possible

Attachment 1. Scene Diagram




Female
Occupant #15
Occupant #16
Female
Occupant #8
Occupant #17
Gouges
Wire fence
Event 2 - Rollover
4 quarter turns
Trip points
Case DS10007
Motorcoach Rollover
Investigation
Subject Vehicle
1992 Dina Marcopolo
Paradiso
Arizona
Dark/Roadway Level
N
0 m
5
10
15
Bottom of embankment
Descending Embankment
Range 15 to 21% top to
bottom

Attachment 2: Seating Diagram