

Bus Crash Investigation / Vehicle to Vehicle
Dynamic Science, Inc. / Case Number: DS03009
1998 Dina Autobus Viaggio 1000 tour bus
California
March, 2003

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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 <p>This on site investigation focused on the performance of a 1998 Dina Autobus Viaggio 1000 tour bus that was involved in a six vehicle crash. This chain reaction crash occurred in March 2003 at 1520 hours in southern California. The crash occurred on an interstate highway. The case vehicle was a 1998 Dina Autobus Viaggio 1000 motor coach (Bus1) being driven by a lap and shoulder belt restrained male. The first other vehicle in the case was an MCI J4500 motor coach (Bus 2). There were a total of 104 people on board the two buses. The second other vehicle is a 2003 Ford Expedition. The third other vehicle was a 2001 Chevrolet Blazer driven by a 46-year-old male. The fourth other vehicle was an unknown make/model automobile. The fifth other vehicle was a 1999 Chrysler Sebring. All six vehicles were traveling southbound in the same lane traveling approximately 89 km/h (55 mph). The vehicles were in the following order, starting from the rear going forward: Bus 1, Bus 2, Ford Expedition, Chevrolet Blazer, unknown automobile, and Chrysler Sebring. The driver of the Ford Expedition slowed due to heavy traffic. Bus 2 did not stop fast enough and rear-ended the Expedition. Bus 2 was then struck in the rear by Bus 1. This impact pushed Bus 2 and the Expedition forward. The Expedition then struck the Chevrolet Blazer, which was then pushed into the rear of the unknown automobile, which was then pushed into the rear of the Chrysler Sebring. There were approximately 104 injured persons with injuries ranging from major to minor.</p>					
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**Dynamic Science, Inc.
Accident Investigation
Case Number: DS03009**

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BACKGROUND

This on site investigation focused on the performance of a 1998 Dina Autobus Viaggio 1000 tour bus that was involved in a six vehicle crash. This chain reaction crash occurred in March 2003 at 1520 hours in southern California. The crash occurred on an interstate highway. The roadway was under construction at the time of the crash. The posted speed limit is 113 km/h (70 mph). The case vehicle was a 1998 Dina Autobus Viaggio 1000 motor coach (Bus1) being driven by a lap and shoulder belt restrained male. The first other vehicle in the case was an MCI J4500 motor coach (Bus 2). This vehicle was being driven by a 59-year-old male. There were a total of 104 people on board the two buses. The second other vehicle was a 2003 Ford Expedition driven by a 32-year-old male. The third other vehicle is a 2001 Chevrolet Blazer driven by a 46-year-old male. The fourth other vehicle was an unknown make/model automobile. The fifth other vehicle is a 1999 Chrysler Sebring driven by a 60-year-old female. All six vehicles were traveling southbound in the same lane traveling approximately 89 km/h (55 mph). The vehicles were in the following order, starting from the rear going forward: Bus 1, Bus 2, Ford Expedition, Chevrolet Blazer, unknown automobile, and Chrysler Sebring. The driver of the Ford Expedition slowed due to heavy traffic. Bus 2 did not stop fast enough and rear-ended the Expedition. Bus 2 was then struck in the rear by Bus 1. This impact pushed Bus 2 and the Expedition forward. The Expedition then struck the Chevrolet Blazer, which was then pushed into the rear of the unknown automobile, which was then pushed into the rear of the Chrysler Sebring. There were approximately 104 injured persons with injuries ranging from major to minor.



Figure 1. Case vehicle (Bus 1)



Figure 2. Other vehicle (Bus 2)

This case was identified from a variety of on-line news sources. The Office of Crashworthiness Standards requested SCI involvement. The case was assigned to DSI on March 11, 2003. The case vehicle was inspected on April 4, 2003.

SUMMARY

Crash Site

This six vehicle crash occurred on a straight section of a north/south interstate highway. At this location there was a slight down grade. There was construction activity going on throughout this area. The original southbound lanes had been closed for construction and southbound traffic had been diverted onto the northbound road bed. A concrete median barrier separated the northbound from the southbound lanes. All vehicles were traveling in the left southbound lane.

The weather was clear and the roadway was dry. The posted speed limit is 113 km/h (70 mph).

Pre Crash

This six-vehicle chain reaction crash occurred in March, 2003 at 1520 hours in southern California. The crash occurred on an interstate highway. The roadway was under construction at the time of the crash. The posted speed limit is 113 km/h (70 mph).

The case vehicle was a 1998 Dina Autobus Viaggio 1000 motor coach (Bus1) being driven by a lap and shoulder belt restrained male. There were a total of 54 occupants, including the driver, on board the bus. The first other vehicle in the case was an MCI J4500 motor coach (Bus 2). This vehicle was being driven by a 59-year-old male. There were a total of 50 people on the second bus.

The second other vehicle is a 2003 Ford Expedition driven by a 32-year-old male. There were six additional occupants in this vehicle. The third other vehicle is a 2001 Chevrolet Blazer driven by a 46-year-old male. The fourth other vehicle is an unknown make/model automobile. The fifth other vehicle is a 1999 Chrysler Sebring driven by a 60-year-old female. There were three additional occupants in this vehicle.

All six vehicles were traveling southbound in the same lane traveling approximately 89 km/h (55 mph). The vehicles were in the following order, starting from the rear going forward: Bus 1, Bus 2, Ford Expedition, Chevrolet Blazer, unknown automobile, and Chrysler Sebring.

Crash

The driver of the Ford Expedition slowed due to heavy traffic. Bus 2 did not stop fast enough and rear-ended the Expedition. Bus 2 was then struck in the rear by Bus 1. This impact pushed Bus 2 and the Expedition forward into the Expedition again. The Expedition then struck the Chevrolet Blazer, which was then pushed into the rear of the unknown automobile, which was then pushed into the rear of the Chrysler Sebring.

Post Crash

For the case vehicle (Bus 1) there were a total of 12 passengers who sustained “A” injuries (Severe Injury), 13 who sustained “B” injuries (Other Visible Injury), and 28 who sustained “C” injuries (Complaint of Pain). All but 10 of the 28 “C” injury occupants were transported to local hospitals for treatment. This group of 10 was transported from the scene by the police to either their homes or other non medical locations. Injury and interview data was obtained from the 13 most seriously injured persons as shown in the following table:

Table 1. Overview of Occupant Injuries

Occupant No.	Seat location	Age/Sex	Injuries
1	Driver	49/Male	Meniscus tear, right knee. Dislocation, right knee. Laceration, anterior and posterior cruciate with complete disruption, right knee. Patellar tendon laceration, right.
2	Row 1, Seat 1	41/Female	Comminuted/displaced fracture right ulna, comminuted fracture right femur, contusion right forearm, laceration to right lower leg, abrasion to right forearm.
3	Row 2, Seat 2	53/Female	Comminuted fractures, right fibula and right tibia. Lacerations, right lower leg.
4	Row 3, Seat 1	62/Female	Maxillary sinus fracture, nose fracture, contusion right thigh.
5	Row 4, Seat 1	72/Female	Left shoulder dislocation.
6	Row 5, Seat 2	72/Female	Displaced/comminuted fracture, right tibia. Lateral/medial meniscus tear.
7	Row 6, Seat 1	58/Female	Displaced/comminuted fracture, right acetabulum.
8	Row 9, Seat 1	61/Female	Left fibula fracture, cervical strain, lumbar strain.
9	Row 9, Seat 3	47/Male	Contusions, right ankle and foot.
10	Unknown	66/Female	Contusion, lower back and right side of chest.
11	Unknown	59/Female	Fracture, bimalleolar, left fibula. Fracture, left tibia. Abrasions right knee.
12	Unknown	77/Male	Fracture, left tibia. Laceration, left foot.
13	Unknown	79/Female	Bilateral fibula fractures, right tibia fracture.

VEHICLE DATA - 1998 Dina Autobus Viaggio 1000 tour bus

The Viaggio 1000 motor coach (Bus 1) was identified by the Vehicle Identification Number (VIN): 3ABBBFHA9WSxxxxxx. The bus was manufactured in 1998. The vehicle was equipped with a Detroit Diesel model Series 60, in line six cylinder 12.7 liter diesel engine that was coupled to an Allison automatic transmission. The vehicle was also equipped with power steering and a tilt/telescoping steering column. The manual throttle was supplemented with an original manufacture electronic cruise control system. Three rocker type cruise control switches (CRUISE, SET, RESUME/ACCEL) were mounted in the left instrument panel. At the time of the police inspection, the cruise control power switch was found in the ON position. The bus had a gross vehicle weight rating of 20,866 kg (46,000 lbs). It was equipped with dual rear tires with a tag axle. The vehicle was equipped with eight 12R/22.5 steel belted radial tires. The bus was equipped with Kumho All Steel 955 tires for the left front, right front, second axle left outboard and second axle right inboard positions; a Hankook F26A tire for the second axle inboard position, a Yokohama RY023 tire for the second axle right outboard position, a Michelin XZ2 tire for the third axle left position, and a General Ameri MSL for the third axle right position. The recommended tire pressure was 758 kPa (110 psi) for front singles, 655 kPa (95 psi) for dual rears, and 655 kPa (95 psi) for single rears. The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
Left front	779 kPa (113 psi)	13 mm (16/32 in)	N	N
Right front	283 kPa (41 psi)	10 mm (12/32 in)	N	N
Axle #2 left outboard	90 psi	10 mm (13/32 in)	N	N
Axle #2 left inboard	Unknown	3 mm (4/32 in)	N	N
Axle #2 right outboard	662 kPa (96 psi)	10 mm (13/32 in)	N	N
Axle #2 right inboard	Unknown	10 mm (12/32 in)	N	N
Axle #3 left	641 kPa (93 psi)	6 mm (8/32 in)	N	N
Axle #3 right	634 kPa (92 psi)	8 mm (10/32 in)	N	N

There was seating for 52 passengers, 1 tour guide, and the driver. The left side included 14-rows of dual seat units. The right side included 12 rows of dual seat units. Each seat was forward facing, cloth covered, had a high back, and was able to be reclined. The seat units were attached

to the side of the vehicle with two bolted clamps and to the floor by stanchions bolted to the floor board. There were overhead luggage racks running the entire length of the bus on both sides. There were six TV/VCR monitors; three on each side. There were six window exits. There was a single restroom in the right rear of the bus behind the row 12 seats. There was 434,065 km (269,716 miles) on the odometer at the time of the vehicle inspection.

VEHICLE DAMAGE

Exterior Damage - 1998 Dina Autobus Viaggio

The vehicle sustained substantial front end damage. The right bumper/frame rail failed and the right sliding door and stairwell were compressed to the B pillar area. The front bus body panels were crushed and pushed upward and rearward. The hydraulic lines, brake lines and electrical wiring were exposed and crushed rearward. The forward portion of the roof was cracked and torn away.

Interior Damage - 1998 Dina Autobus Viaggio

There was intrusion throughout the front end—most of which was to the front right stairwell and the roof/windshield header area. The steering wheel was deformed and the column fractured at the base.

All the passenger seat units (with the exception of the left side row 14 seat unit and the right side row 12 unit) failed to one extent or another (see Table 2). There were three types of failures: complete separation on the outboard side, partial separation on the inboard side, and complete separation on the inboard side. All the failed seats separated on the outboard side. This caused the seat to begin to pivot forward (clockwise on the left, counterclockwise on the right) about the floor mounted stanchion. In most cases the seat rotated at least 45 degrees. Many of the seats showed evidence of occupant loading from the rear. As the movement continued, the stanchions began to separate from the floor. It appears that nine of the seat units completely separated from the vehicle.



Figure 3. Front left, case vehicle



Figure 4. Exemplar view of case vehicle

The passenger seats were composed of a seat frame containing two individual seat positions; each position had a seat bottom cushion, an integral headrest, and an armrest. The seat frame was attached to an aluminum track on the interior sidewall by two C-clamps. A single pedestal offset from the frame center was attached to the floor track by two T-bolt fasteners. The seating was designed so that the seating arrangement can be changed (number of seats and distance between rows). The seats can essentially be moved forward and backward after the bolts are loosened.



Figure 5. Inboard seat unit pedestal, partial separation



Figure 6. Outboard seat unit attachment



Figure 7. Looking towards rear of bus (shows seat rotation)



Figure 8. Exemplar view, looking towards rear of bus



Figure 9. Example of occupant loading from the rear

Table 2. Seat Unit Movement

Left		Right	
Row	Separation status	Row	Separation status
1	C	1	C
2	C	2	D
3	C	3	D
4	C	4	D
5	D	5	D
6	C	6	C
7	C	7	B
8	C	8	D
9	C	9	D
10	C	10	D
11	C	11	D
12	C	12	A
13	C		
14	A		

- A. No movement
- B. Rotated, still attached to both sides
- C. Rotated, detached on outboard side, attached on inboard side
- D. Separated and out of vehicle

Other vehicle

Description:	2001 MCI J4500 bus	
VIN:	1M83JMPA91Pxxxxxx	
Odometer:	Digital, unknown	
Engine:	12.7 liter, six cylinder diesel	
Reported Defects:	None	
Cargo:	Unknown	
Damage Description:	Minor contact and induced damage to front bumper from impact with Ford Expedition. Heavy damage to rear end from impact with case vehicle.	
CDC:	NA	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Other vehicle

Description:	2003 Ford Expedition sport utility vehicle (rental fleet vehicle)	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Per the police report: the rear tailgate/hatch was crushed forward with scrapes and gouges across the tailgate skin. There were white paint smudges from the bus. The rear window glass was shattered. The rear bumper was crushed forward. The plastic bumper cover was gouged and scraped. Both left and right taillight assemblies were cracked. The right and left rear quarter panels were buckled.	
CDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Other vehicle

Description:	2001 Chevrolet Blazer	
VIN:	1GNCS13W71Kxxxxxx	
Odometer:	Unknown	
Engine:	4.4 liter, V6	
Reported Defects:	None noted	
Cargo:	Unknown	
Damage Description:	Per police report: the tailgate/hatch was crushed forward with scrapes and gouges across the tailgate skin. There were silver paint smudges across the rear tailgate. The rear window glass was shattered. The plastic bumper cover was gouged and scraped. Both left and right taillight assemblies were cracked. The right and left rear quarter panels were buckled. The front bumper was crushed rearward. The front grille was broken and the radiator pushed back. The hood was crumpled rearward and upward. The right front headlight was broken.	
CDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Other vehicle

Description:	Unknown automobile	
VIN:	Unknown	
Odometer:	Unknown	
Engine:	Unknown	
Reported Defects:	Unknown	
Cargo:	Unknown	
Damage Description:	Unknown, fled from scene	
CDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Other vehicle

Description:	1999 Chrysler Sebring	
VIN:	4C3AU52N7XExxxxxx	
Odometer:	Unknown	
Engine:	2.5 liter, 4 cylinder	
Reported Defects:	None	
Cargo:	Unknown	
Damage Description:	Per police report: rear bumper was crushed forward. The trunk lid was crushed and buckled forward with scrapes and gouges across its surface. The rear fenders were crushed and buckled. The taillight assemblies were damaged.	
CDC:	Unknown	
Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

Occupants

<u>Case vehicle (Dina bus)</u>	Occupant 1	Occupant 2	Occupant 3
Age/Sex:	49/Male	41/Female	53/Female
Seated Position:	Driver	Row 1, Seat 1	Row 2, Seat 2
Seat Type:	Pedestal	Bench with separate back cushions	Bench with separate back cushions
Height:	180 cm (71 in)	168 cm (66 in)	163 cm (64 in)
Weight:	108 kg (238 lbs)	84 kg (185 lbs)	134 kg (295 lbs)
Occupation:	Bus driver	Unknown	Unknown
Pre-existing Medical Condition:	Back problems. Takes Cortisone shots for the pain.	Hypertension	Hypertension
Alcohol/Drug Involvement:	None	NA	NA
Driving Experience:	Five years (buses)	NA	NA
Body Posture:	Upright	Upright	Upright
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Right foot on brake, left on floor	Unknown	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report	None	None
Air bag:	None available	NA	NA

	Occupant 4	Occupant 5	Occupant 6
Age/Sex:	62/Female	72/Female	72/Female
Seated Position:	Row 3, Seat 1	Row 4, Seat 1	Row 5, Seat 2
Seat Type:	Bench with separate back cushions	Bench with separate back cushions	Bench with separate back cushions
Height:	160 cm (63 in)	165 cm (65 in)	155 cm (61 in)
Weight:	76 kg (167 lbs)	82 kg (180 lbs)	77 kg (169 lbs)
Occupation:	Unknown	Not working	Not working
Pre-existing Medical Condition:	None	None noted	None noted
Alcohol/Drug Involvement:	NA	NA	NA
Driving Experience:	NA	NA	NA
Body Posture:	Upright	Upright	Upright
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:	None	None	None

	Occupant 7	Occupant 8	Occupant 9
Age/Sex:	58/Female	61/Female	47/ Male
Seated Position:	Row 6, Seat 1	Row 9, Seat 1	Row 9, Seat 3
Seat Type:	Bench with separate back cushions	Bench with separate back cushions	Bench with separate back cushions
Height:	165 cm (65 in)	168 cm (66 in)	183 cm (72 in)
Weight:	91 kg (200 lbs)	86 kg (190 lbs)	93 kg (205 lbs)
Occupation:	Unknown	Not working	Unknown
Pre-existing Medical Condition:	Hyperglycemia, end-stage renal disease	None noted	None
Alcohol/Drug Involvement:	NA	NA	NA
Body Posture:	Upright	Upright	Upright
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:	None	None	None

	Occupant 10	Occupant 11	Occupant 12
Age/Sex:	66/Female	59/Female	77/Female
Seated Position:	Unknown	Unknown	Unknown
Seat Type:	Bench with separate back cushions	Bench with separate back cushions	Bench with separate back cushions
Height:	Unknown	Unknown	Unknown
Weight:	Unknown	Unknown	Unknown
Occupation:	Not working	Unknown	Not working
Pre-existing Medical Condition:	None	None	Asthma
Alcohol/Drug Involvement:	NA	NA	NA
Body Posture:	Upright	Upright	Upright
Hand Position:	Unknown	Unknown	Unknown
Foot Position:	Unknown	Unknown	Unknown
Restraint Usage:	None	None	None

	Occupant 13
Age/Sex:	79/Female
Seated Position:	Unknown
Seat Type:	Bench with separate back cushions
Height:	Unknown
Weight:	Unknown
Occupation:	Not working
Pre-existing Medical Condition:	Alzheimer's disease, constipation
Alcohol/Drug Involvement:	NA
Body Posture:	Upright
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	None

<u>Other vehicle (MCI bus)</u>	Driver
Age/Sex:	58/Male
Seated Position:	Front left
Seat Type:	Unknown
Height:	173 cm (68 in)
Weight:	75 kg (165 lbs)
Occupation:	Bus driver
Pre-existing Medical Condition:	Unknown
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report

<u>Other vehicle (Expedition)</u>	Driver
Age/Sex:	32/Male
Seated Position:	Front left
Seat Type:	Unknown
Height:	188 cm (74 in)
Weight:	81 kg (178 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report

Other vehicle (Blazer)

Age/Sex:	46/Male
Seated Position:	Front left
Seat Type:	Unknown
Height:	185 cm (73 in)
Weight:	122 kg (270 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report

Other vehicle (Chrysler)

Age/Sex:	60/Female
Seated Position:	Front left
Seat Type:	Unknown
Height:	163 cm (64 in)
Weight:	57 kg (125 lbs)
Occupation:	Unknown
Pre-existing Medical Condition:	None noted
Alcohol/Drug Involvement:	None
Driving Experience:	Unknown
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt used, per police report

Injuries and Injury Mechanisms

Case vehicle

Driver (01): Injuries obtained from Emergency Room Report, Post ER medical records, Discharge Summary and Radiology Records. Arrived with a GCS score of 14. Driver was hospitalized for two days.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Abrasions, right forearm	790202.1,1	Unknown	Unknown
Abrasions, left elbow	790202.1,2	Unknown	Unknown
Dislocation, involving articular cartilage, right knee	850814.2,1	Lower instrument panel	Probable
Meniscus tear, right knee	850822.2,1	Lower instrument panel	Probable
Laceration(total transection), patellar tendon, right knee	841004.2,1	Lower instrument panel	Probable
Contusion, right tibia	853402.1,1	Lower instrument panel	Probable
Laceration, collateral ligament, right knee	840404.2,1	Lower instrument panel	Probable
Contusion, right patella	not codable	Lower instrument panel	Probable
Contusion, popliteal artery, right knee	not codable	Lower instrument panel	Probable
Laceration, anterior and posterior cruciate with complete disruption	840406.3,1	Lower instrument panel	Probable

Occupant 02: Injuries obtained from Trauma Center Admit, Operative Report, Post ER medical records, Discharge Summary and Radiology Records. Arrived with a GCS score of 15. Hospitalized for 11 days.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Multiple lacerations (minor), right lower leg	890602.1,1	Interior divider	Probable
Multiple abrasions, right forearm	790202.1,1	Interior divider	Probable

Fracture, comminuted/displaced, right ulna	753204.3,1	Interior divider, indirect	Probable
Fracture, comminuted, right femur(distal, supracondylar)	851822.3,1	Interior divider, indirect	Probable
Contusion(hematoma) right forearm	790402.1,1	Interior divider	Probable

Occupant 03: Injuries obtained from Trauma Center Admit, Operative Report, Discharge Report and Radiology Records. Hospitalized for four days.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Fracture, comminuted right tibia	853412.2,1	Seat base	Probable
Fracture, comminuted, right fibula	851610.2,1	Seat base	Probable
Lacerations, right lower leg (minor/1 cm, 3 cm)	890602.1,1	Seat base	Probable

Occupant 04: Injuries obtained from Trauma Center Admit, Post ER medical records and Radiology Records.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Fracture, closed, maxillary sinus, left	250802.2,2	Seat back	Probable
Fractures, closed, nose, bilateral	251002.1,4	Seat back	Probable
Contusion, thigh, right	890402.1,1	Seat back	Possible

Occupant 05: Injuries obtained from Trauma Center Admit, Operative Report, Post ER medical records, Discharge Summary and Radiology Records.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Dislocation, closed, left shoulder	751030.2,2	Seat back	Probable

Occupant 06: Injuries obtained from Emergency Room Report, Post ER medical records, and Radiology Records. Hospitalized for nine days.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Fracture, displaced/comminuted, right tibia, condyles (plateau)	853408.3,1	Seat back	Probable
Meniscus tear, lateral, right knee	850822.2,1	Seat back	Probable
Meniscus tear, medial, right knee	850822.2,1	Seat back	Probable

Occupant 07: Injuries obtained from Trauma Center Admit, Operative Report, Post ER medical records, Discharge Summary and Radiology Records. Arrived with a GCS score of 15. Hospitalized for 12 days.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Fracture, displaced/comminuted, acetabulum (pelvis), right	852604.3,1	Seat back, indirect	Probable

Occupant 08: Injuries obtained from Trauma Center Admit, Operative Report, Post ER medical records, Discharge Summary and Radiology Records. Hospitalized for one day.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Fracture, trimalleolar, left fibula	851612.2,2	Seat back	Probable
Cervical strain	640278.1,6	Seat back	Probable
Lumbar strain	640678.1,8	Seat back	Probable

Occupant 09: Injuries obtained from Emergency Room and Radiology Records. Arrived with a GCS score of 15. Treated and released.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Contusion, right ankle	850202.1,1	Seat back	Probable
Contusion, right foot	890402.1,1	Seat back	Probable

Occupant 10: Injuries obtained from Emergency Room Report, Post ER medical records, Discharge Summary and Radiology Records. Treated and released.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Contusion, lower back	690402.1,0	Unknown	Unknown
Contusion, chest, right	490402.1,1	Seat back	Possible

Occupant 11: Injuries obtained from Trauma Center Report, Post ER medical records, and Radiology Records.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Fracture, displaced, left humerus	752604.3,2	Unknown	Unknown

Occupant 12: Injuries obtained from Trauma Center Admit, Operative Report, Post ER medical records, Discharge Summary and Radiology Records. Arrived with a GCS score of 15.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Laceration, minor(5 cm) left foot	890602.1,2	Seat bottom	Probable
Fracture, medial malleolus (tibia) left	853412.2,2	Seat bottom	Probable

Occupant 13: Injuries obtained from Physical Examination, Operative Report, Post ER medical records, Discharge Summary and Radiology Records. Hospitalized for 23 days.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Fracture, displaced, tibia, right	853422.3,1	Seat back	Probable
Fracture, displaced, fibula, right	851610.2,1	Seat back	Probable
Fracture, comminuted/displaced, fibula, left	851610.2,2	Seat back	Probable

Occupant Kinematics

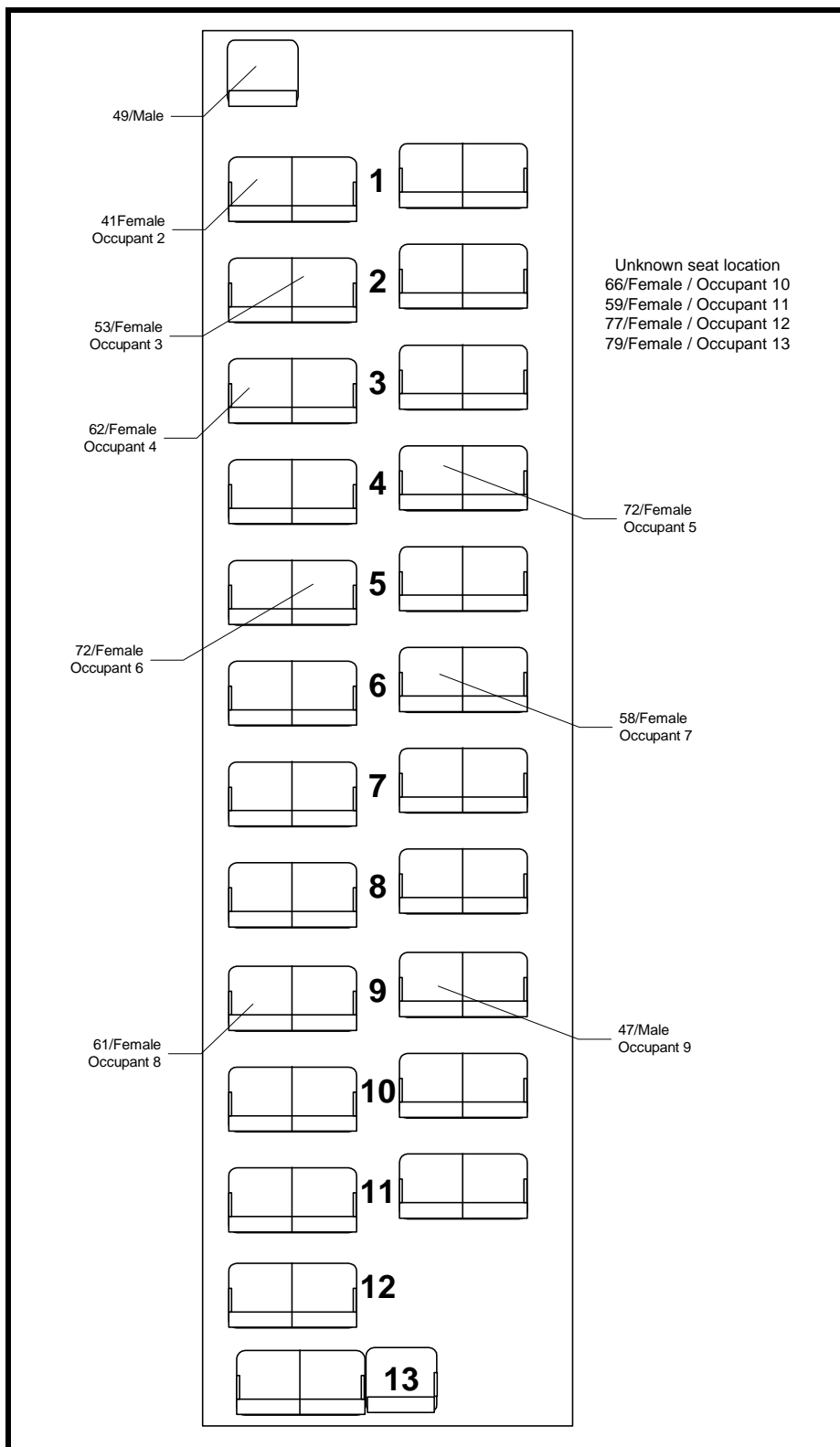


Figure 10. Occupant positions

Driver Kinematics

The 49-year-old male driver was seated in an upright posture and was restrained by the 3-point manual lap and shoulder belt. He was using the cell phone at the time of the crash. At impact, he initiated a forward trajectory. He loaded the lap and shoulder belt. The driver's knees and lower legs engaged the intruding lower instrument panel causing multiple knee joint injuries. He was entrapped in the vehicle and required extrication. He was transported from the scene to a local trauma center. He arrived with a GCS score of 14. He was hospitalized for two days.

Occupant 2 Kinematics

The 41-year-old female seated in bus row 1 in the left window seat was not restrained. At impact, she initiated a forward trajectory and engaged the wall that separates the driver from the passengers with her arms and knees. She sustained an indirect femur fracture and an indirect ulna fracture, in addition to minor contusions and lacerations to her lower and upper extremities. She was removed from the vehicle by rescue personnel due to her injuries. She was transported to a local trauma center by air. She arrived with a GCS score of 15. She was hospitalized for 11 days.



Figure 11. Driver seated position

Occupant 3 Kinematics

The 53-year-old female seated in bus row 2 in the left aisle seat was not restrained. At impact, she initiated a forward trajectory and engaged the seat base in front of her with her right lower leg, causing a comminuted tibia/fibular fracture. She was entrapped in the vehicle by seats that came loose during the crash. She was transported from the scene to a local trauma center where she was hospitalized for four days.



Figure 12. Contacts to separating wall–row 1, left seat–Occupant 2

Occupant 4 Kinematics

The 62-year-old female seated in bus row 3 in the left window seat was not restrained. At impact, she initiated a forward trajectory and engaged the seat back with her face, causing nasal and sinus fractures. She was transported to an area trauma center where she was hospitalized for one day.

Occupant 5 Kinematics

The 72-year-old female seated in bus row 4 right aisle seat. She was not restrained. At impact, she initiated a forward trajectory and engaged the seat back with her left shoulder, causing a left shoulder dislocation. She was transported to an area trauma center where she was hospitalized for one day.



Figure 13. Typical seat movement

Occupant 6 Kinematics

The 72-year-old female seated in bus row 5 left aisle seat was not restrained. At impact, she initiated a forward trajectory and engaged the seat back with her right leg and knee. She sustained lateral and medial meniscus tears to the right knee and a displaced/comminuted fracture to the right tibia. She was transported to an area trauma center where she was hospitalized for nine days.



Figure 14. Common injury contact pattern (seat back and seat base)

Occupant 7 Kinematics

The 58-year-old female seated in bus row 6 right aisle seat was not restrained. At impact, she initiated a forward trajectory and engaged the seat back with her right knee, causing indirect displaced/comminuted fracture to the right acetabulum. She was transported to an area trauma center. She arrived with a GCS of 15 and was hospitalized for 12 days.

Occupant 8 Kinematics

The 61-year-old female seated in bus row 9 left window seat was not restrained. At impact, she initiated a forward trajectory and engaged the seat back with her left lower leg, causing a fibula fracture. She was transported to an area trauma center where she was hospitalized for one day.

Occupant 9 Kinematics

The 47-year-old male seated in bus row 9 right aisle seat was not restrained. At impact, he initiated a forward trajectory and engaged the seat back with his right foot, causing foot and ankle contusions. He was transported to a local hospital where he was treated and released.

Occupant 10-13 Kinematics

By design, none of these bus passengers were restrained. Their exact seat positions are not known. The motion of the passengers at impact was essentially straight forward. These injured passengers either engaged the seat back of the seat in front of them or the rigid seat bottom. Most of the injuries were either to the lower limbs or to the face.

