

Vehicle Defect - Tour Bus Investigation / Vehicle to Object
Dynamic Science, Inc. / Case Number: DS04014
1997 Van Hool tour bus
Arizona
June 2004

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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>The focus of this on site investigation was the performance of the brake system on a 1997 Van Hool tour bus. This single vehicle crash occurred in June 2004 at 0430 hours in an urban area of southern Arizona. The crash occurred at the end of a T intersection. The case vehicle was a 1997 Van Hool 45-foot over the road coach. It has a 49 passenger seating capacity. There were 40 persons on board at the time of the crash. The driver was a 42-year-old male who had been driving for this company for approximately one month. As the bus departed the interstate it failed to make its turn onto a local street due to brake failure. The bus continued forward traveling eastward. There were multiple tire/curb impacts. The vehicle continued forward striking the following objects: a wooden railroad tie fence, the first chain link fence, the second chain link fence, and finally the first metal storage structure. The storage structure was penetrated and then pushed rearward approximately 3.0 m (10 ft) and rotated clockwise. A third chain link fence which ran in an east/west direction was torn down due to the impact with structure. As the structure went rearward is struck a second structure and pushed it rearward. This second structure struck the right side of the parked van and then pushed that vehicle into a second parked vehicle. There were two fatalities in this crash, one of which was the driver.</p>				
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**Dynamic Science, Inc.
Crash Investigation
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BACKGROUND

The focus of this on site investigation was the performance of the brake system on a 1997 Van Hool tour bus.

This single vehicle crash occurred in June, 2004 at 0430 hours in an urban area of southern Arizona. The weather was clear and dry. It was dark at the time of the crash and the streetlights were on. The crash occurred at the end of a T intersection. The case vehicle was a 1997 Van Hool 45-foot over the road coach. It has a 49 passenger seating capacity. There were 40 persons on board at the time of the crash. The driver was a 42-year-old male who had been driving for this company for approximately one month. The bus had departed Los Angeles, California (600 km/373 miles distant) the previous evening. The ultimate destination of the bus was El Paso, Texas (1291 km/802 miles distant).

As the bus departed the interstate it failed to make its turn onto a local street due to brake failure. The bus continued forward traveling eastward.

There were multiple tire/curb impacts. The vehicle continued forward striking the following objects: a wooden railroad tie fence, the first chain link fence, the second chain link fence, and finally the first metal storage structure. The storage structure was penetrated and then pushed rearward approximately 3.0 m (10 ft) and rotated clockwise. A third chain link fence which ran in an east/west direction was torn down due to the impact with structure. As the structure went rearward it struck a second structure and pushed it rearward. This second structure struck the right side of the parked van and then pushed that vehicle into a second parked vehicle.

This ODI - Tour Bus Crash Investigation was initiated in response to an Office of Motor Carrier Safety notification to NHTSA. There were two fatalities in this crash. DSI was notified on July 2, 2004. Initial inspections of the case vehicle and scene took place on July 9, 2004. Mechanics under contract with the police completed their mechanical inspection on August 4, 2004. A summary of their report is included as Attachment 2 to this report.

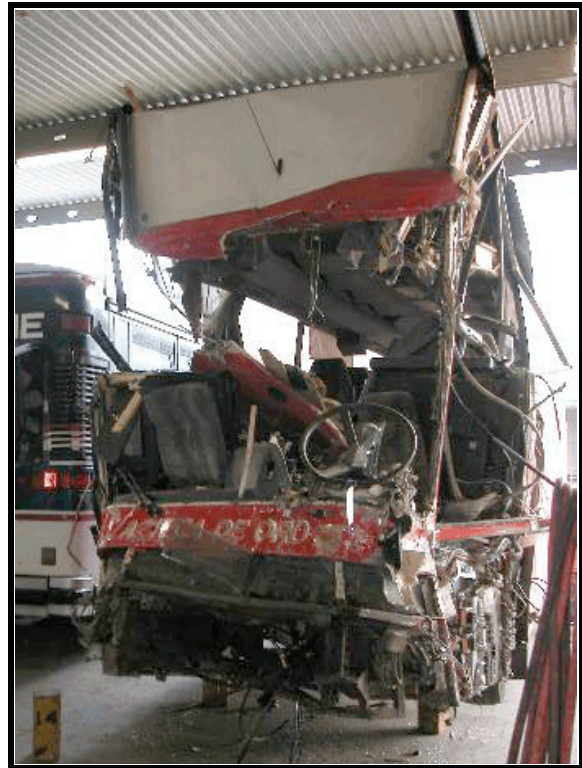


Figure 1. Front, Van Hool coach

SUMMARY

Crash Site

This single vehicle crash occurred in June, 2004 at 0430 hours in an urban area of southern Arizona. The weather was clear and dry. It was dark at the time of the crash and the streetlights were on. The crash occurred at the end of a T intersection. The eastbound approach to the intersection is a three-lane, one-way interstate off-ramp. The left lane is for left turns only, the right for right turns only, and the middle lane for turns in either direction. There is a -1.8% grade approaching the intersection. The north/south intersecting roadway has six lanes and is divided. The eastern edge of the roadway is a concrete curb which is bounded by a concrete sidewalk. The area east of the sidewalk is essentially private property. The property is separated by a railroad tie wooden fence, 5.3 m (17.7 ft) of bare earth, and a chain link fence. Following the chain link fence there is a 4.9 m (16.2 ft) wide ditch. The area east of the ditch is asphalt covered. At a point 18.9 m (61.9 ft) east of the ditch is a second chain link fence/gated area. Immediately east of this point there were two metal storage structures¹, a parked Ford van, and a third vehicle of unknown make and model.



Figure 2. Approach, exit from interstate (east)

Pre-Crash

The case vehicle is a 1997 Van Hool 45-foot over the road coach. The bus is manufactured in Belgium. The body is of monocoque construction², an aluminum roof, galvanized steel side panels, and aluminum luggage doors. It has a 49 passenger seating capacity. There were 40 persons on board at the time of the crash. The driver was a 42-year-old male who had been driving for this company for approximately one month. The bus had departed Los Angeles, California (600 km/373 miles distant) the previous evening. The ultimate destination of the bus was El Paso, Texas (1291 km/802 miles distant).



Figure 3. Final rest

¹Brand name: Mobil Mini. Model Number: Portable Vault (PV) 80. Measured 2.4 m (8 ft) x 6.1 m (20 ft) with an empty weight of 1383 kg (3050 lbs) and a maximum weight of 4105 kg (9050 lbs). Both were reported to be empty at the time of the crash.

²Monocoque (French for "single shell") or unibody is a construction technique that uses the external skinning of an object to form some, or most, of the load-bearing structure.

As the bus departed the interstate it failed to make its turn onto a local street due to brake failure. The bus continued forward traveling eastward at a police estimated speed of 101 km/h (63 mph).

Crash

There were multiple tire/curb impacts. The vehicle continued forward striking the following objects: a wooden railroad tie fence, the first chain link fence, the second chain link fence, and finally the first metal storage structure. The storage structure was penetrated and then pushed rearward approximately 3.0 m (10 ft) and rotated clockwise. A third chain link fence which ran in an east/west direction was torn down due to the impact with structure. As the structure went rearward it struck a second structure and pushed it rearward. This second structure struck the right side of the parked van and then pushed that vehicle into a second parked vehicle.

Post-Crash

There were two fatalities in this crash, one of which was the driver. The driver sustained an intraventricular cerebral hemorrhage, a laceration of the corpus callosum, cerebral cortical contusions, multiple skull fractures, a subgaleal hemorrhage, a subarachnoid hemorrhage, multiple left side rib fractures, a dislocated right ankle, and multiple contusions, abrasions, and lacerations. He was pronounced dead at the scene at 0425 hours. The cause of death was listed as “blunt force trauma due to a bus crash”.

A 60-year-old female was the second fatally injured person. Her seating location is unknown. There were conflicting statements regarding her position. The consensus was that she was in one of the first two rows. This occupant sustained a liver laceration, a right adrenal gland laceration, right side retroperitoneal hemorrhage, bilateral conjunctival hemorrhage, and multiple contusions, abrasions, and lacerations. The cause of death was listed as “multiple injuries due to a bus crash”.

There were 13 additional injured parties. All the injured were taken to local hospitals. The remaining occupants were transported to a local community center where they waited for another bus to take them to their destination. An overview of the police reported injuries is included in the following table.



Figure 4. First metal storage structure



Figure 5. First storage unit, second storage unit, parked van

Table 1. Overview of Additional Occupant Injuries

Age	Sex	Police Injury Severity
62	Female	Incapacitating Injury
52	Female	Non Incapacitating Injury
79	Female	Non Incapacitating Injury
52	Female	Non Incapacitating Injury
36	Female	Non Incapacitating Injury
28	Male	Non Incapacitating Injury
37	Female	Non Incapacitating Injury
57	Female	Non Incapacitating Injury
56	Female	Incapacitating Injury
47	Female	Non Incapacitating Injury
16	Female	Non Incapacitating Injury
51	Female	Non Incapacitating Injury
22	Male	Non Incapacitating Injury
52	Female	Non Incapacitating Injury
27	Female	Non Incapacitating Injury
11	Female	Non Incapacitating Injury
32	Male	Non Incapacitating Injury

Table 1. Overview of Additional Occupant Injuries (continued)

Age	Sex	Police Injury Severity
5	Male	Non Incapacitating Injury
28	Male	Non Incapacitating Injury
7	Female	Non Incapacitating Injury
23	Female	Non Incapacitating Injury
14	Female	Non Incapacitating Injury
42	Female	Non Incapacitating Injury
41	Female	Non Incapacitating Injury
4	Male	Non Incapacitating Injury
10	Male	Non Incapacitating Injury
38	Male	Non Incapacitating Injury
64	Male	Non Incapacitating Injury
60	Female	Non Incapacitating Injury
1	Female	Non Incapacitating Injury
61	Female	Non Incapacitating Injury
14	Male	Non Incapacitating Injury
12	Female	Non Incapacitating Injury
8	Male	Non Incapacitating Injury
4	Male	Non Incapacitating Injury
19	Male	Non Incapacitating Injury
23	Female	Non Incapacitating Injury
54	Female	Non Incapacitating Injury

VEHICLE DATA -1997 Van Hool tour bus

The 1997 Van Hool 45-foot over the road 49 passenger tour bus was identified by the Vehicle Identification Number (VIN): YE2TA76B3U2xxxxxx. The bus was manufactured in Belgium. It was equipped with a Cummins M11 plus diesel engine, an Allison six speed automatic transmission, and a Bendix braking system.

The 1997 Van Hool tour bus was equipped with Sumitomo 315/80R22.5 tires for the front wheels and the first set of rear wheels. The bus was equipped with Firestone FS400 315/80R22.5 tires for the third axle.

The specific tire data is as follows:

Tire	Tread	Pressure	Damage
LF	7 mm (9/32 in)	Flat	Debeaded
LR 1 outer	10 mm (13/32 in)	Unknown	None
LR 1 inner	2 mm (2/32 in)	Unknown	None
LR 2	3 mm (4/32 in)	Unknown	None
RF	11 mm (14/32 in)	Flat	Sidewall holed
RR 1 outer	6 mm (7/32 in)	Unknown	None
RR 1 inner	6 mm (8/32 in)	Unknown	None
RR 2	6 mm (8/32 in)	Unknown	None

VEHICLE DAMAGE

Exterior Damage - 1997 Van Hool tour bus

Damage Description: The Van Hool bus sustained major external damage. The front end was entirely caved in. There was 78 cm (31 in) of crush at the front right corner. Both A pillars and the windshield header were forced rearward causing the roof to buckle upwards. The front right entry way was crushed rearward, with a maximum opening width of 56 cm (22 in) at the bottom and a minimum opening width of 12 cm (5 in) at the belt line. Both front seats were crushed by instrument panel/dash intrusion. The front right tire was flattened and restricted. The left front tire was flattened. There was side swiping type contact damage down the entire right side extending vertically from the frame level to 59 cm (23 in) at the highest point. There was also scraping contacts along the right side undercarriage.

CDC: NA

Delta V:	Total	Unknown
	Longitudinal	Unknown
	Latitudinal	Unknown
	Energy	Unknown

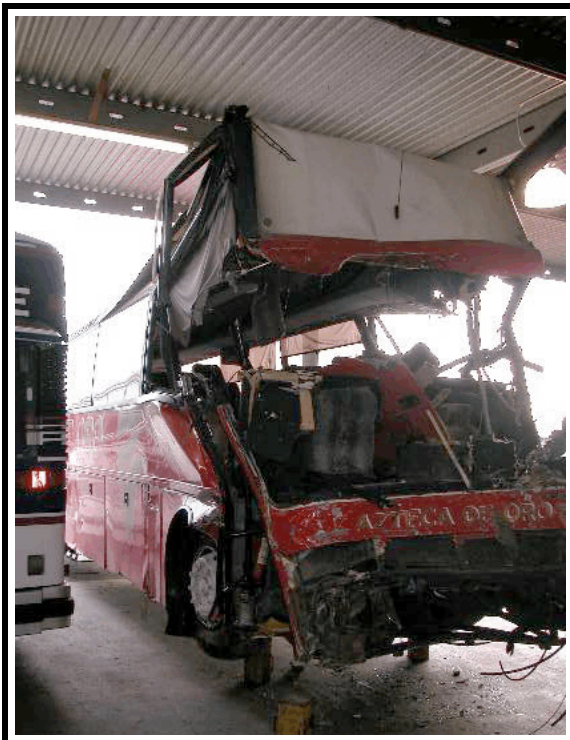


Figure 6. Front right, 1997 Van Hool tour bus



Figure 7. Exemplar view of Van Hool bus



Figure 8. Left side, case vehicle



Figure 9. Right side contact damage



Figure 10. Front right, shows crushed entry way

Interior Damage - 1997 Van Hool tour bus

There was damage to the driver's seat and the front right guide seat due to front end intrusion. There was also damage to a variety of passenger seats due to occupant contact and impact forces. 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 clamps. A single pedestal offset from the frame center was attached to the floor track by two T-bolt fasteners. A summary of seat damage is shown in the table below.

Driver - seat bottom crushed, extrication damage			Aisle	Guide - seat bottom crushed		
1	2 - seat back forward 40.0 cm (15.7 in)			3 - seat back off	4 - seat back off	
5	6 - seat back forward 46.0 cm (18.1 in)			7 - seat removed	8 - seat removed	
9	10			11	12 - seat back twisted	
13	14 - seat track forward 9.0 cm (3.5 in), seat back forward 22.0 cm (8.7 in)			15	16	
17	18			19 - seat track forward 9.0 cm (3.5 in)	20	
21	22 - seat back forward 25.0 cm (9.8 in)			23	24	
25	26			27	28	
29	30			31 - seat back forward 39.0 cm (15.3 in), seat track forward 6.0 cm (2.4 in)	32	
33	34 - seat back forward 42.0 cm (16.5 in), seat track forward 12.0 cm (4.7 in)			35	36	
37	38			39 - seat track forward 18.0 cm (7.1 in)	40	
41	42 - seat back forward 55.0 cm (21.7 in)			43	44	
45	46			Restroom		
47	48 - seat bottom off	49 - seat bottom off				



Figure 11. Bus row 1, left aisle seat



Figure 12. Example of seat back deformation. Bus row 2, aisle seat

OCCUPANT DEMOGRAPHICS - 1997 Van Hool tour bus

	Driver	Occupant 2
Age/Sex:	42/Male	60/Female
Seated Position:	Front left	Unknown. In one of the front rows.
Seat Type:	Fabric covered bucket seat	Fabric covered bench seat with separate back cushions
Height:	160 cm (63 in)	160 cm (63 in)
Weight:	68 kg (149 lbs)	66 kg (146 lbs)
Occupation:	Bus driver	Unknown
Pre-existing Medical Condition:	None noted	Chronic hepatitis
Alcohol/Drug Involvement:	None	NA
Driving Experience:	Unknown	NA
Body Posture:	Presumed upright	Unknown
Hand Position:	Unknown	Unknown
Foot Position:	Right foot believed to be on brake	Unknown
Restraint Usage:	None used, per police report	None
Air bag:	Not equipped	NA

OCCUPANT INJURIES -1997 Van Hool tour bus

Driver: Injuries obtained from autopsy report.

<u>Injury</u>	<u>OIC Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Abrasion, right arm	790202.1,1	External, metal storage structure	Possible
Contusion, left arm	790402.1,2	External, metal storage structure	Possible
Abrasion, left forearm	790202.1,2	External, metal storage structure	Possible
Abrasion, left elbow	790202.1,2	External, metal storage structure	Possible
Multiple abrasion, left hand	790202.1,2	External, metal storage structure	Possible
Laceration, left hand, minor	790602.1,2	External, metal storage structure	Possible
Multiple abrasion, right hand	790202.1,1	External, metal storage structure	Possible
Abrasion, left arm	790202.1,2	External, metal storage structure	Possible
Multiple abrasions, right thigh	890202.1,1	Steering wheel rim	Possible
Burn, unspecified, right thigh (subepidermal blister)	892000.1,1	Unknown	Unknown
Contusion, right thigh	890402.1,1	Steering wheel rim	Possible
Abrasion, right ankle	890202.1,1	Foot control	Possible
Contusion, right ankle	890402.1,1	Foot control	Possible
Abrasion, right leg	890202.1,1	Left instrument panel	Possible
Multiple abrasions, left thigh	890202.1,2	Steering wheel rim	Possible
Contusion, left lower leg	890402.1,2	Left instrument panel	Possible
Dislocation NFS, right ankle	850210.2,1	Foot control	Possible
Abrasion, chin, left side	290202.1,8	External, metal storage structure	Possible
Multiple rib fractures, L7, L8, L9, L10, L11	450230.3,2	Steering wheel rim	Probable

Abrasion, left ear	290202.1,2	External, metal storage structure	Possible
Laceration, left ear	290602.1,2	External, metal storage structure	Possible
Contusion, right eyelid	297402.1,1	External, metal storage structure	Possible
Multiple abrasions, left periorbital area	297202.1,2	External, metal storage structure	Possible
Multiple abrasions, nose	290202.1,4	External, metal storage structure	Possible
Laceration (major), scalp, left side	190604.2,2	External, metal storage structure	Possible
Intracerebral laceration (corpus callosum) with intraventricular hemorrhage	140688.4,1 140688.4,2	External, metal storage structure	Probable
Multiple, comminuted, basilar fractures, left temporal skull(both squamus and petrous portions)	150206.4,8	External, metal storage structure	Probable
Vault fracture NFS, frontal skull, left side	150400.2,2	External, metal storage structure	Probable
Multiple cerebral contusions NFS, bilateral (left and right temporal lobes, right occipital lobe)	140620.3,3	External, metal storage structure	Probable
Subarachnoid hemorrhage, cerebellum NFS	140466.3,6	External, metal storage structure	Probable
Subarachnoid hemorrhage, cerebrum NFS	140684.3,9	External, metal storage structure	Probable
Subarachnoid hemorrhage NFS, brainstem	140210.5,8	External, metal storage structure	Probable

Occupant 2: Injuries obtained from autopsy report.

<u>Injury</u>	<u>OIL Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Multiple minor abrasions, face	290202.1,0	Unknown	Unknown
Multiple minor lacerations, face	290602.1,0	Unknown	Unknown
Multiple minor contusions, face	290402.1,0	Unknown	Unknown
Contusion(conjunctival petechia), left eyelid, upper and lower	297402.1,2	Unknown	Unknown
Conjunctival hemorrhage, left eye	240416.1,2	Unknown	Unknown
Multiple abrasions, left shoulder	790202.1,2	Unknown	Unknown
Multiple contusions, left shoulder	790402.1,2	Unknown	Unknown
Multiple abrasions, chest	490202.1,0	Unknown	Unknown
Multiple contusions, chest	490402.1,0	Unknown	Unknown
Multiple abrasions, lower back	690202.1,8	Unknown	Unknown
Contusion, lower abdomen	590402.1,8	Unknown	Unknown
Multiple major lacerations (intraparenchymal), liver	541826.4,1	Unknown	Unknown
Laceration NFS, right adrenal gland	540220.1,1	Unknown	Unknown
Retroperitoneum hemorrhage; accompanied by hemorrhages in right kidney, right side pelvis and right adnexa	543800.3,8	Unknown	Unknown
Multiple abrasions, right arm	790202.1,1	Unknown	Unknown
Multiple contusions, right arm	790402.1,1	Unknown	Unknown
Laceration, minor, right hand	790602.1,1	Unknown	Unknown
Multiple abrasions, left arm	790202.1,2	Unknown	Unknown
Multiple contusions, left arm	790402.1,2	Unknown	Unknown
Abrasion, right hand (finger)	790202.1,1	Unknown	Unknown
Multiple contusions, left thigh	890402.1,2	Unknown	Unknown
Multiple contusions, right thigh	890402.1,1	Unknown	Unknown
Multiple abrasions, right knee	890202.1,1	Unknown	Unknown
Multiple abrasions, left knee	890202.1,2	Unknown	Unknown

OCCUPANT KINEMATICS - 1997 Van Hool tour bus

Driver Kinematics

The 42-year-old male driver was seated in an upright posture. According to the police, he was not restrained. Both hands were likely on the steering wheel. His right foot appeared to be on the brake. The seat track position is not known. During the curb and fence impacts there would have been little occupant movement—given the speed and mass of the bus. At impact with the portable storage structure, the driver began a forward trajectory. At this same time, the metal structure began intruding into the passenger compartment. The driver sustained multiple facial and head injuries due to contact with the metal structure as it penetrated into the bus. The driver sustained lower extremity injuries due to contact with the steering wheel rim, the lower instrument panel and the brake pedal. The driver was killed instantly. He was entrapped in the wreckage and it took several hours for rescue personnel to extricate his body.



Figure 13. Overview of driver's seated position

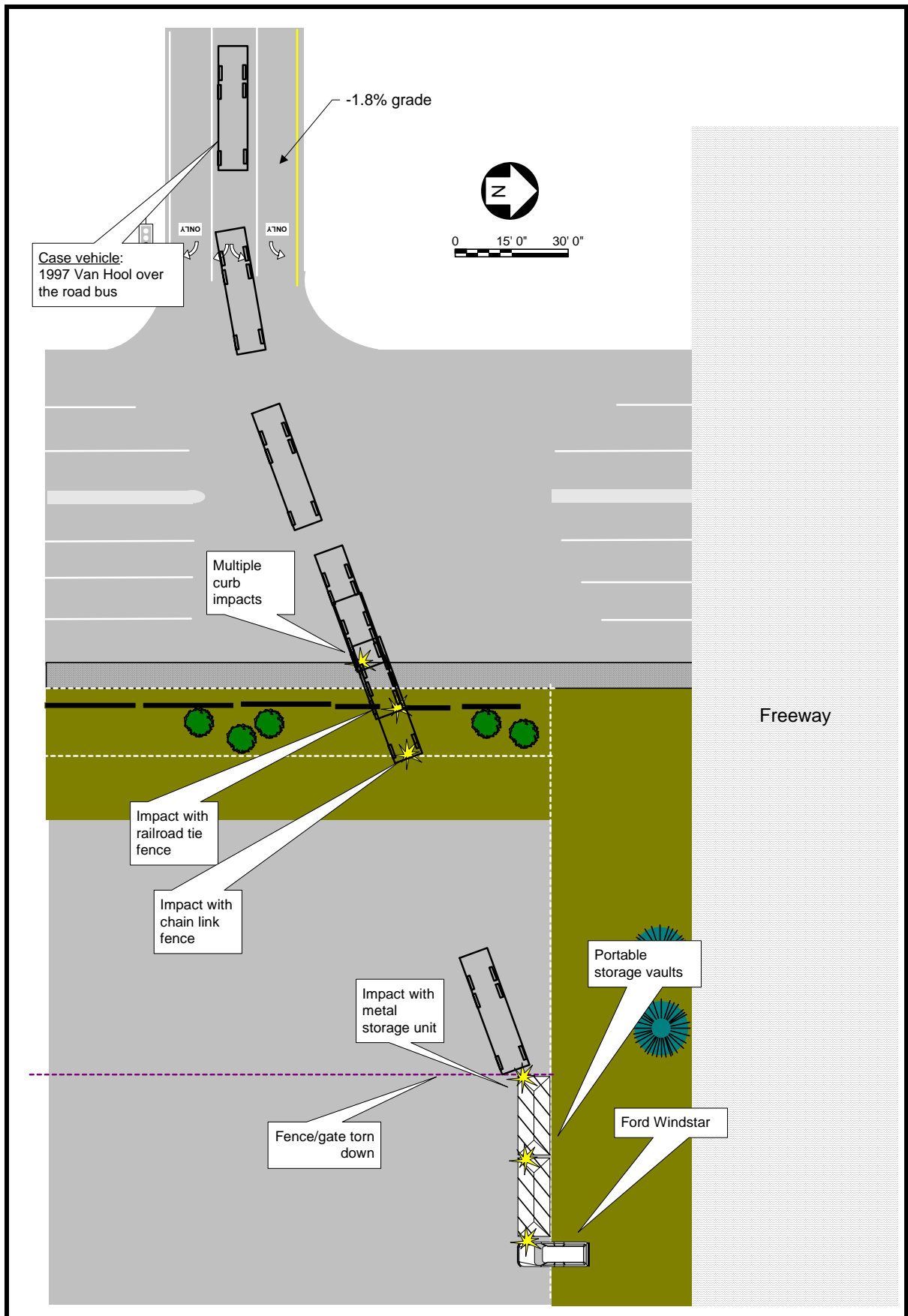
Occupant 2 Kinematics

The 60-year-old female passenger appears to have been seated in one of the front passenger row seats. Her injuries were inconsistent with having been in the tour guide (front right) seat; the seat in this position was crushed. Her kinematics are largely unknown, other than she initiated a forward trajectory during the impact with the portable storage structure.



Figure 14. Exemplar view of driver's seated position

Attachment 1. Scene Diagram



Attachment 2. Summation of bus brake inspection report

The bus had automatic brake adjusters, also known as automatic slack adjusters. Slack adjusters, which link the air brake chamber to the service brake, adjust brakes as necessary to compensate for wear in the brake lining. Manual slack adjusters must be adjusted periodically by hand; automatic slack adjusters adjust automatically while the vehicle is in operation.

<p>Front left:</p> <ul style="list-style-type: none"> • appears that the disc brake has not been making full contact with the rotor—visual: dark streaks left by the brake material instead of a smooth burnished surface • brake throw = 2.0 in (spec is 2.13 in) • pad thickness = 0.735 in (95% of new) • no sign of intense stopping (almost like new) • calipers slide freely—suggesting that the front calipers were worn out of slipping internally 	<p>Front right:</p> <ul style="list-style-type: none"> • appears that the disc brake has not been making full contact with the rotor—visual: dark streaks left by the brake material instead of a smooth burnished surface • brake throw = 2.0 in (spec is 2.13 in) • pad thickness = 0.735 in (95% of new) • no sign of intense stopping (almost like new) • calipers slide freely—suggesting that the front calipers were worn out of slipping internally
<p>Drive axle left:</p> <ul style="list-style-type: none"> • brake throw = 2.0 in • drum within spec • show signs of glazed drum and brake material • when manually adjusting brake throw is 1-3/8 in, however drums will not turn freely without several quarter turns of back off. This suggests that drum is warped or bell-mouthed, shoes are arced wrong, or shoes and drum are mismatched. 	<p>Drive axle right:</p> <ul style="list-style-type: none"> • brake throw = 1-11/16 in • slack adjuster obstructed by radius rod mount • 2 axle to spring nuts missing. This is causing the “C” support or axle and frame to separate and thus the radius rod mount to interfere with the slack adjuster (may be crash related) • drum within spec • show signs of glazed drum and brake material • when manually adjusting brake throw is 1-1/2 in, however drums will not turn freely without several quarter turns of back off. This suggests that drum is warped or bell-mouthed, shoes are arced wrong, or shoes and drum are mismatched.

Tag axle left:	Tag axle right:
<ul style="list-style-type: none">• appears that the disc brake has not been making full contact with the rotor—visual: dark streaks left by the brake material instead of a smooth burnished surface• brake throw = 1-7/8 in• major rotor wear and glazing on pads and rotors• heat cracks noted on pads• rotor thickness out of spec for standard pads and backing plates. Minimum before going to oversized is 1.61 in, rotors were at 1.60.• tag axle adjuster—adjuster arm is found to be stripping or slipping on its splines. It is loose and worn out and will not hold force against the pads without slipping. The adjuster cannot be tested because the calipers are “load dependent” which means they sense load against the pad to adjust correctly.	<ul style="list-style-type: none">• appears that the disc brake has not been making full contact with the rotor—visual: dark streaks left by the brake material instead of a smooth burnished surface• brake throw = 1-3/8 in