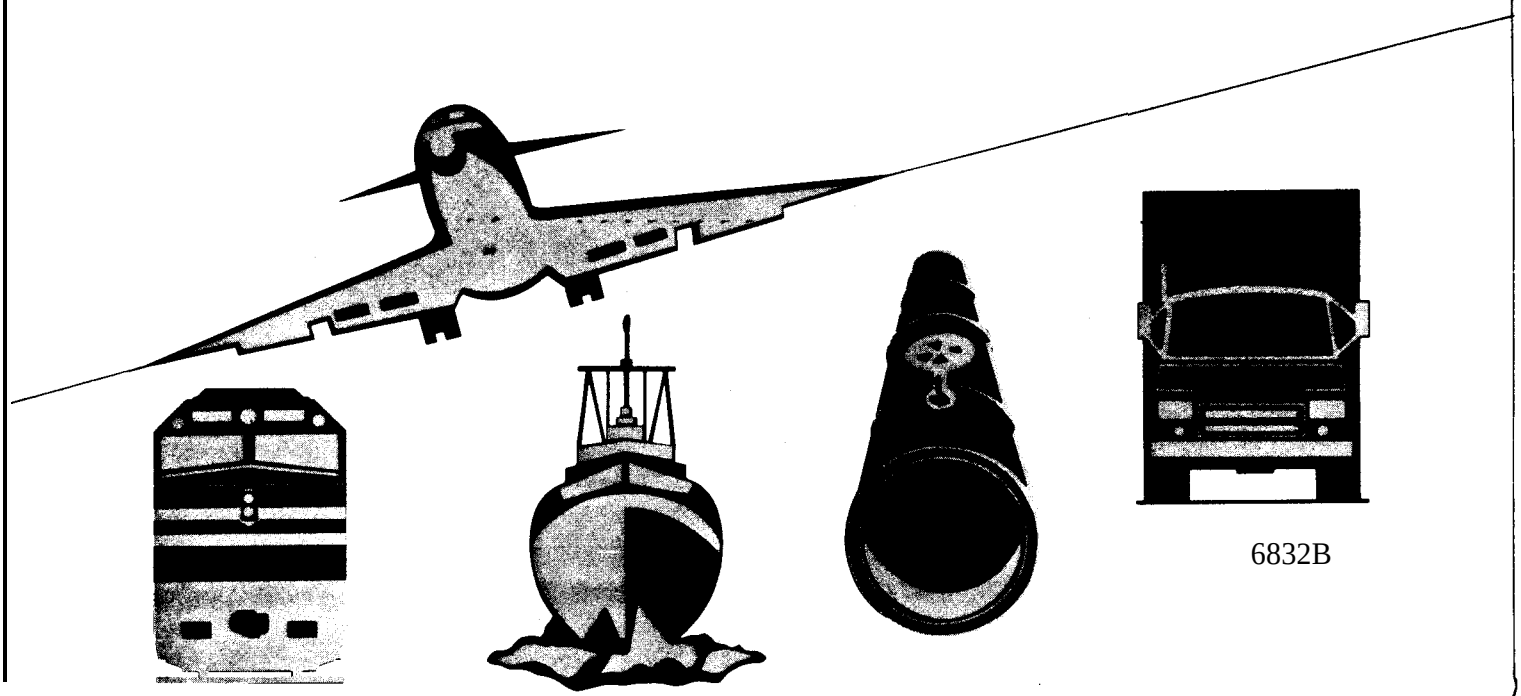
PB98-916203
NTSB/HAR-98/01

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT

MULTIPLE VEHICLE CROSSOVER ACCIDENT
SLINGER, WISCONSIN
FEBRUARY 12, 1997



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Abstract: About 5:52 a.m. on February 12, 1997, a doubles truck that was traveling northbound on U.S. Route 41 near Slinger, Wisconsin, lost control and crossed over the median into the southbound lanes. A flatbed truck traveling southbound on U.S. Route 41 collided with the doubles truck, lost control, and crossed over the median into the northbound lanes. A northbound passenger van struck and underrode the right front side of the flatbed truck. A refrigerator truck struck the right rear side of the flatbed truck. Eight persons suffered fatal injuries.

The safety issues discussed in this report are: judgment and experience of the doubles truckdriver; stability of doubles trucks; effectiveness of snow and ice removal; adequacy of the American Association of State Highway and Transportation Officials divided freeway median barrier warrants; adequacy of the States' accident report forms to capture cross-median accident data; and availability and use of restraints.

As a result of its investigation, the National Transportation Safety Board issued recommendations to the Federal Highway Administration, the National Highway Traffic Safety Administration, the National Association of Governors' Highway Safety Representatives, the American Trucking Associations, the Motor Freight Carrier Association, the International Brotherhood of Teamsters, the American Association of State Highway and Transportation Officials, the Wisconsin Department of Transportation, the Independent Truckers and Drivers Association, the National Private Truck Council, and the Owner-Operators Independent Drivers Association, Inc. The Safety Board reiterated one recommendation to the State of Wisconsin.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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MULTIPLE VEHICLE CROSSOVER ACCIDENT
SLINGER, WISCONSIN
FEBRUARY 12, 1997

HIGHWAY ACCIDENT REPORT

Adopted: July 24, 1998
Notation 6832B

NATIONAL
TRANSPORTATION
SAFETY BOARD

Washington, D.C. 20594

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EXECUTIVE SUMMARY

About 5:52 a.m. on February 12, 1997, a doubles truck with empty trailers, operated by Consolidated Freightways, Inc., that was traveling northbound on U.S. Route 41, a four-lane divided limited access highway near Slinger, Wisconsin, lost control and crossed over the 50-foot depressed median into the southbound lanes. A flatbed truck loaded with lumber, operated by McFaul Transport, Inc., that was traveling southbound on U.S. Route 41 collided with the doubles truck, lost control, and crossed over the median into the northbound lanes. A northbound passenger van with nine adult occupants struck and underrode the right front side of the flatbed truck at the landing gear. A refrigerator truck loaded with produce, operated by Glandt/Dahlke, Inc., that was also traveling northbound, struck the right rear side of the flatbed truck. Although it had snowed from about 8 p.m. to 3 a.m. the night before, it was clear at the time of the accident. Other motorists and the emergency responders to the accident scene reported icy patches in the roadway. Eight of the nine van occupants suffered fatal injuries, and the remaining occupant suffered serious injuries. Two of the three commercial truckdrivers were treated for minor injuries and released; the third refused treatment.

The National Transportation Safety Board determines that the probable cause of the accident was the doubles truckdriver's lack of judgment in driving too fast for the configuration of his truck under the hazardous highway weather conditions. Contributing to the severity of the injuries and the reduced potentiality for survival was the lack of restraint use by the unrestrained occupants of the passenger van.

The major safety issues identified in this accident are:

- Judgment and experience of the doubles truckdriver;
- Stability of doubles trucks;
- Effectiveness of snow and ice removal;
- Adequacy of the American Association of State Highway and Transportation Officials divided freeway median barrier warrants;
- Adequacy of the States' accident report forms to capture cross-median accident data; and,
- Availability and use of restraints.

As a result of this accident investigation, the Safety Board makes recommendations to the Federal Highway Administration, the National Highway Traffic Safety Administration, the National Association of Governors' Highway Safety Representatives, the American Trucking Associations, the Motor Freight Carrier Association, the International Brotherhood of Teamsters, the American Association of State Highway and Transportation Officials, the Wisconsin Department of Transportation, the Independent Truckers and Drivers Association, the National Private Truck Council, and the Owner-Operators Independent Drivers Association, Inc. Also, the Safety Board reiterates one recommendation to the State of Wisconsin.

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INVESTIGATION

The Accident

About 5:52 a.m.[1] on February 12, 1997, a doubles truck with empty trailers,[2] operated by Consolidated Freightways, Inc., (CF)[3] that was traveling northbound on U.S. Route 41 (US 41), a four-lane divided limited access highway, near Slinger, Wisconsin, lost control and crossed over the 50-foot depressed median into the southbound lanes. A flatbed truck loaded with lumber, operated by McFaul Transport, Inc., that was traveling southbound on US 41 collided with the doubles truck, lost control, and crossed over the median into the northbound lanes. A northbound passenger van with nine adult occupants struck and underrode the right front side of the flatbed truck at the landing gear.[4] A refrigerator truck loaded with produce, operated by Glandt/Dahlke, Inc., also traveling northbound, struck the right rear side of the flatbed truck. Figure 1 represents several major events in the accident sequence: (1) the doubles truck's loss of control and median crossover, (2) the doubles truck and flatbed collision, (3) the flatbed truck's loss of control and median crossover, (4) the collision of the blue passenger van and the refrigerator truck with the flatbed truck. See figure 2 for a photo showing the accident aftermath.

Although it had snowed from about 8 p.m. to 3 a.m. the night before, it was clear at the time of the accident. Other motorists and the emergency responders to the accident scene reported icy patches in the roadway.

Eight of the nine van occupants suffered fatal injuries, and the remaining occupant suffered serious injuries. Two of the three commercial truckdrivers were treated for minor injuries and released; the third refused treatment.

Event Sequence -- On the evening before the accident, it began to snow about 8 p.m. The Washington County, Wisconsin, road maintenance crew began plowing the roadway and salting the ramps on US 41 between 10 and 10:30 p.m. Although the snow stopped between 2 and 3 a.m. on the morning of the accident, the road crew continued to conduct snow and ice removal because of blowing snow and the freezing temperatures. About 3:45 a.m., they noticed "black ice"[5] forming on the roadway and began applying salt with a wetting agent. By 5:15 a.m., the area of US 41 near the intersection of County Trunk Highway K (CTH K) had received two applications of salt and wetting agent.

The following are the surviving drivers' and witnesses' accounts of what happened during this accident. The accident involved four vehicles — the doubles truck, the flatbed truck, the passenger van, and the refrigerator truck (see figure 3) — and three collisions that occurred at two different locations.

Doubles Truck -- According to the doubles driver, he went to bed at 7 p.m. on the evening before the accident. The CF dispatcher called him at 12:30 a.m. to alert him that he would be needed later that morning. He returned to bed at 1 a.m. and slept until he awoke at 3:30 a.m., when he got up and reported to work at 4:30 a.m. He left the CF Milwaukee, Wisconsin, terminal at 5 a.m. to deliver a pair of empty trailers to Menasha, Wisconsin, about 100 miles to the north. The trip was routine and no deadline for delivery was specified.

[1] Times are given in central standard time.

[2] For the purposes of this report, the tractor/double semitrailer combination unit will be referred to as the "doubles truck," the tractor/flatbed semitrailer combination unit as the "flatbed truck," and the straight refrigerator truck as the "refrigerator truck."

[3] See the last page for a list of all acronyms and abbreviations used in this report.

[4] The landing gear on a semitrailer is a device that provides support for the trailer when it is not connected to the tractor.

[5] Black ice is a very thin coating of clear, bubble-free, and homogeneous ice, which forms on roadway pavements under certain temperature conditions.

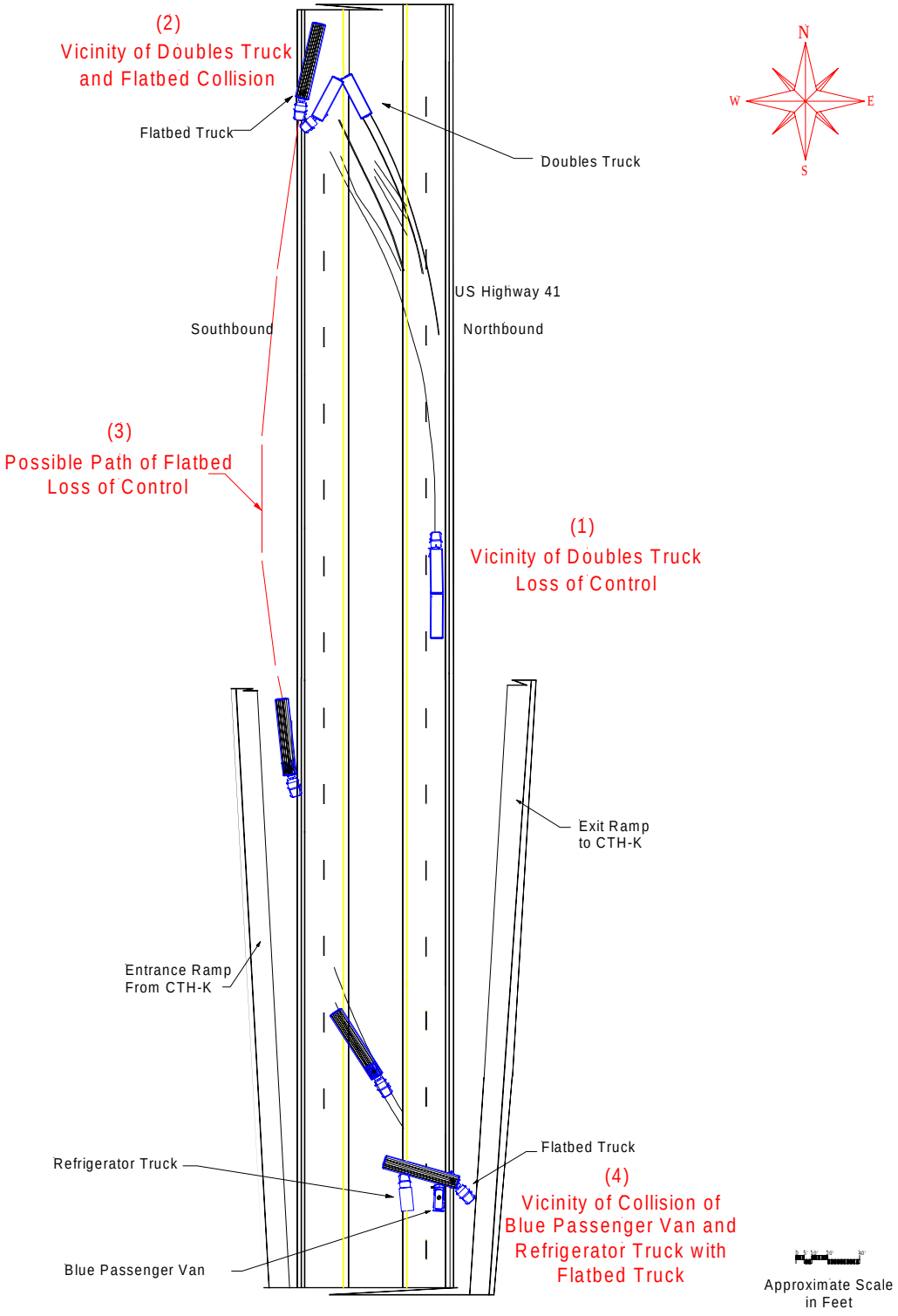
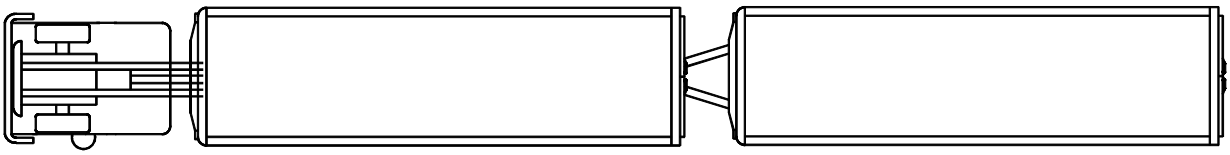
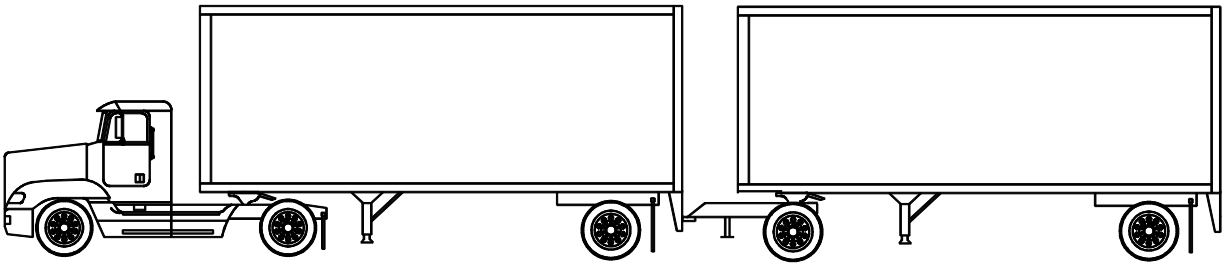


Figure 1 -- Accident events

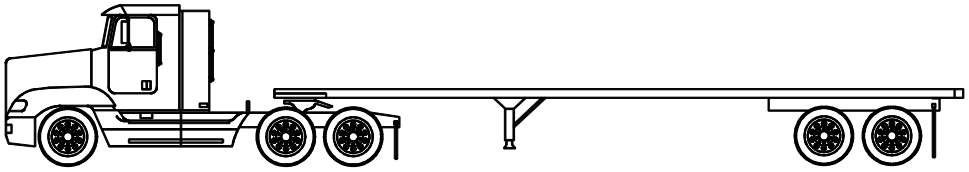
Figure 2 -- Aftermath of the accident



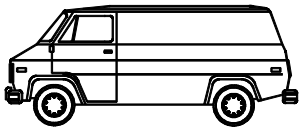
Overhead View of Doubles Truck



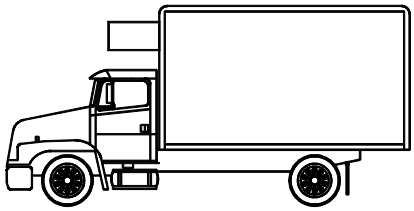
Doubles Truck



Flatbed Truck



Passenger Van



Refrigerator Truck

Figure 3 -- Configuration of four accident vehicles

The doubles driver indicated in several interviews[6] that the "roads in Milwaukee were wet" and became icy "a couple of miles north of the split." US 41 and U.S. Route 45 diverge approximately 8 miles south of the accident site.

The doubles driver initially indicated to police that his trailers slipped at least three times en route, so he switched to a lower (4^{th}) gear. He later told Safety Board investigators that about 15 miles out of the CF yard, he was traveling about 50 to 55 mph in 7^{th} gear and felt the trailer do a slight fishtail, which indicated to him that the roads were not in good condition. He stated that at some time while he was traveling further north, snow was blowing across the road from the west when he felt the trailer do a second fishtail. He said that at that point, he reduced his speed from about 50 to 55 mph to about 35 to 40 mph. He did not know where this location was relative to the accident site.

The doubles driver told the Safety Board investigators that no traffic was in his immediate vicinity when he lost complete control. He said he was traveling between 30 and 35 mph in 6^{th} gear. He had just checked his mirrors when he suddenly felt the trailers slip on the icy roadway. He said when the trailers "pushed forward and towards the right," he "immediately let off the accelerator." He indicated that he was neither shifting gears at the time nor did he apply his brakes. He also indicated that he had no time to react to the developing situation, and he attempted to countersteer the tractor.

The doubles driver said that just after the truck slipped, he noticed several cars traveling southbound and the lights of a [southbound] tractor/semitrailer. His vehicle was still moving in a circular motion when his face hit the dash or steering wheel. He sensed that he had been stopped for 30 to 60 seconds when he felt another impact.

Flatbed Truck -- About 4:15 a.m. on the morning of the accident, the flatbed truck loaded with lumber left the McFaul Transport, Inc., (MTI) yard in New London, Wisconsin. The flatbed truckdriver told Safety Board investigators[7] that about 5:45 a.m., he was southbound on US 41 traveling about 55 mph when he observed a truck in the median. At the time, he wondered why the truck was making an illegal U-turn.

After observing the truck for a moment, he realized it was not turning around but had lost control. He recalled seeing a lot of snow swirling around the moving vehicle. He told the police[8] that he was "trying to avoid the northbound truck and went off towards the right shoulder" and the truck hit him "on the driver's side." He continued moving in the right lane but lost control and crossed over the left lane and median into the northbound lanes. He remembered seeing a lot of snow swirling around him and also seeing headlights; he then recalled coming to a complete stop.

Passenger Van -- About 5:15 a.m., nine adults left Milwaukee, heading north for an annual ice fishing trip. The group had rented a blue 15-passenger van from May Fair Rent A Car, Inc., for the trip. The sole survivor in the van, who had been seated in the middle of the van's fourth row, told Safety Board investigators that the road was wet when they departed Milwaukee, and that it had snowed earlier that morning. He said that immediately before the van struck the trailer of the flatbed truck, everything in the van was quiet.

Refrigerator Truck -- About 5:10 a.m., a refrigerator truck with a load of produce and dairy products left the Glandt/Dahlke, Inc., yard, in Milwaukee. The driver told Safety Board investigators that he stopped in Richfield, Wisconsin, about 5:35 or 5:40 a.m. to make a delivery.[9] He indicated that when he left Richfield, the roads were intermittently icy, the wind seemed to be coming from the west or

[6]This driver gave two statements to the police on the day of the accident and was later interviewed by Safety Board investigators on March 14 and October 20, 1997, with counsel present.

[7]The flatbed truckdriver was interviewed by Safety Board investigators on March 14, 1997.

[8]The flatbed truckdriver gave a statement to the police on the day of the accident.

[9]The refrigerator truckdriver was interviewed by Safety Board investigators on March 13, 1997.

northwest, the visibility was clear, and it was dark.

The refrigerator truckdriver said that he was traveling in the right lane at 50 to 55 mph when he noticed a van 6 to 8 vehicle lengths ahead of him. He indicated that he saw a dark object enveloped in swirling snow moving at him from the median at about a 45° angle. He recalled thinking about whether he should turn to the left or the right to avoid hitting it when he noticed a brief illumination of the van's brake lights before it collided with the trailer. He said that when the van hit the trailer, the trailer was sliding and wood was flying from it. He slammed on his brakes, swerved to the left, and hit the end of the trailer, which moved in response to the impact. His truck came to rest in the median.

Witness Accounts -- Several witnesses observed the doubles truck as it traveled northbound on US 41. One witness, a tractor/semitrailer driver,[10] was following the blue passenger van and was subsequently passed by the doubles and refrigerator trucks. He indicated that a light wind was blowing from the west and, although it was not strong enough to affect his truck, the wind was blowing snow across the road. He said that the right lane appeared wet, with more swirling snow in the left lane.

He stated that he was traveling in the right lane at 50 to 55 mph [the speed limit was 65 mph] because of the weather and road conditions. The blue passenger van was ahead of him traveling at roughly the same speed. Just south of the State Trunk Highway 144 overpass (2 miles south of the accident site), he noticed a set of headlights behind him that was "wavering from side to side." He thought the headlights might belong to a doubles truck because tractor/trailer headlights normally appear to bounce up and down. When the passing truck had reached the midpoint of his trailer, he saw that it was a doubles truck, and he started to slow so the truck could pass more quickly. He slowed to 45 mph and estimated that the passing truck was traveling in excess of 60 mph.

As the doubles truck passed him, the witness noticed the rear trailer swaying back and forth about 6 inches in an even, continuous manner. He stated that, from the way the trailers were behaving, it appeared to him either that they were empty or that the rear trailer was heavier than the front. He said he flashed his headlights to signal the doubles truck that it was clear to move into the right lane, but the doubles truck stayed in the left lane until he could no longer see it. He also saw the doubles truck pass the blue passenger van. Then, both the doubles truck and the passenger van disappeared from his view.

After the doubles truck had passed him and he was in the vicinity of Arthur Road (1.3 miles south of the accident site), the witness said he accelerated, but the acceleration was slow due to a slight upgrade and the weight of his truck. When he reached about 50 mph, he noticed a cloud of smoke coming from the median ahead of him. A few seconds later, he saw another cloud, also in the median but closer and moving towards him. He did not see any lights in this cloud. He said that, as he slowed, he saw the headlights of the vehicle behind him [the refrigerator truck] move into the left lane to pass him. He started to move towards the shoulder and noticed the on-ramp for CTH K. He headed for the ramp.

He heard a crash, saw a white tractor with a flatbed trailer, and saw that a blue van had hit the trailer. He stated that although he heard the collision, he did not see it, nor did he see any brake lights on the blue passenger van at any time. As he was slowing to a stop on the ramp, he saw the refrigerator truck attempt to avoid the flatbed trailer. He said the "rear axles of the straight truck were off the ground at impact." He reached for his cell phone, heard another noise, looked up, and saw another van driving across the lumber that had been knocked off the

[10] The Washington County Sheriff's Department interviewed this witness on the day of the accident. He gave them a written statement on February 13, 1997, and they reinterviewed him on March 5, 1997. A Safety Board investigator interviewed him on June 3, 1997. This witness has a commercial driver's license with hazardous materials, tank trailer, and double and triple trailer endorsements. He has been driving tractor/semitrailers for 10 years with some doubles experience. He was familiar with the route, as he drove US 41 professionally once or twice a week and occasionally drove it privately. On the day of the accident, he was driving a conventional tractor with a 42-foot trailer; the total vehicle weight was 60,000 to 65,000 pounds.

flatbed. He then called 911 and reported the accident.

Another northbound truckdriver stated that the doubles truck had passed him just outside Milwaukee at State Trunk Highway 145. This witness indicated that he was traveling approximately 47 to 49 mph, and it took almost a mile for the doubles truck to pass him. (See figures 4 and 5 for maps showing the accident area and important reference points.)

Emergency Response -- The first witness notified the Washington County Sheriff's Department (WCSD) dispatch of the collision at 5:53 a.m. by cellular phone. Emergency Medical Service (EMS) units were dispatched at 5:54 a.m. (See table 1 for a timeline of the emergency response.) Two units from the Slinger Police Department, the first emergency personnel on scene, arrived at 5:56 a.m. They were followed by the Slinger Fire Department (SFD) command vehicle, which arrived at 6:02 a.m. The Incident Commander established the command post near the blue passenger van, aboard the SFD command vehicle, which had communications equipment. Two other firefighters aboard the command vehicle conducted an initial reconnaissance of the accident scene and reported back to the Incident Commander. Several emergency vehicles arrived after the SFD command vehicle.

Seventeen WCSD officers, seven Wisconsin State troopers, seven fire departments, one private ambulance service, and one Flight for Life helicopter responded to the accident. Two additional helicopters were dispatched to the scene but were turned back because they were not needed. Four patients were transported; three by ambulance to local hospitals and one by helicopter to a trauma center in Milwaukee. One victim from the van was not transported to a trauma center until 2 hours and 8 minutes after the notification, because on-scene medical personnel decided to stabilize the patient before transporting him. The north- and southbound lanes of US 41 were reopened by 2:03 p.m. (8 hours and 10 minutes after the accident).

Table 1 -- Emergency response

Time*	Time from initial notification	Action
0553	00:00	Initial 911 call received by WCSD dispatch
0554	00:01	EMS dispatched
0556	00:03	Two Slinger Police Department units arrived on scene
0602	00:09	SFD command vehicle arrived on scene
0607	00:14	First EMS unit arrived
0619	00:26	Flight for Life dispatched from Milwaukee
0638	00:45	Flight for Life arrived on scene
0652	00:59	Ambulance delivered first van victim to area hospital
0801	02:08	Flight for Life helicopter delivered second van victim to trauma center
1228	06:35	Northbound lanes of US 41 reopened
1403	08:10	Southbound lanes of US 41 reopened; area cleared

*Times are based on the 24-hour clock (for example, 1403 is 2:03 p.m.).

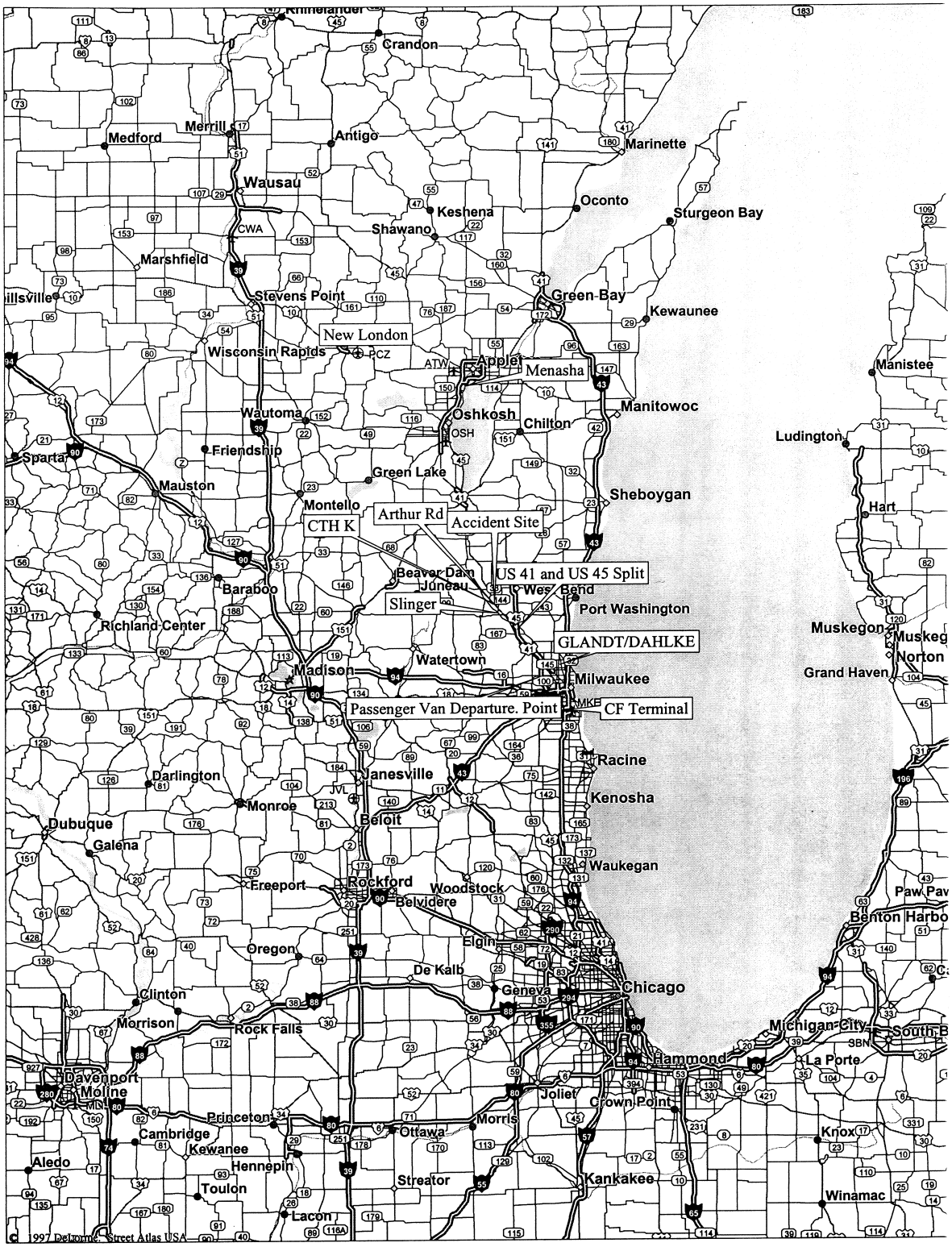


Figure 4 -- General accident area and reference points

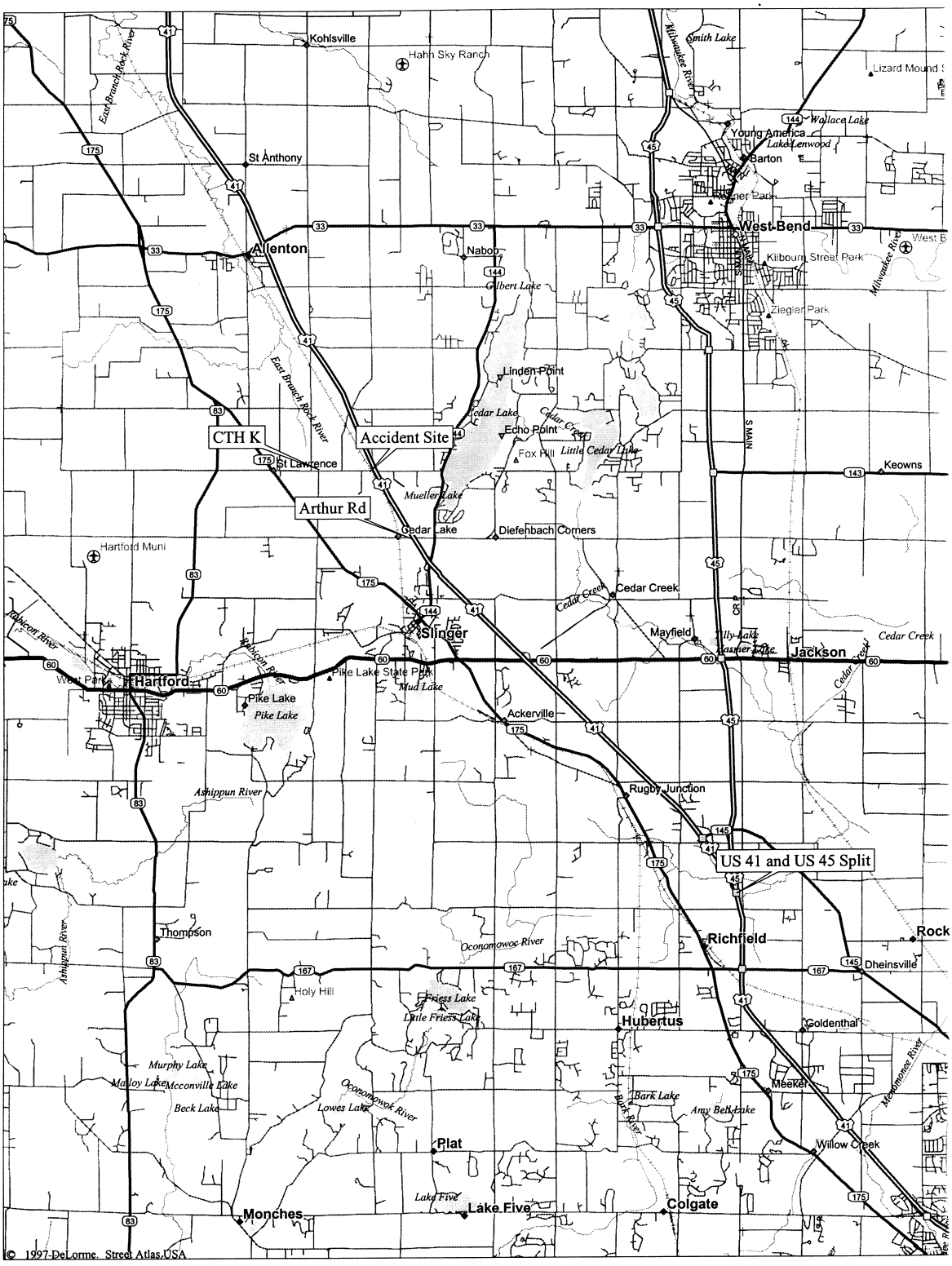


Figure 5 -- Immediate vicinity of Slinger accident

Injuries

The doubles and flatbed truckdrivers were treated for minor injuries and released that day from local hospitals. The refrigerator truckdriver refused treatment. Table 2 is based on the injury criteria[11] of the International Civil Aviation Organization, which the Safety Board uses in accident reports for all transportation modes. (See appendix B for an injury table based on the Abbreviated Injury Scale of the Association for the Advancement of Automotive Medicine.)

Damage

The doubles truck tractor was a total loss. The front of the doubles lead trailer and the top of the rear trailer both had moderate damage. The single-axle converter dolly was not damaged. The flatbed truck tractor was also a total loss, and the semitrailer sustained major damage. The passenger van was a total loss. It sustained major damage to the front, with intrusion into the driver's and front passenger's spaces. Damage to the refrigerator truck was limited to the front bumper grille and hood assembly.

Vehicle Information

Doubles Truck -- The doubles truck, a tractor/double semitrailer combination unit, consisted of a conventional 1993 Freightliner two-axle tractor, a 1992 Road Systems, Inc., 28-foot single-axle box trailer, a 1985 Road Systems, Inc., single-axle converter dolly, and a 1989 Road Systems, Inc., 28-foot single-axle box trailer. The overall length of the combination unit was 72.5 feet; it had a calculated gross vehicle weight of 33,000 pounds. This tractor/double or twin semitrailer configuration is commonly referred to as a western double or a double-bottom.

The tractor was equipped with a Cummins diesel engine with an electronic control module (ECM), an Eaton-Fuller 7-speed manual transmission, and cruise control. The Rockwell RS-23-185 rear-drive axle had a 3.42 gear ratio. The front axle had type 9 wedge[12] brakes and ribbed tread tires. The rear axle had dual (two per wheel) type 12 wedge brakes with type 16 spring brakes and traction tread tires.

Table 2 -- Injuries

TYPE	Doubles Truck Driver	Flatbed Truck Driver	Van Driver	Van Passengers	Refrigerator Truck Driver	TOTAL
Fatal	--	--	1	7	--	8
Serious	--	--	--	1	--	1
Minor	1	1	--	--	--	2
None	--	--	--	--	1	1
Total	1	1	1	8	1	12

[11]Title 49 *Code of Federal Regulations* (CFR) 830.2 defines *fatal injury* as "Any injury which results in death within 30 days of the accident." It defines serious injury as an injury that: "(1) Requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, or tendon damage; (4) involves any internal organ; or (5) involves second or third degree burns, or any burn affecting more than 5 percent of the body surface."

[12]With wedge brakes, the brake power unit, in either air or hydraulic chambers, "forces a wedge between two rollers and two plungers, which causes the plungers to spread apart and push the brake shoes against the drum." Source: Rockwell Stopmaster Brakes, *Field Maintenance Manual*, 4R, revised October 1979.

According to the engine manufacturer, on a level roadway, the doubles truck could achieve a maximum speed of 26.5 mph in 4th gear, 36.4 mph in 5th gear, 49.4 mph in 6th gear, and 66.2 mph in 7th gear, all based upon 1,800 rpm.[13] Because of the setting of the vehicle speed sensor (governor), the vehicle would not ordinarily (except when traveling on a downgrade) exceed 62 mph in 7th gear or 47 mph in 6th gear, both at 1,700 rpm. The tractor was equipped with a "governor override," which, under certain conditions, temporarily permits the engine to overspeed by about 10 percent above the 1,800 rpm programmed into the ECM.

The empty trailers were similarly equipped with wedge brakes and ribbed tread tires, and both weighed about 7,380 pounds with gross vehicle weight ratings (GVWRs) of 40,000 pounds. The converter dolly was equipped with type 9 wedge brakes and highway tread tires. The unloaded dolly weighed 2,850 pounds.

The on-scene examination of the tractor, which included the brake, steering and suspension systems, tires, fifth wheel, and cab controls, found no safety defects. A later examination[14] of the steering box and components found no preimpact defects or damage. The on-scene examination of the two trailers and the A-dolly found no defects.

The tractor sustained damage to the right side and left rear corner of the cab. The rear chassis was skewed to the right, and the right-drive dual-axle wheel had been moved forward. The floorboard section over the transmission had been moved forward. The rear edge of the opening for the gear-shift lever was found tight against the lever arm. The shift lever arm was found in 6th gear. The right side of the cab's front hood and fender assembly had contact damage. The front axle was dislodged and the right front bumper end, outboard of the chassis, was bent forward 90°.

The lead trailer sustained damage to the front bulkhead and left front cornerpost area. The A-dolly did not appear to be damaged. The rear trailer had damage to the top of the right center front bulkhead and roof edge.

Flatbed Truck -- The flatbed truck, a tractor/flatbed semitrailer combination unit, was composed of a 1993 Mack conventional three-axle tractor and a 1992 Fruehauf tandem-axle 45-foot flatbed semitrailer. The overall length of this combination vehicle was about 60 feet, and the calculated gross weight was about 76,675 pounds.

The on-scene examination of the tractor's brakes, steering and suspension systems, tires, fifth wheel, and cab controls found no defects. The examination of the trailer's brake system, suspension, tires, and 5th wheel plate revealed no defects. During the postaccident towing operations, the rear axle brakes had been "backed off," which precluded a determination of the precollision pushrod position.

The flatbed tractor sustained major damage, mainly to the left side. The bumper extension and lower front fairing were dislodged. The fender and left side of the hood were dislodged. The front axle was displaced rearward. The left side of the windshield was fractured. The left side rearview mirror was torn away from the door. The left side fuel tank was damaged but had not ruptured. The left side chassis-mount toolbox was damaged. Both of the left outside rear-dual wheels and tires were damaged.

The trailer had impact damage along the left rub rail about 10 feet to the rear of the header board. The left front tandem wheel was damaged, and the suspension was fractured. The right landing gear leg was damaged and pushed under the trailer mainframe rail. The red paint on the leg bore clean scrape marks through the coating of spray from snow, slush, and road salt. The right front tandem axle had damage to the outer wheel, and the suspension was separated.

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[13]The Cummins Engine Company computer simulation program is capable of calculating vehicle speeds within each gear. In this instance, the parameters (vehicle weights, transmission type, axle ratio, and engine type) were furnished to the Cummins Engine Company by Safety Board investigators.

[14]The examination took place at the CF Milwaukee facility and was performed by a representative of TRW, the manufacturer, on April 28, 1997. Representatives from the Safety Board, the Wisconsin State Highway Patrol, the Freightliner Corporation, and CF participated in the examination.

Passenger Van -- The passenger van was a 1997 Dodge Ram 3500 Maxi-wagon. The van was equipped with a 5.9L magnum V-8 gasoline engine, a 4-speed automatic transmission, and rear-wheel drive. It was also equipped with an antilock braking system with disk brakes on the front and drum brakes on the rear axles.

The van was designed to seat 15 passengers. As shown in figure 6, the van had five rows of seats. The first row had bucket seats for the driver and the right front passenger; both seats were equipped with lap/shoulder belts. The driver-side restraint system was equipped with a supplemental airbag and a pre-tensioner for the belt.

Rows 2 through 4 were bench seats with three seating positions each. These seats were designed so they could be removed. The left outboard seating position in each of these bench seats was equipped with a lap/shoulder belt, while the center and right outboard seating positions were equipped with lap belts only.

Row 5, which was also a bench seat, differed from the other rear rows in that it was not designed for easy removal and had four seating positions. The left and right outboard seating positions were equipped with lap/shoulder belts. The two inboard positions were equipped with lap belts only. As shown in figure 6, rows 2 and 3 in the accident van were removed in accordance with the rental agreement. The rented configuration had nine seating positions, five with lap/shoulder belts and four with lap belts only.

A complete examination of the passenger van could not be made because of the extensive front end damage. All the front brake pads and rear shoes appeared to be almost new and showed very little wear. The tires showed very little tread wear. The master cylinder was damaged, and the damage to the front end precluded examination of the steering components. No defects were found in the limited examination.

The front of the van, where the driver and the right front passenger were seated, showed extensive intrusion and loss of survivable space. The amount of intrusion varied across the width of the van, from about 29 inches[15] on the left side to about 52 inches on the right side. The rear of the van, where seat rows 4 and 5 were located, showed no intrusion or loss of survival space. (See figure 7.)

The front bumper was pushed up and aft and showed evidence of direct contact with a rear wheel of the tractor and the landing gear of the trailer. The front wheels were displaced rearward. The grille, hood, headlamp area, radiator, and engine front had major impact damage and red paint transfers. Shearing-type impact damage affected the entire upper area of the van from across the top of the cowl/dash at the windshield opening to each A-pillar and from the front doors and the roof panel extending rearward to the driver area and the passenger seatbacks.

Refrigerator Truck -- The refrigerator truck was a 1992 two-axle, straight "box" truck equipped with a refrigerator unit. It was powered by a Ford diesel engine and equipped with a 6-speed manual transmission. The wheel base was 227 inches and the overall length was 31.5 feet. The loaded weight at the time of the accident was approximately 20,290 pounds and the GVWR was 33,000 pounds.

The on-scene examination of the refrigerator truck included the brake, steering, and suspension systems; the tires; and the cab controls. One of the automatic slack adjusters was found to be out of adjustment and a second one was found to be in need of adjustment. No other defects were found.

The damage to the refrigerator truck was limited to the truck front. The top right chassis rail end, at the bumper attach bracket, had a clean deep indent, and the steel bumper face had two curved line impressions with the same radii as the flatbed trailer tandem wheels. The right fender, headlamp assembly, and grille were damaged. The suspension system, front axle, engine, and drive line were not damaged.

[15]Measured from the precollision location of the base of the A-pillar, the forward-most roof support.

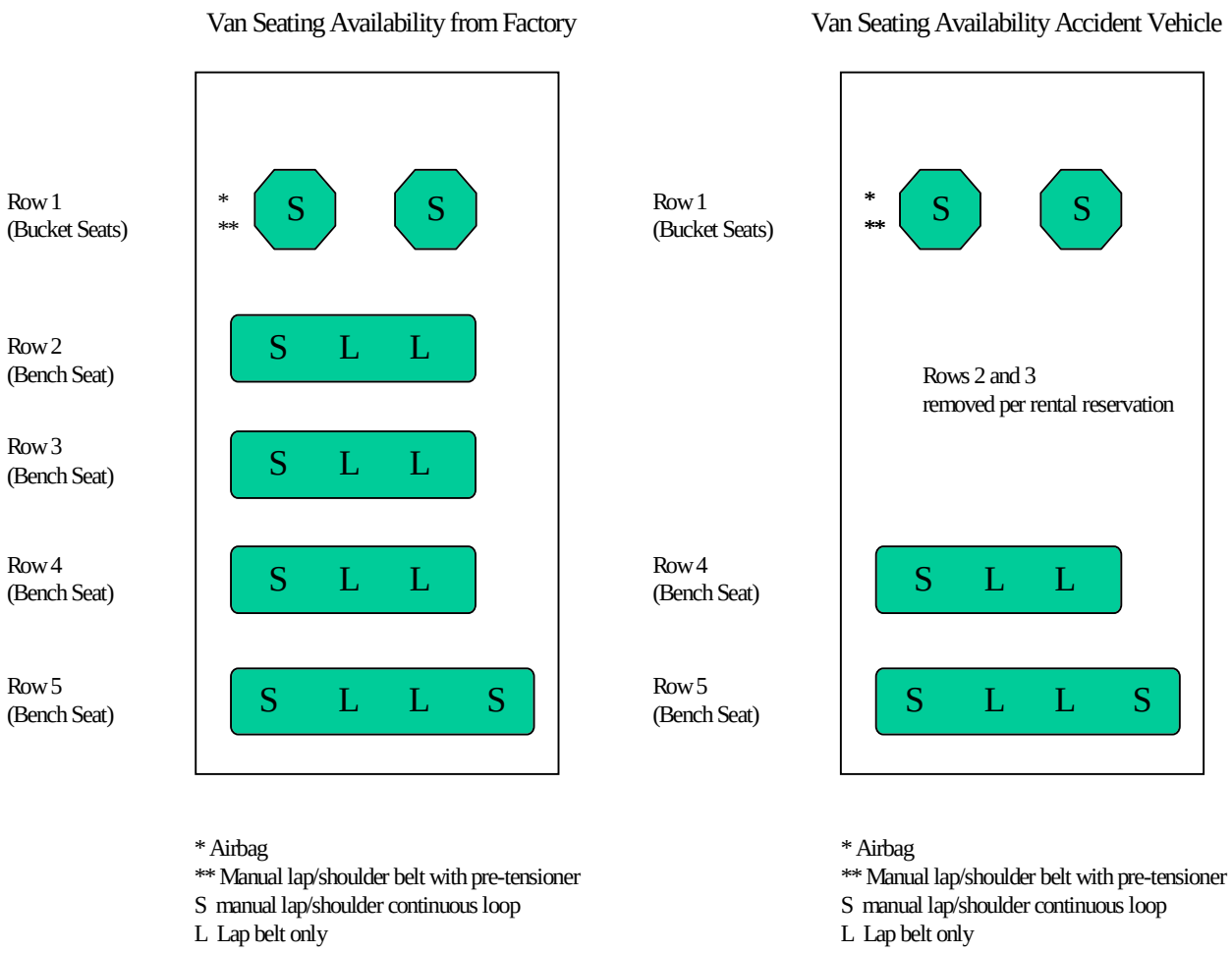

Figure 6 -- Passenger van seating and restraint availability

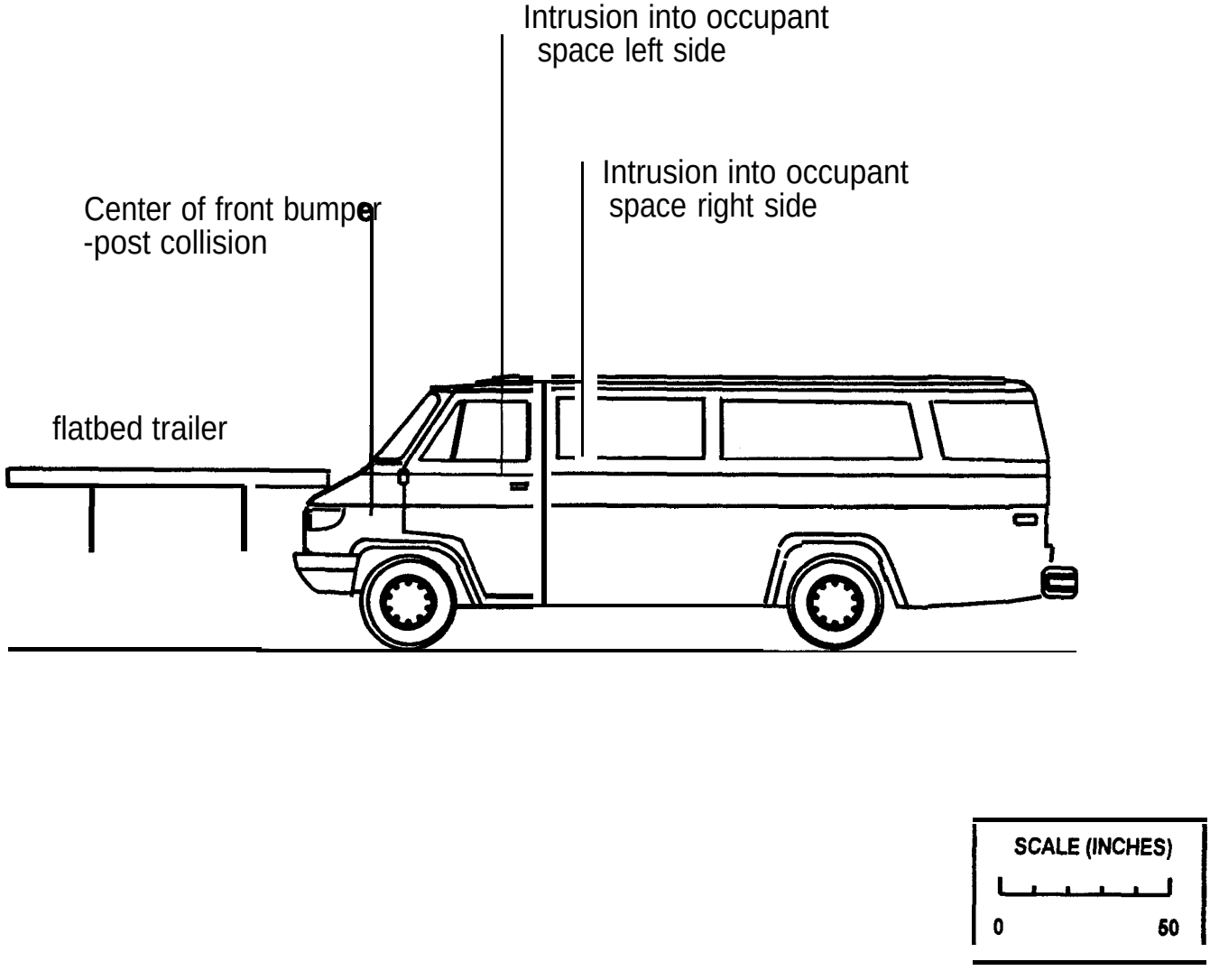

Figure 7-- Van and flatbed intrusion profile

Driver Information

Doubles Truck -- The doubles driver was 33 years old and had a valid Wisconsin State commercial driver's license (CDL). During interviews with Safety Board personnel, the driver indicated that he had been adequately rested in the 72 hours before the accident. At the time of the accident, he had been awake for 2 hours, 15 minutes, and had been driving the doubles truck for about 45 minutes.

License and Citations -- The license had a doubles/triples endorsement and an expiration date of October 29, 1998. The driver also held a valid medical examiner's certificate with an expiration date of October 17, 1998. A check with the National Driver Register (referred to as the NDR) database showed no adverse records. Local checks of his record found:

- 1/11/97 - accident in personal vehicle, citation for running a red light in Milwaukee;
- 9/24/96 - speeding conviction on CDL (40 mph in a 25 mph zone) in Ripon, Wisconsin;
- 8/28/95 - speeding (70 mph in a 55 mph zone);
- 7/8/93 - speeding in Iowa on CDL (no record in Iowa);
- 6/25/93 - speeding (71 mph in a 55 mph zone), dismissed after trial;
- 9/21/89 - motorcycle accident, cited for following too close and not having a motorcycle endorsement on his license; and,
- 7/31/88 - speeding conviction.

Training and Qualifications -- The doubles driver had been employed by CF since October 24, 1996. He took a written knowledge test and a road test on October 11, 1996, as part of the company's new-hire procedures. Table 3 lists the driver's previous employment and driving history.

Table 3 -- Doubles driver employment and driving history

DATES*	COMPANY*	EXPERIENCE/POSITION*
10/24/96 - 02/12/97	Consolidated Freightways	Doubles driver (16 hours a week)
01/31/96 - 10/22/96	American Transport	Tractor-trailer driver
10/20/95 - 12/29/95	United Parcel Service	Doubles driver
07/95 - 10/95	Roadway Package Systems	Driver
03/95 - 10/95	Federal Express	Package handler, dockworker, tractor-trailer driver
04/20/94 - 10/6/95	Tandem Transport (JDC Trucking)	Tractor-trailer driver
06/24/93 - 04/15/94	Custom Cuts, Inc.	Over-the-road tractor-trailer driver
01/04/93 - 01/28/93	Pro-Drive Truck Driving School	Student

*Note: Discrepancies appear in the information provided on the driver's different job applications, in his interview, and by his attorney.

The doubles driver told the police that he had driven the accident route five times. In an October 20, 1997, interview with Safety Board personnel, the driver indicated that he had never driven the accident route with two empty trailers. The carrier later informed the Safety Board[16] that 4 days before the accident, the doubles driver drove empty doubles from Sheboygan, Wisconsin, to Menasha, Wisconsin, without incident. The doubles driver told the police that he drove 16 hours a week and that CF "calls me when they need me." His experience at United Parcel Service (UPS), coupled with his experience at CF, gave him a maximum of 6 months' experience driving doubles.

On the day of the accident, the police asked the doubles driver, "How did you know that the road was slippery?" He replied, "I could feel the truck slide."

The police asked, "Were you concerned and how many times did the truck slide prior to losing control?" He replied, "Being empty was a big concern. I could feel it slide at least three times from the split to when I lost complete control."

They asked, "Due to your experience, due to the road conditions and two empty trailers, do you feel that this was dangerous?" He replied, "I didn't think it was dangerous enough to turn around. I slowed down and lowered to 4th gear."

The police also asked him, "In your training, were you ever told what maneuvers to make when losing control, or what procedures to follow in icy conditions?" He replied, "Pro Drive training stress safety first, combination of skills and instincts, if icy conditions stay off brakes, keep in gear, maintain [control] best as possible, feather brakes until you pull off to the side."

The police asked the driver for his opinion on "What could you have done to prevent this accident?" The driver said, "I could have pulled off the first second I felt slide in back."

Doubles Training -- The driver told Safety Board investigators that in January 1993 he attended 3 weeks of tractor-trailer training at Pro-Drive of Racine, Wisconsin.[17] He also indicated that in 1995 he attended UPS doubles training consisting of 2 days of seminars with videos of doubles and adverse weather, homework, 3 days of yard and road experience, and pretrips in doubles. He said that at the end of 5 days, he was certified to drive doubles, which he did daily for 9 weeks in Wisconsin and Illinois.

An examination of UPS records revealed that on November 6, 1995, the doubles driver received new driver orientation. The following items were discussed: introduction to UPS, emergency evacuation procedures, hazard communication, hazardous response (1 hour), U.S. Department of Transportation (DOT) hazardous materials training, defective equipment, controlled substances, book control, space and visibility, and habits. The orientation included a skid presentation, a video on pretrip/couple/uncouple/post-trip activities, and a timecard review. He also took a DOT quiz. On November 8, 9, 10, and 13, 1995, UPS personnel observed his performance on pretrip equipment items, coupling, backing, uncoupling and post-trip actions, engine start and engine operation, parking, general driving and safety habits, and multiple trailer operations.

The Safety Board examined UPS training documents[18] and found the following information relating to skid control:

[16]February 17, 1998, letter from CF concerning the technical review of an earlier draft of this report.

[17]This firm no longer exists.

[18]Training Schedule-Day 1, Skid Control Outline and UPS Feeder, Emergency Reaction Driving, Liberty Mutual, Hopkinton, MA, Decision Driving Notes, Skid Control Tractor-Trailer (April 1996).

Part IV. C. Recovery from rear/drive axle skid

Get off the brake
Push in the clutch
Regain rolling traction
Countersteer

Power skid

This skid does not involve braking but rather an excessive application of power. This causes the drive wheels to lose traction, spin and go into sliding traction.

The action of the tractor will be the same as in a drive axle braking skid. A jackknife will occur unless corrected.

It can occur when leaving a stop sign/light, climbing a grade, powering around a curve, or, even on level, slippery roadway when power is applied excessively.

To control it, get off the fuel and be prepared to countersteer.

CDL Doubles Endorsement -- The CDL examination consists of a general knowledge (multiple choice) test and a driving test in a commercial vehicle. The doubles endorsement consists of an additional knowledge test, but it does not require a driving test in a doubles truck. The following are excerpts from the January 1997 *Wisconsin Commercial Driver's Manual*, Part One (general knowledge):

Section 2.6 Controlling Speed:

Empty trucks require greater stopping distances, because an empty vehicle has less traction. It can bounce and lock up its wheels, giving much poorer braking.

You can't steer or brake a vehicle unless you have traction. Traction is friction between the tires and the road. There are some road conditions that reduce traction and call for lower speeds.

Section 2.6 Controlling Speed (continued):

Wet roads can double stopping distances. Reduce speed by about one third (e.g., slow from 55 to about 35 mph) on a wet road. On packed snow, reduce speed by half, or more. If the surface is icy, reduce speed to a crawl and stop driving as soon as you can safely do so.

Melting ice. Slight melting will make ice wet. Wet ice is much more slippery than ice that is not wet.

Black Ice. Black ice is a thin layer that is clear enough that you can see the road underneath it. It makes the road look wet. Anytime the temperature is below freezing and the road looks wet, watch out for black ice.

Hydroplaning. In some weather, water and slush collects on the road. When this happens, your vehicle can hydroplane. It's like water skiing: the tires lose their contact with the road and have little or no traction. You can regain control by releasing the accelerator and pushing in the clutch. This will slow your vehicle and let the wheels turn freely. If the drive wheels start to skid, push in the clutch to let them turn freely.

Section 2.10 Driving in Winter:

Slippery Surfaces. Drive slowly and smoothly on slippery roads. If it is very slippery, you shouldn't drive at all. Stop at the first safe place.

In the doubles endorsement section of the manual, it recommends steering gently because of "rearward amplification" or the "crack-the-whip effect," but it does not mention oscillatory sway. Regarding handling in adverse weather, the doubles and triples section includes the following:

Part Two: Section Seven: Doubles and Triples

Be more careful in adverse conditions. In bad weather, slippery conditions, and mountain driving, you must be especially careful if you drive double and triple bottoms. You will have greater length and more dead axles to pull with your drive axles than other drivers. There is more chance for skids and loss of traction.

Flatbed Truck -- The flatbed truckdriver, who was 53, had a valid Wisconsin State CDL with an October 30, 2000, expiration date and a valid medical examiner's certificate with a corrective lenses restriction and an expiration date of October 13, 1997.

During interviews with Safety Board personnel, the driver indicated that he had been adequately rested in the 72 hours before the accident. At the time of the accident, he had been awake for 3 hours and had been driving for about 90 minutes.

The flatbed driver had been employed by MTI since March 1, 1977. Although he did not have any formal truck driving training, the flatbed driver successfully completed a written exam that tested his knowledge of transportation regulations on October 14, 1987, and a road test on November 6, 1987.

Passenger Van -- The passenger van driver, who was 39, had a valid Wisconsin Class D driver's license with a glasses restriction and an April 23, 1998, expiration date.

The van driver's sleep history for the 72 hours before the accident was not determined. He had been driving for about 45 minutes when the accident occurred.

Refrigerator Truck -- The refrigerator truckdriver, who was 39, had a valid Wisconsin State CDL with a December 4, 1997, expiration date. His valid medical examiner's certificate had an expiration date of July 10, 1998.

During interviews with Safety Board personnel, the driver indicated that he had been adequately rested in the 72 hours before the accident. At the time of the accident, he had been awake for 2 1/2 hours and had been driving for about 42 minutes.

The refrigerator truckdriver had been employed with Glandt/Dahlke, Inc., since March 2, 1993. He had driven for two other Milwaukee companies during the preceding 5 years and, before becoming a truckdriver, he had worked as a machine operator for 4 1/2 years. He did not have any formal truck driving training.

Motor Carrier Information

Doubles Truck -- CF, based in Menlo Park, California, operates a network of 373 service centers in all 50 States, Mexico, and 8 provinces of Canada. CF has 21,000 employees and a fleet of 40,800 trucks, tractors, and trailers, and, in 1995, earned revenues of about $2.1 billion. Founded in 1929, CF is a full-service trucking company, but it competes primarily in the less-than-truckload segment of the general freight industry. In August 1996, CF separated the less-than-truckload portion of its business into Consolidated Freightways Corporation of Delaware.

The doubles driver worked out of the Milwaukee terminal, which has about 92 drivers, with 70 truck tractors and 300 to 400 trailers.

Driver Qualification File -- The doubles driver's CF qualification file contained an application for employment dated August 9, 1996. The company's October 15, 1996, pre-employment driving record check showed the following citations, both for speeding:

- 8/28/95 - speeding [70 mph in a 55 mph zone]; and,
- 7/8/93 - speeding in Iowa on CDL.

According to his CF file, the driver had not informed CF about the September 24, 1996, speeding conviction on his CDL and the January 11, 1997, accident in his personal vehicle. Nor did these episodes appear on a

February 18, 1997, driving record abstract obtained by the carrier from the State after the accident.

According to CF, prospective truckdrivers for the firm undergo a background investigation by a private organization before they are offered a position. The applicant's employment history, experience, job knowledge, and social behavior are investigated, and the overall evaluation contains a recommendation on whether to hire the individual. The report issued on the doubles driver involved in this accident recommended that he be hired. The CF employee safety manager said that decisions to hire truckdrivers are based on good judgment by company personnel. He further stated that an applicant will be rejected if a records check reveals any of the following:

- License revoked two times in the last 10 years;
- License suspended three times in the last 10 years; or,
- Traffic violations (moving) that exceed a maximum of:
  - ◊ two in the last 2 years,
  - ◊ three in the last 3 years, or
  - ◊ four in the last 4 years.

In addition, truckdrivers are required to inform CF if they incur any infraction while operating under the authority of their CDLs.

Doubles Training -- CF does not have a training program that specifically addresses doubles operations. Rather, CF hires drivers who have either graduated from an acceptable driving school or who have not less than 1 year's experience with comparable types of equipment. The CF employee training manual contains a section about safe driving tips, but it does not address operating doubles in adverse weather. The employee safety manager indicated that the operation of doubles is reviewed as part of equipment familiarization for new hires.

Role of Safety in the Corporate Structure -- CF has 10 full-time safety managers: the senior safety manager at corporate headquarters and 9 others who handle employee safety in 22 divisions and 330 terminals. The CF senior safety manager reports to the director of Employee Relations and Safety, who reports to the executive vice president, who reports to the chief executive officer, who reports to the chairman of the board.

According to the director of Employee Relations and Safety, emphasis on safety has increased since CF's establishment as a separate entity in 1996. He has stated that it is CF policy that safety is every employee's job. The chairman of the board has stated that he will "commit each member of the board of directors to sponsor one terminal and one division for improvement in workers' safety." The chief executive officer has instituted an "I Want To Hear From You" program through which employees are encouraged to report safety concerns directly to him by mail. CF permits disciplinary steps, including termination, to be taken against supervisors who seek reprisals against employees who use the chief executive officer's program.

Each CF senior manager is responsible for becoming actively involved in safety. Division managers hold monthly safety meetings with their respective employee safety manager, terminal managers, supervisors, and all employees who are not performing other duties. The director of Employee Relations and Safety or the senior employee safety manager also participates in these meetings by conference call. CF told the Safety Board that the topic for the Milwaukee terminal's November 21, 1996, safety meeting was Winter Driving and Hazard Perception. The doubles driver did not attend this meeting, during which a video on winter driving was shown.

Driver safety is monitored primarily through the reporting of accidents, traffic citations, driving records, and citizen complaints. The carrier conducts an annual record check in the respective State where the driver works. A complete driving history is obtained every 2 years by CF from the State in which the driver is licensed. On occasion, CF safety managers may monitor a suspected problem driver while he is driving his assigned route, but this method is generally considered

impractical because of the number of drivers and routes within a safety manager's assigned territory. The doubles driver was never monitored while driving.

Flatbed Truck -- MTI, based in New London, Wisconsin, is an interstate, for hire, motor carrier of general freight operating in Wisconsin, Illinois, Indiana, and Iowa. Founded in 1994, the company employed 3 full-time drivers and 2 office personnel, and maintained a fleet of 3 tractor trucks, 6 flatbeds, and 10 van semitrailers. At the time of the accident, the flatbed was hauling lumber to be used for the construction of wooden pallets.

Passenger Van Rental Contract -- The passenger van was rented from May Fair Rent A Car, Inc., located in Milwaukee. According to the rental office records, the passenger van driver made the reservation on January 7, 1997. The van was to be picked up at 4:30 p.m. on February 11, 1997, and returned by "late p.m." the next day. The reservation had a notation that read "first 2 seats out."

Refrigerator Truck -- Glandt/Dahlke, Inc., a company based in Milwaukee, is a private carrier of produce. Founded in 1929, the family-run business supplies produce to restaurants within a 150-mile radius of Milwaukee. The company employs 13 drivers, operates 13 straight trucks, and, in 1996, accumulated 811,407 miles. Seven of the drivers have CDLs and two operate in interstate commerce; the others drive smaller trucks in the local area.

Glandt/Dahlke does not perform its own vehicle maintenance. The accident truck and two others are leased from SIVA Truck Leasing under a full-service lease. SIVA performs all vehicle and file maintenance. The company-owned trucks are maintained by area dealers who keep the maintenance records, and the company keeps copies of the repair bills.

The company's driver qualification file for the refrigerator truckdriver contained a copy of the medical examiner's certificate and an application for employment but did not contain previous employment history or background checks. Although Glandt/Dahlke conducted pre-employment controlled substance tests on all new hires, the firm did not have a written policy about the use of controlled substances and misuse of alcohol. Nor had it conducted random controlled substance or alcohol testing. Federal regulations (49 CFR 382.601) require employers to promulgate a policy on the misuse of alcohol and controlled substances. The regulations further require that the employer ensure that copies of the materials be distributed to each driver.

Motor Carrier Oversight

Doubles Truck -- The DOT Office of Motor Carriers (OMC) had conducted a compliance review of CF on December 27, 1993. This review indicated 311 recordable accidents, or an accident rate of .46 per million miles, based on 661,991,416 miles. The overall FY 1994 accident rate for the industry was .804 per million miles.[19] The OMC fined CF for a violation of 49 CFR 177.823 (a) "marking and placarding of vehicles," for which CF entered into a settlement agreement for $4,500. The OMC compliance review resulted in a satisfactory rating.

Flatbed Truck -- After the accident, a check with the Motor Carrier Management Information System of the OMC revealed that MTI had never been subject to a compliance review by either Federal or State authorities. On March 11, 1997, the OMC conducted a compliance review of MTI.

During the compliance review, the OMC found several violations of the motor carrier safety regulations. The OMC provided education and guidance to MTI through the *Federal Motor Carrier Safety Regulations* and the OMC Accident Countermeasures Program.[20] MTI corrected most of the violations before the OMC completed the review, which resulted in a satisfactory rating.

Refrigerator Truck -- Glandt/Dahlke, Inc., serves customers in several cities in Wisconsin and in Rockford, Illinois. The owner had previously registered the company as a private

[19] *Federal Register*, November 6, 1997, p. 60037.

[20] The Accident Countermeasures Program is a computer database used by the OMC to provide accident reduction countermeasures to motor carriers.

interstate carrier, but in 1993, he reregistered it as an intrastate operation. According to Wisconsin Motor Carrier Safety Assistance Program records, in 1993, when program personnel were planning a compliance review of the company, they learned it was an intrastate carrier. Consequently, compliance reviews were not conducted.

Highway Information

The accident occurred in the north- and southbound lanes of US 41 at milepost 67.9 in Washington County, just south of CTH K. (Refer to figures 4 and 5.) US 41, a principal rural arterial, runs north from Milwaukee through Wisconsin to Michigan and was originally constructed in the late 1950s as a two-lane road. Two more lanes were added in the late 1960s, and the four-lane roadway was upgraded to freeway standards in 1994. Before the upgrade, the intersection of US 41 and CTH K was at-grade with stop signs on CTH K. After the upgrade, US 41 became a limited access highway with a diamond interchange at CTH K.

In the area of the accident, the northbound roadway was straight with a 0.60-percent grade. The pavement surface north and south of the interchange was primarily asphalt, and the interchange was concrete, beginning about 3/4 mile south of CTH K. The concrete surface was tined with transverse grooves that run the entire width of each lane. The roadway cross section consisted of a 10-foot right shoulder (6-foot asphaltic concrete), two 12-foot travel lanes, a 6-foot left shoulder (3-foot asphaltic concrete), and a 38-foot grass median. The total median width, including the left shoulders, was 50 feet.

The roadway cross slope was 2 percent for each lane. The sideslope of the depressed median ranged from -12.5 percent (an 8:1 ratio) to -14.3 percent (a 7:1 ratio). The design plans show a typical shoulder slope of -16.7 percent (a 6:1 ratio). The sideslope recommended for a depressed median by the American Association of State Highway and Transportation Officials (AASHTO) in its 1990 publication, *A Policy on Geometric Design of Highways and Streets*, is a 6:1 ratio. The pavement markings met the requirements in the *Manual on Uniform Traffic Control Devices*.[21] According to the Wisconsin Department of Transportation (WisDOT), within a mile of State Trunk Highway 145 (just outside Milwaukee), US 41 has a series of vertical curves with an approximate average grade of 2.2 percent.

Physical Evidence -- The Safety Board documented tire marks on the pavement and in the snow, fluid trails, and pavement scrape and gouge marks. The WCSD had documented the position of the vehicles at rest. The accident scene extended about 1,000 to 1,700 feet south of CTH K.

The doubles truck tractor was found facing southeast in the southbound left lane; its semitrailer was facing southwest, also in the southbound left lane, and the full trailer was facing northwest in the median. Tire marks in the northbound lanes started approximately 1,260 feet south of the CTH K overpass. The 127-foot-long tire marks on the pavement began in the right lane and continued across the left lane into the median. They were clean scrub marks that started out faint and became more distinct and uniform. The 145-foot-long plow marks in the median led to the point-of-rest for the doubles truck.

The flatbed's tractor and semitrailer were facing south in the area between the northbound lanes and the exit ramp to CTH K. The fluid trail (battery acid) in the southbound lanes started about 1,577 feet south of the CTH K overpass. The 146-foot-long fluid trail began in the right lane, crossed the left lane, and led to the median. The average length of the tire marks that crossed this area of the median was 96 feet; the tire marks led to a scrape mark in the northbound lanes. The scrape mark crossed the left lane and went into the right lane toward the final rest position of the flatbed truck.

The van was found facing north-northeast, partially in the right lane and partially on the right shoulder. Additional scrape marks, about

[21]The *Manual on Uniform Traffic Control Devices* is approved by the Federal Highway Administration as the standard for all streets and highways in accordance with Title 23, *United States Code*, Sections 109 (b), 109 (d), and 402 (a) and 23 CFR 1204.4.

Table 4 -- Traffic volumes

Year	Average Daily Traffic	Northbound	Southbound	Percent Trucks
1993	21,370	11,160	10,210	21
1994	21,940	11,450	10,490	NA
1995*	23,980	12,040	11,940	NA
1996	24,050	11,930	12,120	NA

*The ADT for 1995 is incomplete (missing 2 months of data) because of equipment problems.

10 inches long and curved, were found in the right lane near the passenger van.

The refrigerator truck came to rest facing north in the median. (See figure 8 for a diagram showing the physical evidence.)

Traffic Volumes and Speeds -- WisDOT has a vehicle monitoring station on US 41, in Allenton, 4 miles north of the accident site. The station monitors traffic volumes and speeds. The average daily traffic (ADT) counts obtained from this station for 1993 through 1996 are shown in table 4.

The posted speed limit was 65 mph and the highway design speed was 70 mph. On the morning of the accident, between midnight and 6 a.m., the average speed for northbound vehicles was 57 mph and the 85th percentile[22] speed was 64 mph. The average speed for southbound vehicles was 62 mph and the 85th percentile speed was 69 mph.

Accident Statistics -- According to WisDOT accident records, the 6-mile span of US 41 centered on the accident site (3 miles of the roadway in each direction from the site) had 21 reported accidents from 1994 through 1996. Seven accidents involved collisions with deer; six others occurred on ice or snow. Two accidents involved tractor semitrailers that jackknifed.

A review of the individual reports found that none of the reported accidents involved vehicles crossing over the median. Like the accident forms for most States, the Wisconsin accident form does not have a specific code for crossover accidents.

Because "head-on collision" was the closest descriptive code available in existing accident information to the circumstances of the Slinger accident, the Safety Board examined head-on collision data to determine the extent of crossover accidents in Wisconsin. Head-on collisions involving fatalities on divided highways with and without median barriers in Wisconsin are shown in table 5.

[22]The 85th percentile represents the speed at or below which 85 percent of the vehicles had been moving during that period of time.

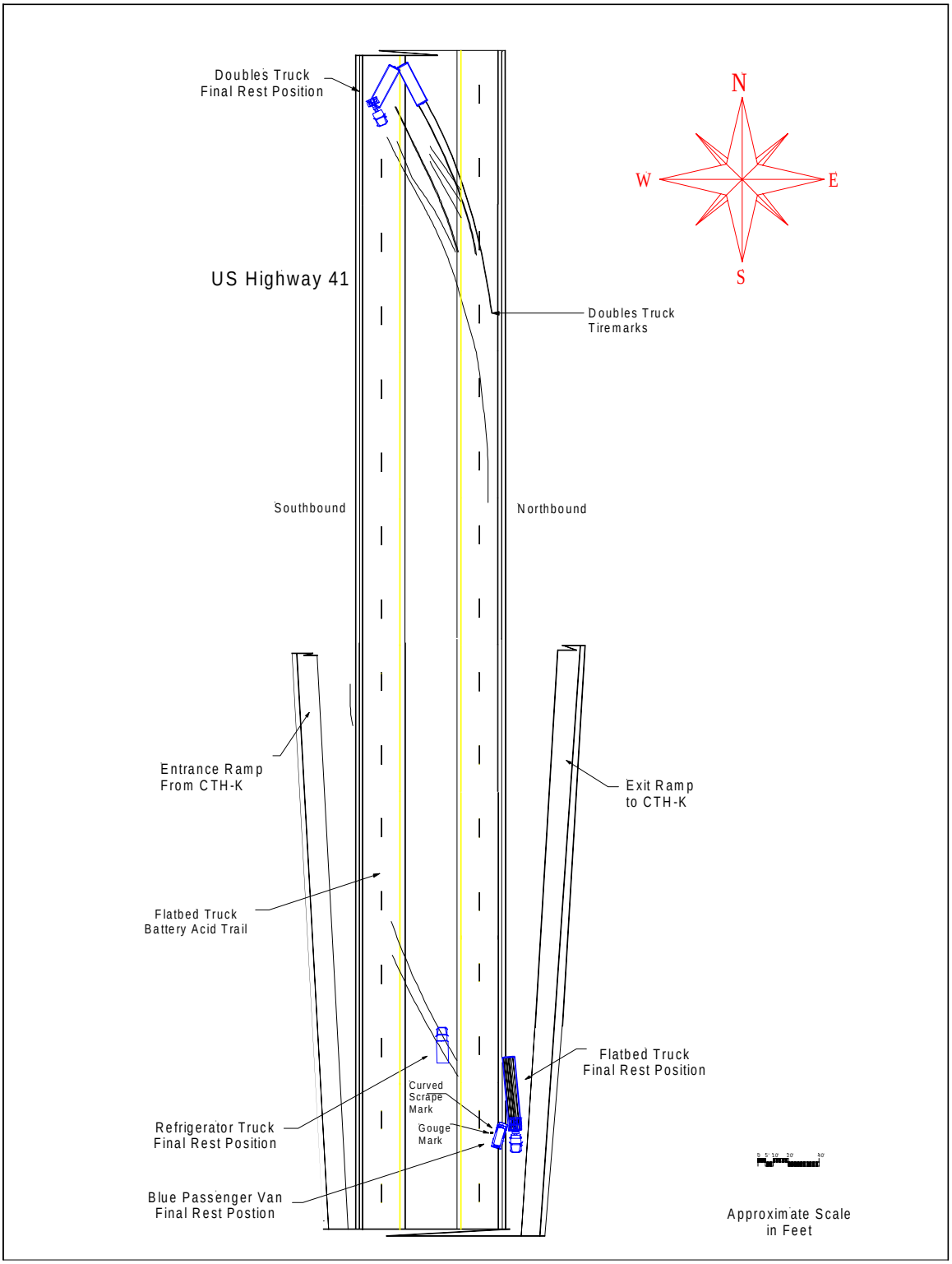

Figure 8 -- Diagram highlighting the physical evidence

Table 5 -- Head-on collisions in Wisconsin on divided highways

Year	With Median Barriers			Without Median Barriers		
	Fatal	Percent of Total	Total	Fatal	Percent of Total	Total
1994	1	0.6	166	4	1.2	339
1995	0	--	86	7	2.9	244
Jan -Nov 1996*	1	1.2	81	4	2.0	196
TOTAL	2	0.6	333	15	1.9	779

*In June 1996, the speed limit was raised from 55 to 65 mph on certain freeways and expressways in Wisconsin, including the section of US 41 where the crash occurred. Between June 1996 and February 1997, a total of 21 highway fatalities occurred in Wisconsin.

To determine the extent of crossover accidents nationwide, the Safety Board examined the National Highway Transportation Administration (NHTSA) 1995 Fatality Analysis Reporting System (FARS).[23] The FARS data does not have a separate crossover accident code. To capture cross-median accidents, the Safety Board examined accidents in which the most harmful event was coded as "a motor vehicle in transport in other roadway"[24] or head-on collision. Of the 830 vehicles involved in these accidents, 728 were on divided highways without barriers and 91 were on divided highways with traffic barriers. There were 560 fatalities in the accidents that occurred on the divided highways without traffic barriers and 60 fatalities in the accidents on the divided highways with traffic barriers.

Adverse Weather Countermeasures -- Snow and ice removal on the Wisconsin State highway system is performed by contract with the county highway departments. Winter storm maintenance on State highways in Washington County is carried out by the Washington County Highway Department. The 26 miles of US 41 are divided into three parts, identified as sections 7, 8, and 9. The accident took place in section 8. Each section is about 8 miles long, not including ramps. (The section boundaries are shown in figure 9.)

Each of the snow and ice removal equipment drivers for the accident region had 8 to 10 years of experience in their respective sections. All three (one driver per section) drove 1997 International Harvester Corporation trucks equipped with MA-5000 Ice Control System Power Drive units and Gresen Model GRS-32 Spreader Control Systems. Each truck had a 10- to 11-ton load capacity.

On the morning of the accident, as the crews were plowing the blowing snow, the driver in section 8 noticed black ice forming in the right lane. He notified the other drivers, and they began applying salt and a wetting agent (liquid calcium chloride) to the roadway as well as to the ramps.

[23]FARS formerly referred to the Fatal Accident Reporting System.

[24]This code applies to events in which the vehicle leaves one roadway and enters a different roadway and has a collision with a motor vehicle in transport in a different roadway. For example, one vehicle travels across the median of a divided highway, enters oncoming traffic, and is struck. Another example would be when a vehicle traveling on an overpass leaves that trafficway and strikes or is struck by a vehicle traveling on a trafficway below.

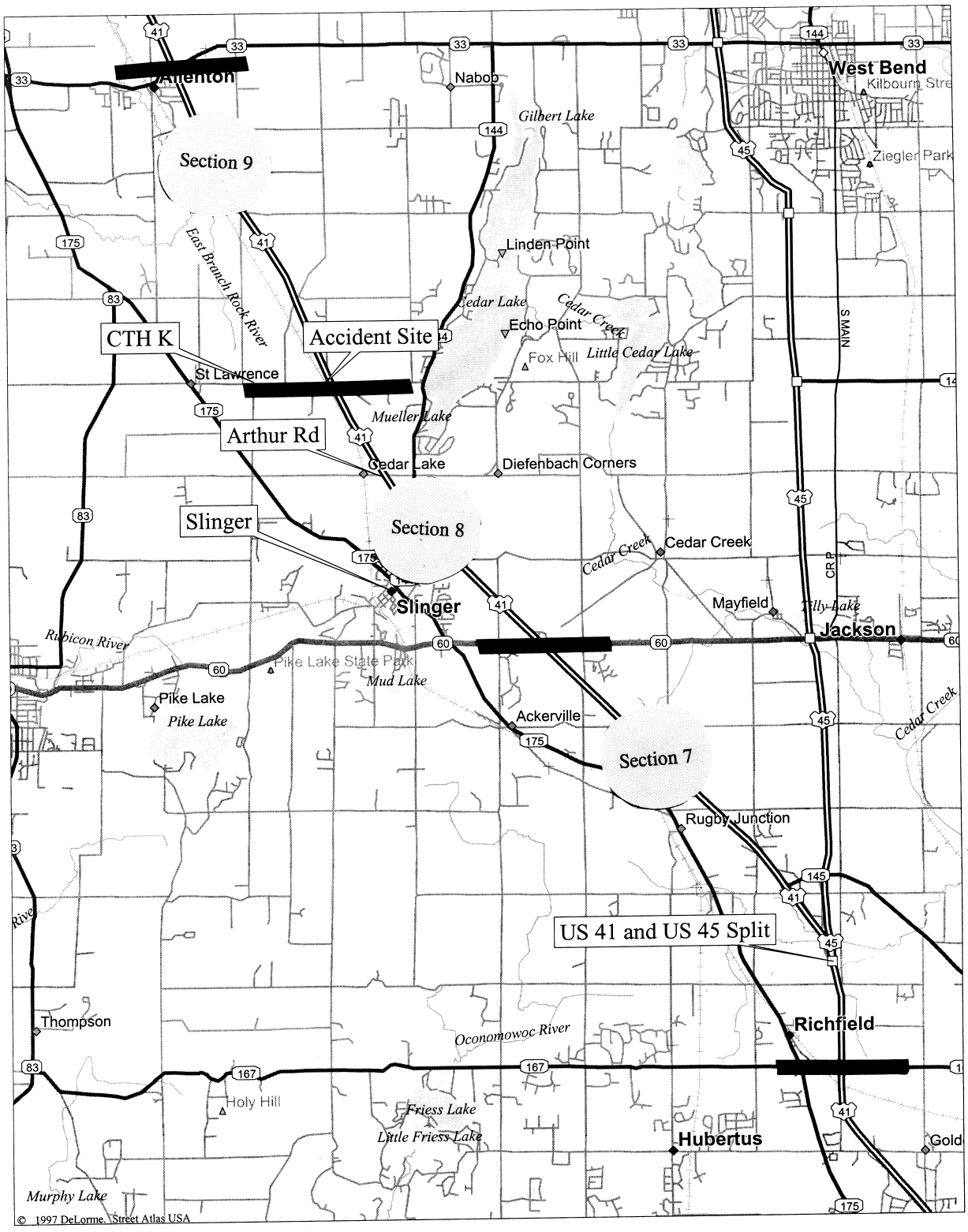

Figure 9 -- Snow section boundaries

According to the drivers, it took an average of 1 1/2 to 2 hours to cover each section, including the ramps. The driver in section 8 said that, by about 5:15 a.m., he had completed a loop over the north- and southbound lanes in his section and his truck was empty. While en route to the maintenance shop to pick up another load of salt and wetting agent, he noticed that the southbound roadway was wet. He was reloading chemicals when he was advised that an accident had occurred at 5:52 a.m. in the northbound lanes near CTH K.

The accident site received two applications of salt and wetting agent. The driver in section 9 stated that he overlapped section 8 as he completed his loop and made his U-turn south of the interchange. All three crew drivers indicated that it was not uncommon for them to overlap sections as they completed their loops.

Wisconsin Department of Transportation Maintenance Manual -- According to the WisDOT *Highway Maintenance Manual* (HMM), plowing or other mechanical means of snow removal are preferable, for environmental and budgetary reasons, to using chemicals, such as rock salt (sodium chloride) and a wetting agent (calcium chloride liquid), or abrasives (sand).

The Washington County crews applied salt at a rate of 400 to 500 pounds per lane mile, with 8 to 9 gallons of liquid calcium chloride per ton, after black ice conditions were reported. The HMM specifies that spreaders should have the capability of delivering chemicals to the center two-thirds of the pavement at a maximum application rate of about 300 pounds per lane mile. The Washington County superintendent told the Safety Board that, from his experience, 300 pounds per lane mile of material was insufficient. He said he routinely instructed his crews to begin applying the material at 400 pounds per lane mile or more as needed. He also stated that salt alone is less effective when the surface temperature is below 20°F and that at such temperatures, liquid calcium chloride, which acts as a dehydrator, is needed to begin the brining action on the roadway to further enhance the removal of snow and ice.

The WisDOT District 2 supervisor told the Safety Board that,

> There are numerous variables that could affect the rate at which the chemicals and surface moisture begins to refreeze, such as a drop in the surface and ambient temperatures, high winds, and little to no traffic to continue the brine action.

Based on the conditions on the morning of the accident, he thought it could have taken 2 hours or longer for the surface moisture to refreeze after the last application of chemicals.

The HMM states that locally available abrasive material, usually sand, should be used when pavement temperatures are 0°F or less, or when chemicals are ineffective because of high winds or other storm conditions. According to the Washington County superintendent, abrasives are rarely used when it is windy because they are blown off the roadway. Instead, road crews use a premix consisting of 99.9 percent pure calcium chloride in the form of pellets or flakes, applied with sodium chloride at a rate of 10 percent.

The accident site was open, unlike the areas north and south of CTH K, where living snow fences (evergreen trees or shrubs or both) break the wind. The HMM specifically addresses the problem of blowing and drifting snow causing slush and ice; it states that "Snow fences can be effective in preventing snowdrifts, improving visibility, and reducing slush and ice." The HMM further states that living snow fences are desirable in areas where right-of-way widths are adequate to provide snow storage.

Road Weather Information System -- The nearest WisDOT road weather information system (RWIS) monitoring station with pavement sensors was located about 10 miles east of the accident site, near the intersection of U.S. Route 45 and State Highway 60. Station records indicate that, at the time of the accident, the road surface temperature on U.S. Route 45 was approximately 16°F and the surface wind was out of the west at about 11 mph. The air temperature was approximately 15°F and the subsurface temperature was about 30°F. The report indicated that the road had precipitation on its surface, in the form of snow and ice, consistently from 8:05 p.m., February 11, until 6:03 a.m., February 12. (See appendix C,

Roadway Weather Information System, for further information.)

The General Billy Mitchell Airport, located about 3 nautical miles southeast of Milwaukee, reported that light snow began falling at 8:08 p.m., February 11, and continued until 3:16 a.m., February 12. About the time the accident occurred, the airport weather station reported clear skies, 9 miles visibility, winds out of the northwest at 12 mph (310° at 10 knots), and a temperature of 19.4°F. No National Weather Service advisories were in effect.

The HMM provided guidance for storm management, stating that the county storm supervisor should provide the media with storm information as appropriate. In addition, WisDOT has a "1-800" roadway weather line and a Web site that provide current road conditions statewide. On the morning of the accident, the weather line was reporting that the roads were snow-covered and icy.

Other States -- The Safety Board examined the deicing practices in States other than Wisconsin. New York uses an application of 225 pounds of salt per lane mile; Iowa and Minnesota use 250 pounds per lane mile during and after snow and ice storms. A 1974 National Cooperative Highway Research Program (NCHRP) survey of 13 States[25] showed application rates that varied from 100 to 600 pounds per lane mile.[26]

In New York, when temperatures fall below 15°F, the State (depending upon conditions) begins using abrasives (sand, cinders, and ash). The sand piles are mixed with 4 to 10 percent salt to allow the abrasives to stick to the pavement and not blow away. Abrasives are used to provide traction, not to melt the ice. When conditions change and it warms up, New York reverts to using chemicals (salt and wetting agent).

Recent Research -- One of the technologies examined under the Strategic Highway Research Program (SHRP)[27] was snow and ice removal. Conventional winter maintenance operations involve deicing techniques, that is, sending plows and trucks loaded with salt and other materials to clear the roadways after a storm has begun. The principle of anti-icing is to inhibit the bond between the pavement and packed snow and ice by applying a chemical that lowers the freezing point of water. The SHRP undertook a project[28] to examine five of the available types of chemical brines commonly used in anti-icing: sodium chloride, calcium chloride, magnesium chloride, calcium magnesium acetate, and potassium acetate. Chemical applications were made before a storm, early in the course of a storm, or during a storm, as plows created bare or nearly bare pavement. The chemical could be applied to the roadway to prevent frost or black ice if road surface temperatures were expected to drop below freezing. Sections of roadway could be selected for different anti-icing treatments based on such variables as traffic flow or pavement type. Through this project, the SHRP found that an anti-icing strategy coupled with an RWIS could reduce winter maintenance costs, improve travel conditions, and help protect the environment. (Wisconsin, one of the 15 States in this SHRP project, tested sodium chloride brine at temperatures above 25°F.)

Subsequently, the Federal Highway Administration (FHWA) and the States conducted a field test to evaluate the anti-icing technologies tested and reviewed in the SHRP project. The field test included a two-winter experimental anti-icing evaluation and analysis of the experimental data. The recently issued report[29] of this evaluation concluded that well-

[25]California, Idaho, Illinois, Kansas, Minnesota, Missouri, Nebraska, New Jersey, New York, Pennsylvania, South Dakota, Vermont, and West Virginia.

[26]*Synthesis of Highway Practices #24, Minimize Deicing Chemicals*, NCHRP, 1974.

[27]Congress established the SHRP in 1987 as a 5-year, $150 million project to develop and evaluate innovative technologies for roadway construction, maintenance, and operations. The SHRP was administered by the Transportation Research Board and the Federal Highway Administration.

[28]Blackburn, R. R.; McGrane, E. J.; Chappelow, C. C.; Harwood, D. W.; and Fleege, E. J., *Development of Anti-Icing Technology*, Report No. SHRP-H-385, National Research Council, Washington, D.C., 1994.

[29]Ketcham, S. A.; Minsk, L. D.; and Danyluk, L. S. *Test and Evaluation Project No. 28: Anti-icing Technology, Field Evaluation Report*, FHWA-RD-97-132, March 1998.

timed initial chemical applications can prevent or mitigate reductions in friction, as well as support the anti-icing objective of preventing a strong bond from developing (between the ice and the pavement).

Research in Wisconsin -- According to WisDOT,[30] Wisconsin is reviewing three new anti-icing technologies during winter 1997-98. The first, being tried in Columbia and Brown Counties, involves spreading fine- and medium-grade salt in addition to the coarser road salt. The finer-graded salts are used because they react more quickly with moisture during conditions under which ice is expected to form. The effects of the finer grades typically do not last as long as the effects of the coarser-grade salts. The second technology, being tested in Walworth County, is an anti-icing device that is mounted directly on one of two parallel bridges on Interstate 43. The device, which is activated when ice conditions are forecast, will automatically spray the bridge with deicing chemicals to prevent the formation of ice. The third program, being conducted in eight counties (Adams, Brown, Douglas, Eau Claire, Florence, Oneida, St. Croix, and Trempealeau), involves the use of liquid magnesium chloride to treat roads just before a storm.

Nationwide Standards -- Although national standards for snow and ice removal do not currently exist, the issue continues to be explored. In 1996, the FHWA published a *Manual of Practice for an Effective Anti-icing Program: A Guide for Highway Winter Maintenance Personnel.* In addition, a current NCHRP Project 20-7 Task 83 is developing a "Guide for Snow and Ice Control," which is expected to be completed in 1998. NCHRP Project 6-13, which began in March 1998, is to develop "Guidelines for Snow and Ice Control Materials and Methods."

The AASHTO Winter Maintenance Policy Committee's Snow and Ice Cooperative Pooled Fund Program sponsored, in cooperation with 34 States, the American Public Works Association, and the National Association of County Engineers, a conference in Minneapolis in April 1997. One of the outcomes of this conference was the recognition of the need for training in new anti-icing and RWIS technologies.

Large Truck Crashes -- According to the NHTSA statistics from the FARS data, in 1994, some 5,112 people died in large-truck crashes. (NHTSA defines a large truck as one weighing more than 10,000 pounds.) Twenty-four percent of large-truck crashes occur on freeways.

A University of Michigan Transportation Research Institute *Truck and Bus Accident Factbook* analysis of truck accidents indicated that, during 1994, "most truck accident involvement occurred on dry roads."[31] Table 6 summarizes the findings of this analysis.

A recent study[32] conducted in Indiana by the Insurance Institute for Highway Safety, in conjunction with the Indiana University Transportation Center, found that doubles trucks were significantly over-involved in crashes on roads with snow, ice, or slush. The study examined 2,033 incidents involving a tractor pulling one or two trailers that occurred on the interstate from October 31, 1989, to March 31, 1991. The study excluded crashes involving bobtails (truck tractors without trailers), single-unit trucks, and triples, as well as crashes occurring at toll plazas or entrance or exit ramps. (A high proportion of doubles rollover accidents occur on ramps and curves.)

[30]WisDOT: News Releases, "Doing Battle with Winter: Counties, State, and FHWA Test Ways to Make Winter Roads Safer," December 8, 1997. "Doing Battle With Winter: Eight Counties Test Liquid Anti-icing Approach to Keep Roads Ice Free," November 20, 1997.

[31]*Truck and Bus Accident Factbook, 1994*, prepared by the Center for National Truck Statistics, University of Michigan Transportation Research Institute, for the Office of Motor Carriers, FHWA, October 1996, UMTRI-96-40, p. 21.

[32]Braver, Elisa, R.; Zador, Paul, L.; Thum, Denise; Mitter, Eric, L.; Baum, Herbert, M.; and Vilardo, Frank, J., "Tractor-Trailer Crashes in Indiana: A Case-Control Study of the Role of Truck Configuration," *Accident Analysis and Prevention*, Vol. 29, No. 1, 1997, pp. 79-96.

Table 6 -- 1994 Truck accidents by road conditions*

ROAD CONDITION	FATAL		INJURY		TOW AWAY		ALL	
	No.	%	No.	%	No.	%	No.	%
Dry	3,820	79.7	41,000	73.4	64,000	71.0	109,000	72.1
Wet	718	15.0	11,000	20.3	16,000	18.4	29,000	19.0
Snow/slush	109	2.3	1,000	1.2	3,000	3.7	4,000	2.7
Ice	116	2.4	3,000	4.8	6,000	6.9	9,000	6.0
TOTAL	4,795	100.0	56,000	100.0	90,000	100.0	151,000	100.0

*These numbers come directly from the 1994 *Truck and Bus Accident Factbook.*

The study found that, compared to single-trailer vehicles, double-trailer vehicles had a decreased risk of crash involvement on dry and wet pavements (excluding snow, ice, and slush) and in multiple vehicle crashes but an increased risk of involvement in crashes occurring on road surfaces with ice, snow, or slush. In Indiana, 14 percent of passenger car crashes on the interstate occurred on snow, ice, or slush during 1990. This finding compared to 21 percent of interstate crashes for single-trailer vehicles and 45 percent of interstate crashes for double-trailer vehicles, for the period from October 31, 1989, to March 31, 1991.

The *Truck and Bus Factbook* indicated that "jackknife"[33] occurred in 5 percent of all combination vehicle (tractor and one or more trailers) accidents. The *Factbook* found that combination vehicles weighing 20,000 to 30,000 pounds jackknifed in 15 percent of these accidents, compared to 3.2 percent for combination vehicles weighing 70,000 to 80,000 pounds. These data show that lighter vehicles tended to jackknife about five times more often than heavier vehicles.

In four separate Safety Board safety studies[34] involving 502 truck accidents that occurred between 1985 and 1993, a total of 83 accidents involved tractors pulling double-trailers. Of these 83 accidents, 19 involved empty or lightly loaded doubles (gross vehicle weights of 45,000 pounds or less) and 12 of the 19 occurred on slippery pavement, where the coefficient of friction between the tire and the roadway was considered a factor in accident occurrence.[35] The Safety Board knows of no public or privately funded studies that have specifically quantified and compared the number of empty doubles accidents on slippery pavements to the number of loaded doubles accidents on slippery pavements.

Medians -- In the course of the investigation, the Safety Board looked at factors affecting highway medians.

[33]The term jackknife describes what happens when a tractor's drive axle(s) loses traction, causing the tractor to rotate and hit the trailers. When the rotation exceeds 15°, the result is usually loss of control.

[34]For more information, see (1) NTSB/SS-88/05, *Case Summaries of 189 Heavy Truck Accident Investigations*, (2) NTSB/SS-90/01, *Fatigue, Alcohol, Other Drugs, and Medical Factors in Fatal-to-the-Driver Heavy Truck Crashes*, (3) NTSB/SS-92/01, *Heavy Vehicle Airbrake Performance*, and (4) NTSB/SS-95/01, *Factors That Affect Fatigue in Heavy Truck Accidents.*

[35]Safety studies do not claim to be statistically representative in either the number or type of accidents investigated.

Widths -- The current design guidelines of the FHWA, AASHTO, and WisDOT recommend 60-foot medians on freeways. In January 1990, when WisDOT increased its *Facilities Development Manual* design guidelines for medians from 50- to 60-foot for freeways, most of the right-of-ways for the US 41 upgrade had been purchased. According to WisDOT officials, this change in median width standards came too late in the development process for a significant change to be incorporated into the US 41 upgrade.

Barriers -- In the area of the accident, US 41 does not have median barriers, and, according to the current median barrier guidelines, no barriers are needed. The AASHTO *Roadside Design Guide* "suggests a warrant for median barriers on high-speed, controlled-access roadways which have relatively flat, traversable medians."[36] The AASHTO warrant provides the criteria for such median barriers. (See appendix D for more information regarding median barrier warrants.)

The AASHTO warrant criteria are based on a 1968 California accident study[37] and 1974 research[38] performed by Texas A&M University; they consider ADT, median width, and cross-median accident history. The warrant criteria do not take into account the percentage of heavy trucks in the ADT.

In June 1997, the California Department of Transportation (Caltrans) changed its policy regarding its freeway median barrier volume/width study warrant.[39] Caltrans recognized that a 25-percent increase in freeway traffic; changes in vehicle designs; adjustments in driver skills, abilities, and attitudes; and increases in speed limits had altered the historical trend surrounding the probability of cross-median accidents. Caltrans extended its policy to a 75-foot median-barrier-freeway-volume/width-study warrant. Caltrans expects to cut the annual number of fatal cross-median accidents on the State's freeway system in half by this action. During the past 5 years, California has averaged 35 fatal cross-median accidents a year.

In 1993, North Carolina conducted a study that found that 105 deaths had occurred in 751 head-on collisions that took place from April 1988 through October 1991. These collisions represented 3 percent of the State's highway crashes and nearly one-third of the fatalities. As a result of the study, North Carolina began a $24 million dollar project to install median barriers in 24 locations on the interstate system.

Cross-median Accident Coding -- Since the Slinger accident occurred, the Safety Board has investigated several other cross-median accidents and has found that cross-median accident histories are not readily available. Most States do not have a cross-median accident code on their accident report forms.

About 9:55 p.m. on April 25, 1997, a southbound doubles truck operated by UPS lost control and crossed over the 64-foot grass median of Interstate 95 in Jacksonville, Florida. The doubles truck collided with a passenger car and a tractor semitrailer in the northbound lanes. All vehicles were damaged extensively and four fatalities resulted.[40]

While trying to determine the accident history for this location, the Safety Board was told by Florida Department of Transportation officials that they had experienced difficulty in identifying median crossover accidents. For example, at one location, a few miles in length, they were aware of several median crossover accidents, yet their efforts to identify these accidents by searching the records were unsuccessful. On the official report of the Jacksonville accident, both the contributing circumstance and the harmful event were coded as "other."

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[36] *Roadside Design Guide*, AASHTO, Washington, D.C., 1990, chapter 6, p. 1.

[37] Graf, V. D. and Wingerd, N. C., "Median Barrier Warrants," Traffic Department of the State of California, 1968.

[38] Ross, H. E. Jr., "Impact Performance and Selection Criterion for the Texas Median Barriers," *Research Report 140-8*, Texas Transportation Institute, Texas A&M University, 1974.

[39] Caltrans internal memorandum to all district directors from Traffic Operations, dated June 27, 1997.

[40] For more information, see docket for CHR-97-FH-005.

A review of the NHTSA publication, *State Accident Report Forms Catalog, 1995 Update*, revealed that six States, (Hawaii, Indiana, Louisiana, Massachusetts, Michigan, and Missouri) have a data element on their reporting forms for "median crossover" accidents. NHTSA, the FHWA, and the National Association of Governors' Highway Safety Representatives (NAGHSR) are developing a *Guideline for Minimum Uniform Crash Criteria*. The Safety Board reviewed the October 1997 draft of this document and found no mention of crossed medians as a data element.

Toxicological Tests

Results -- In accordance with the DOT regulations (49 CFR 382.303), which require specimens to be tested for alcohol, cocaine, marijuana, amphetamines, PCP, and opiates, initial laboratory toxicology tests were performed on specimens from the three truckdrivers involved in the Slinger accident. Specimens for testing were obtained from the van driver during an autopsy conducted by the Milwaukee County Office of the Medical Examiner. The results are in table 7.

Table 7 -- Results of initial laboratory toxicology tests

DRIVER	SPECIMENS	TIME SPECIMENS TAKEN*	RESULTS	
			ALCOHOL	DRUGS
Doubles truck	Breath	11:06 a.m.	negative	negative
	Urine	11:00 a.m.	negative	negative
Flatbed truck	Blood	4:30 p.m.	negative	negative
	Breath	5:08 p.m.	negative	negative
	Urine	4:30 p.m.	negative	negative
Passenger van	Blood	February 13	negative	negative
	Urine	February 13	negative	negative
	Vitreous humor	February 13	negative	negative
Refrigerator truck	Breath	11:34 a.m.	negative	negative
	Urine	11:45 a.m.	negative	positive

*Except for the specimens taken during the autopsy of the van driver on February 13, 1997, all specimens were taken on the day of the accident, February 12, 1997.

The Safety Board submitted specimens from all drivers except the CF doubles truckdriver[41] for additional analysis to the Center for Human Toxicology in Salt Lake City, Utah. These tests were negative for alcohol and drugs, except for the urine specimen test for the refrigerator truckdriver, which showed the following:

- 41 ng/ml[42] COOH-THC, (an inactive metabolite of marijuana);
- 346 ng/ml diphenhydramine (a sedating over-the-counter antihistamine); and,
- 11.1 ug/ml[43] acetaminophen (an over-the-counter medication for mild pain and fever).

After the accident, the refrigerator truckdriver stated that he had ingested marijuana several days before the accident.

Timeliness -- Federal regulations require that a breath test for alcohol be obtained within 2 hours of an accident. If that is not accomplished, the carrier must have a record on file as to why the test was not performed. The regulations further state that if alcohol tests are not accomplished within 8 hours, the carrier shall cease attempts to administer the tests and prepare and maintain a record as to why the specimens were not obtained. Urine specimens for drug testing must be obtained within 32 hours of an accident.

Toxicological specimens were obtained from the doubles and refrigerator truckdrivers within 6 hours of the accident and from the van driver's autopsy the next day. Specimens were not obtained from the flatbed truckdriver until late afternoon, 10 1/2 hours after the accident, which did not meet Federal drug testing timeliness requirements for the breath test for alcohol.

The flatbed truck carrier's Human Relations representative informed Safety Board investigators that she was notified midmorning on February 12, 1997, that the driver had been involved in an accident, and that he was required to undergo postaccident alcohol and drug testing. She indicated that the driver thought the specimens had been taken at the hospital, and it was late afternoon before the carrier could arrange to have them taken at a clinic.

Survival Aspects

Restraint Use -- The refrigerator truckdriver, who was not injured, was wearing the available lap/shoulder belt. The doubles and flatbed truckdrivers, who received minor injuries, were both wearing the available lap/shoulder belts.

According to rescue workers, the driver and the right front passenger of the van, both of whom sustained fatal injuries, were wearing the available lap/shoulder belts. The driver's supplemental airbag had deployed and the pre-tensioner device[44] had activated. Although restraint systems were available, nothing indicated that the remaining van passengers had been restrained. The surviving passenger initially stated that none of the passengers beyond the front seat of the van had been using seat belts. He also indicated that he was aware that Wisconsin had a mandatory seat belt law. (Refer back to figure 6 for seating and restraint availability and see figure 10 for injury distribution and restraint use.) He told investigators that the cargo in the van had been stored several feet in front of him.

[41]After the lab that CF hired to analyze the urine specimen provided by the doubles truckdriver found the specimen negative for the presence of drugs, it destroyed the specimen.

[42]Denotes nanograms (billionths of a gram) of drug or metabolite present per milliliter of specimen.

[43]Denote micrograms (millionths of a gram) of drug or metabolite present per milliliter of specimen.

[44]A pre-tensioner device is designed to take the slack out of a seat belt during the first milliseconds of a collision.

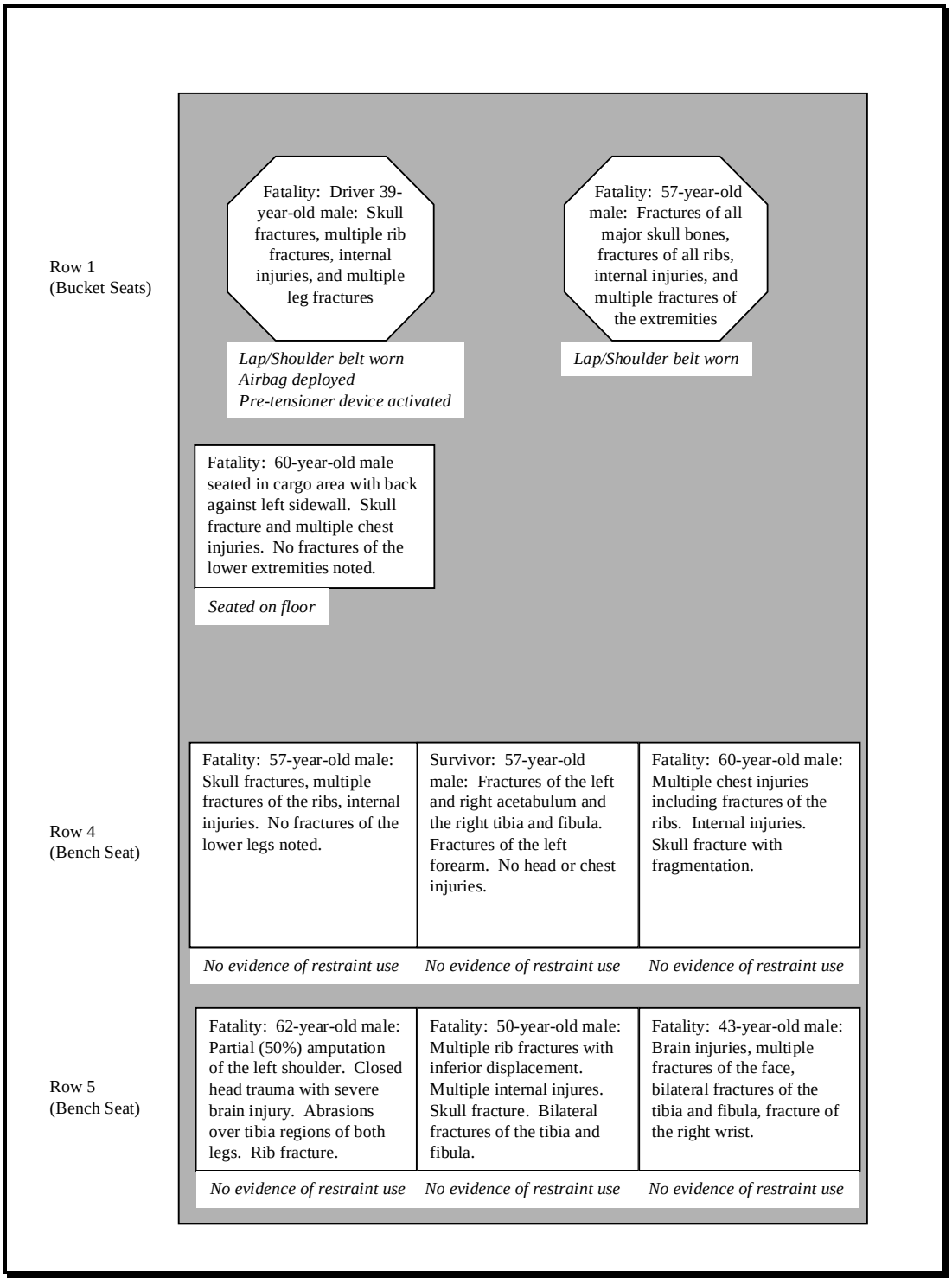

Figure 10 -- Injury distribution and restraint use

Wisconsin Seat Belt Use Law -- The Wisconsin seat belt mandatory use law (MUL)[45] is enforceable for seating positions with lap/shoulder belts only. The Wisconsin MUL is, like those in the majority of States, a secondary enforcement law. Secondary enforcement means that a police officer cannot issue an individual a ticket for not wearing a seat belt unless the officer has had to stop the individual for some other infraction. Wisconsin allows evidence of failure to wear a seat belt in a court of law, permitting mitigation of 15 percent of the damages that may be recovered by a plaintiff who failed to wear a seat belt.

According to the Wisconsin Governor's office, the Wisconsin seat belt use rate is 61.7 percent,[46] compared to the national average of 68 percent. Evidence indicates that States and countries with stricter seat belt use laws have higher seat belt use rates.[47]

Emergency Operations Plan -- Washington County has an Emergency Operations Plan. The EMS portion of the plan can be called upon in several different emergency situations, including weather, fires with large numbers of victims, and public transportation accidents (bus, train, and plane). Although the plan does not have a specific provision for multi-victim accidents involving private vehicles, it makes provision for natural or man-made disasters that exceed the routine capabilities of the local EMS response system. In addition, the SFD and other local response agencies have a mutual aid agreement.

Tests and Research

The Safety Board tested several components of the vehicles involved in the collisions.

Doubles Truck ECM -- The Cummins ECM on the doubles truck was read at the Cummins Great Lakes facility in Milwaukee, Wisconsin, on February 15, 1997. The ECM did not have optional on-board recording features; it was only configured to operate as an ECM. Consequently, the readout did not provide any vehicle speed or engine rpm data for the doubles truck.

Passenger Van ECM -- The airbag system on the passenger van was equipped with an ECM manufactured by Bosch. According to Chrysler, the module cannot archive any vehicle crash deceleration "G-pulse" information.

One method of determining the crash pulse to which a vehicle is exposed during a collision is the use of a crash-pulse-recording device. Currently, 60,000 vehicles in Sweden equipped with crash recorders are being tracked to gather data aimed at improving occupant protection in collisions.[48] Similar research is being conducted in the United States involving race cars.[49] Some vehicles currently marketed in Europe and the United States have crash pulse recorders. As noted above, the model of van involved in this accident does not require the storage of a crash pulse, and none was recorded.

The Safety Board attempted to calculate the crash pulse and delta-v (change of velocity) of the passenger van's collision with the flatbed truck using force deflection curves determined from crash test data. This calculation could not be successfully completed because different impact configurations for the same vehicle produce different force deflection curves.[50] Because the passenger van sustained underride engagement at two different levels, in addition

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[45]Found in *Wisconsin Statutes Vehicle Code*, chapter 347, section 347.48 (as of 1991).

[46]January 5, 1998, telephone conversation between a Safety Board staff member and a member of the Governor's staff.

[47]See *Proceedings of the National Transportation Safety Board Public Forum on Air Bags and Child Passenger Safety, March 17-20, 1997, Washington, D.C.*, Report of Proceedings (NTSB/RP-97/01).

[48]From the proceedings of the 1996 International Research Council on the Biomechanics of Impact, September 11-13, 1996, p. 212.

[49]Melvin, John, W; Baron, Kenneth, J.; and Little, William, C: *Investigation of Indy Car Crashes Using Impact Recorders*, 1996, Society of Automotive Engineers.

[50]An underride crash test and a flat frontal barrier crash test performed at the same impact speed can produce different force deflection curves for the same vehicle. These differences occur because underride damage is sustained in the "softer" sheet metal above the frame, which results in lower forces being generated during the collision for a given crush depth. The flat frontal barrier test engages "harder" structures, such as the frame and the engine, in a longitudinal direction, and so generates greater forces than the underride at the same impact speed.

to partial engagement of the front bumper, a force deflection curve could not be accurately calculated using the available crash test data for frontal flat barrier impacts. A search of underride crash test data found no relevant testing for similar vans.

Passenger Van Restraint Systems -- The Safety Board's Materials Laboratory examined the seat belt, belt retractor, retractor mount bolt, and D-ring assembly from the left outboard of the row 4 seat belt assembly. Plastic transfers from the D-ring were found on the belt.

Doubles Truck Road Test -- On July 23, 1997, Safety Board investigators, in conjunction with CF representatives, performed a road test in a doubles truck that was "sister" to the accident vehicle to determine the maximum speed at which an operator could downshift from 7th to 6th gear. The test showed that the maximum speed was 55 mph. This downshift was accomplished with the benefit of a "governor override" and, according to CF personnel, the normal downshift from 7th to 6th gear would be made at speeds of less than 47 mph, the top speed in 6th gear.

Other Information

Vehicle Underride -- NHTSA reports that about 500 to 600 deaths occur each year when smaller vehicles underride large trucks or trailers. The current Federal law (dating back to 1953)[51] requires "rear guard" (rear end) protection if the trailer has a ground clearance of more than 30 inches. No specific requirements regulate the strength of the rear guards. In the intervening years, lower-hood-profile cars have been manufactured and this configuration is currently the "norm" for most small cars.

The new *Rear Impact Guards; Rear Impact Protection*[52] law became effective on January 26, 1998. The main change in the standard is that rear guard protection is required if the trailer has a ground clearance of more than 22 inches. Further, specific strength requirements, which did not appear in the 1953 law, are present in the new law.

Neither the previous Federal law nor the current law addresses the issue of side underride. The Safety Board knows of no Federal regulations currently being drafted to address side underride. The situation is different in Europe as "Side-underride guards developed to protect motorcyclists, bicyclists, and pedestrians from entrapment are now utilized in Europe."[53]

Vehicle Conspicuity -- Neither the doubles truck nor the flatbed truck had any special reflectorized markings on the trailers other than the required lights and lens reflectors. The Federal *Conspicuity Systems* law[54] mandates that all trailers manufactured after December 1, 1993, with a GVWR in excess of 10,000 pounds and a width of at least 80 inches have "retro-reflective sheeting" tape along the sides and rear of the trailer. The law also requires each truck tractor manufactured on or after July 1, 1997, to be equipped with either reflective sheeting, reflex reflectors, or a combination of sheeting and reflectors. The commercial vehicles in this accident were all manufactured before the effective dates in the law.

Phase 4 Computer Simulation -- The Safety Board sought to determine, by conducting simulations, whether the use of a traction control device or system could have ameliorated the doubles truck's jackknife. One model for such a simulation is the Phase 4 vehicle dynamics model. The Safety Board contracted with University of Michigan Transportation Research Institute staff to run the Phase 4 model with input parameters from this accident.[55]

The primary focus of the simulation was on the jackknife loss-of-control event and how a wheel slip control mechanism (traction control)

[51] 49 CFR, Part 393.86.

[52] 49 CFR, Parts 571.223 and 571.224.

[53] Badger, Joseph E., *Trailer Underride* (a publication of the Institute of Police Technology and Management, University of North Florida), revised 1995, p. 30.

[54] 49 CFR, Part 571.108, S5-7.

[55] MacAdam, Charles C., *Summary Report of Findings from a Computer Simulation Analysis of the Slinger, Wisconsin, Accident Involving an Unladen Doubles Combination*, December 1997.

on the tractor rear axle might have influenced the outcome of this accident. Traction control devices are based on antilock brakes in that they assess the rate of wheel spin-up and apply brake force to control those situations in which the wheel is loosing traction. Antilock brakes can help avoid locked wheels in braking by using sensors that monitor the rate of wheel rotation. If the sensors sense that a wheel is "spinning down" at a rate that will lock, the system momentarily releases the brake force to that wheel. Antilock brakes are required to be installed on all truck tractors manufactured after 1997.

Traction control systems can assist passenger vehicles and trucks in maintaining headway when ascending snow- or ice-covered grades. Also, these systems can prevent loss of traction at truck tractor drive wheels while under power and reduce the incidence of power-induced jackknife. Brake manufacturers indicate that the cost of adding traction control devices to a tractor would be about 10 to 28 percent of the cost of antilock brakes, which makes up 1 to 2 percent of the cost of a tractor. The percentage of the cost for trailers would be higher.

In conducting the Phase 4 model simulations in this case, simulated operating conditions included an icy road and an 11-mph crosswind. Simulated driver behavior included an initial throttle application to maintain speed and subsequent throttle release at the beginning of the tractor directional instability. The findings of the simulations indicated that the wheel spin-up and the accompanying loss of lateral tire forces at the rear tractor axle resulted in an initial jackknife by the tractor that could not be arrested by the driver, even with rapid countersteering. The simulation identified the main contributors to the loss of control as vehicle speed, vehicle loading/configuration, tire/road friction level, and crosswind magnitude.

Examination of the basic slip control mechanisms on the tractor's rear axle suggested some potential for assisting drivers in maintaining better directional control of the tractor under such severe operating conditions. Although tractor instability was not prevented by the use of tractor slip control mechanisms in several simulations, the rapidity of control loss was generally diminished and often resulted in driver responses that prevented an immediate jackknife and ensuing median crossover. The simulations indicated that an apparent benefit of traction control might be the redirection of the tractor by the driver following the onset of the initial instability and improved, albeit oscillatory, path control. (See appendix E for the Phase 4 simulation summary.)

Heavy Truck Simulators -- Simulations of conditions have been shown to be helpful in training operators in various transport modes. The insurance and trucking industries have used trucks with outriggers on skid pads for training safety directors and conducting research. Simulators have been used extensively in the aviation industry to train operators on how to deal with those conditions that would be either too dangerous or impractical to enact for practice purposes. Simulators are also used extensively in the railroad industry as a primary training tool to teach new engineers about train handling.

The Safety Board has learned that Lockheed-Martin Information Systems (LMIS) in Orlando, Florida, is developing a heavy truck simulator. The LMIS manager of Trainer Systems Programs described the mechanism as a full-motion simulator based on a standard tractor-trailer configuration. The simulator allows individuals to operate in simulated conditions of various degrees of light, snow, wind, and fog. Additionally, the simulator can alter some vehicle dynamics, such as changing gross vehicle weights. LMIS plans to construct another simulator that will be configured for double trailer operation.

ANALYSIS

This analysis will begin with a discussion of the factors and conditions that the Safety Board was able to exclude as neither causing nor contributing to the accident. It will then provide a brief overview of the accident events, a detailed discussion of the issues and countermeasures, and a discussion of the emergency response.

In this accident investigation, the Safety Board identified the following safety issues:

- Judgment and experience of the doubles truckdriver;
- Stability of doubles trucks;
- Effectiveness of snow and ice removal;
- Adequacy of the AASHTO divided freeway median barrier warrants;
- Adequacy of the States' accident report forms to capture cross-median accident data; and,
- Availability and use of restraints.

General

None of the drivers' specimens tested positive for alcohol. A specimen from only one driver, the refrigerator truckdriver, showed any evidence of drug consumption. The Safety Board examined the significance of the presence of COOH-THC, a non-psychoactive metabolite of marijuana, in the refrigerator truckdriver's urine specimen, and his statement that he had ingested marijuana several days before the accident. The presence of this metabolite is not indicative of the level of tetrahydrocannabinol, the psychoactive component of marijuana. Also, the presence of an antihistamine and mild pain and fever medication did not affect the driver's behavior in response to the accident circumstances. All evidence indicates that the refrigerator truckdriver swerved to the left to avoid the collision with the flatbed truck. The Safety Board considers that any unimpaired driver faced with the rapidly developing accident situation would respond similarly.

The Safety Board also examined driver fatigue as it related to this accident and found that none of the drivers involved in the accident suffered from nor were impaired by fatigue before the accident. The Safety Board did not find any mechanical defects that caused or contributed to the severity of the accident in any of the involved vehicles. The Safety Board therefore concludes that no alcohol use, drug use, fatigue, or vehicle mechanical defects contributed to this accident.

The Accident

The following material explains how the combination of the wind, roadway conditions, and speed of the doubles truck resulted in the initial loss of control and the subsequent three collisions of this accident sequence.

Wind -- The nearby WisDOT RWIS station recorded surface wind out of the west at about 11 mph at the time of the accident. The Milwaukee airport reported winds out of the northwest at 12 mph. The doubles truckdriver, the refrigerator truckdriver, and the witness who followed the passenger van all stated that they saw swirling snow on the roads and commented on the slight wind from the west. Therefore, the Safety Board concludes that at the time and in the vicinity of the accident, the wind was blowing at about 11 to 12 mph from the west.

Roadway Surface Conditions -- The WisDOT RWIS station recorded that, at the time of the accident, the road surface temperature was about 16°F. The Washington County road maintenance crews had noticed, and were treating the roadway for, black ice. The truckdrivers stated that the roads were wet in Milwaukee, that the conditions became worse (with the appearance of icy patches) as they traveled north, and that the accident area was icy. The emergency responders and other witnesses also commented on the icy pavement at the accident site. The Safety Board concludes

that at the time and in the vicinity of the accident, the road had patches of ice.

Speed of the Doubles Truck -- The doubles truck did not have a speed recorder and the driver gave inconsistent statements to the Safety Board and the police about the gear and speed of his vehicle. He initially told the police he was traveling in 4th gear; he later told the Safety Board he was traveling in 6th gear at 35 to 40 mph. The Safety Board examined the physical evidence, the witness statements, and the limitations of the truck to determine the speed at and gear in which the doubles truck was traveling before the accident.

Although the doubles driver stated that he did not apply the brakes before the loss of control, the physical evidence indicates that the brakes were applied during the accident sequence. The tire marks on the pavement and through the snow on the median were made by locked wheels. The tire marks on the roadway were clean scrub marks that started out faint and became more distinct and uniform, indicative of a locked wheel sliding across a wet pavement. A rolling wheel would have left a "footprint" and a spinning wheel would have left a mark that started out darker and became light. In addition, the tire marks across the snow-covered surface and in the median were plow marks indicative of a wheel sliding across the snow. A rolling wheel would have left an imprint, not have plowed the snow on the edge of the roadway or in the median. It therefore appeared that the doubles driver probably applied the brakes after the initial loss of control.

The estimated speed of the doubles truck at the time it lost control was calculated to have been between 43 and 58 mph. This estimate is based on the tire marks, the slope of the roadway (0.006), and a range of coefficients of friction for locked wheels on ice (a low of 0.07 and a high of 0.20) and snow (a low of 0.35 and a high of 0.55).[56] The actual speed may have been higher because the roadway may not have been entirely covered with ice; it might have been wet or snow-covered with icy patches. Wet and snow-covered pavements have higher coefficients of friction than icy pavement and would result in higher calculated speeds.

About 1.3 miles south of the accident site, a witness estimated that the doubles truck was traveling at about 60 mph. The witness stated that he was traveling at 50 to 55 mph when the doubles truck overtook him and started to pass. The witness slowed to 45 mph to allow the maneuver to take place quickly. This witness also stated that he had been following the passenger van for a while and that it was traveling at the same approximate speed of 50 to 55 mph. Therefore, according to the witness, at a point about 1.3 miles south of the accident site, the doubles truck, the passenger van, and the witness were in the same approximate location at the same time.

After the witness slowed to 45 mph during the passing maneuver, the doubles truck and the passenger van disappeared from his view. Unless the passenger van slowed suddenly, the doubles truck would have to have passed the van at about 55 to 60 mph in order to get several seconds in front of it. It can be determined that the doubles truck was several seconds in front of the van during this period because the median crossover by the doubles truck, its impact with the flatbed truck, and the flatbed's subsequent median crossover all took place before the passenger van reached the accident site.

Based on the minimum coefficient of friction for the doubles truck and the minimum deceleration factor for the flatbed truck, the Safety Board calculated that the minimum time necessary for the sequence of events to take place from when the doubles truck lost control until the van hit the flatbed truck was 16.1 seconds. For the doubles truck to have been 16.1 seconds ahead of the passenger van traveling at 50 mph over the same distance of 1.3 miles, the doubles truck would have to have been traveling at 60 mph.

The doubles truck was governed to a maximum speed of 62 mph in 7th gear and 47 mph in 6th gear. Although the doubles truck was ultimately found in 6th gear, the Safety Board considers that, during the accident sequence, the floorboard in the doubles cab moved forward, causing the gear shift lever to

[56] Traffic Accident Reconstruction, Volume 2, *Traffic Accident Investigation Manual*, Northwest University Traffic Institute, Lynn B. Fricke, Exhibit 15, "Coefficients of Friction of Various Roadway Surfaces," pp. 62-64.

move forward from the 7th gear position to the 6th gear position. (See figure 11 for the gear diagram.) In addition, in order to achieve the speed of 60 mph necessary to pass the passenger van as occurred in this circumstance, the truck would have to have been in 7th gear. Based on the foregoing information, the Safety Board concludes that, although the doubles truck was found in 6th gear after the accident took place, it had been traveling at the upper limits of the calculated speed estimate of 43 to 58 mph, and therefore it had been in 7th gear.

Doubles Truckdriver's Initial Loss of Control -- The doubles driver stated that he "suddenly felt the trailers [tires] slip on the icy roadway," that the trailers "pushed forward and towards the right," and that he "immediately let off the accelerator." He further indicated that he was neither shifting gears at the time nor did he apply his brakes. In addition, he said that he had no time to react to the developing situation, and that he attempted to countersteer the tractor.

The tire marks and subsequent position of the tractor and trailers as they entered the median indicate that the tractor began to jackknife toward the left. The curved tire mark that begins in the right lane leading toward the median was made by the left front (steering) axle tire and confirms that the driver tried to countersteer.

Doubles Jackknife -- A typical jackknife occurs when the drive axle(s) on a tractor loses traction because of a locked or spinning wheel, and the tractor rotates into the trailer.[57] The situation develops quickly and usually results in a loss of control. Although a jackknife is most often caused by excessive braking or an excess power application for the available roadway friction, it can also be the result of downshifting, immediately letting off the accelerator, or wind acting on empty trailers. The Safety Board identified several factors that suggest how the doubles truck may have jackknifed.

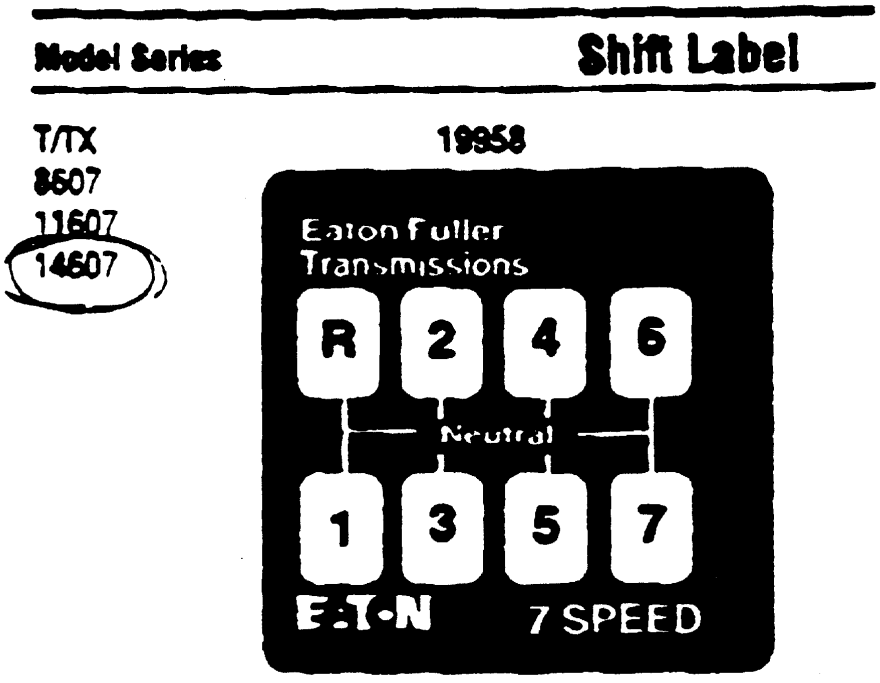

Figure 11 -- Gear box diagram

[57]Radlinski, Richard W., *The Anatomy of a Tractor Trailer Jackknife*, Vehicle Research and Test Center, NHTSA, undated.

The doubles truck had a single-drive axle and the trailers were empty. A witness observed the truck traveling in the left lane at approximately 60 mph about 1.3 miles south of the accident site. The same witness observed the doubles truck's rear trailer swaying approximately 6 inches in both directions. Icy patches were present on the roadway, and the wind was blowing from the west at about 11 mph. The doubles driver stated that the truck had fishtailed at least three times before the accident.

The driver stated that when he felt the trailers (actually the drive axle) slip and push the tractor forward and to the right, he immediately let off the accelerator. The Safety Board considers that the speed of the truck and the effect of the wind on the empty trailers likely set up a harmonic swaying motion, or oscillatory sway, in the trailers; thus, when the drive axle wheels passed over the icy patches, the wheels began to spin, causing the tractor to lose both lateral and longitudinal stability. When the driver let off the accelerator, the tractor was pushed into a jackknife by the trailers, and the driver was unable to recover, even by immediately countersteering. Therefore, the Safety Board concludes that the initial loss of stability was the result of wheel spin-up. (See figure 12 for a diagram of the doubles jackknife event.)

Collision of the Doubles Truck and the Flatbed Truck -- The doubles truckdriver said the vehicle was still moving in a circular motion when he hit the interior of the cab, and that he sensed he had been stopped for 30 to 60 seconds when he felt another impact. The southbound flatbed truckdriver indicated that when he realized the doubles truck was out of control, he "went off towards the right shoulder" and the doubles truck hit him "on the driver's side." Although the flatbed driver observed the doubles truck in the median for some period of time before reacting to the emergency situation, the tire marks found confirm that he tried to avoid the collision.

The damage to the flatbed truck's left-steer axle indicated that it was disabled and the driver lost all steering control during the collision. A fluid trail left by battery acid scarring the pavement shows the path of the flatbed truck as it left the right shoulder and angled across the right and left lanes before crossing the median.

The flatbed truck tractor came to rest facing southbound in the "gore area"[58] between the northbound lanes and the ramp to CTH K. The semitrailer came to rest across both northbound lanes.

Collision of the Flatbed Truck and the Passenger Van -- Witnesses placed the passenger van traveling northbound at 50 to 55 mph in the right lane. The sole survivor in the passenger van said that, immediately before the collision, he looked up and saw something in the roadway. The refrigerator truckdriver said he saw a dark object enveloped in swirling snow moving at him from the median at about a 45° angle. He noticed a brief illumination of the passenger van's brake lights before the van collided with the flatbed semitrailer.

The refrigerator truckdriver further indicated that the semitrailer was still moving when the van hit it. The damage indicates that the van hit the right side of the front tandem wheels and landing gear of the flatbed semitrailer. The passenger van underrode the semitrailer and, as the two vehicles rotated, the van left a curved scrape mark in the pavement.

Collision of the Refrigerator Truck and the Flatbed Truck -- The refrigerator truckdriver said he witnessed the van collision with the flatbed truck as he was trying to decide in which direction to steer to avoid a collision. He slammed on the brakes, swerved to the left, and collided with the rear tandem wheels of the semitrailer. The truck slid off the roadway into the median, and the semitrailer rotated clockwise off the roadway into the area between the northbound lanes and the ramp for CTH K.

[58]The gore area lies immediately beyond the divergence of two roadways; the gore area is bounded by the edges of those roadways.

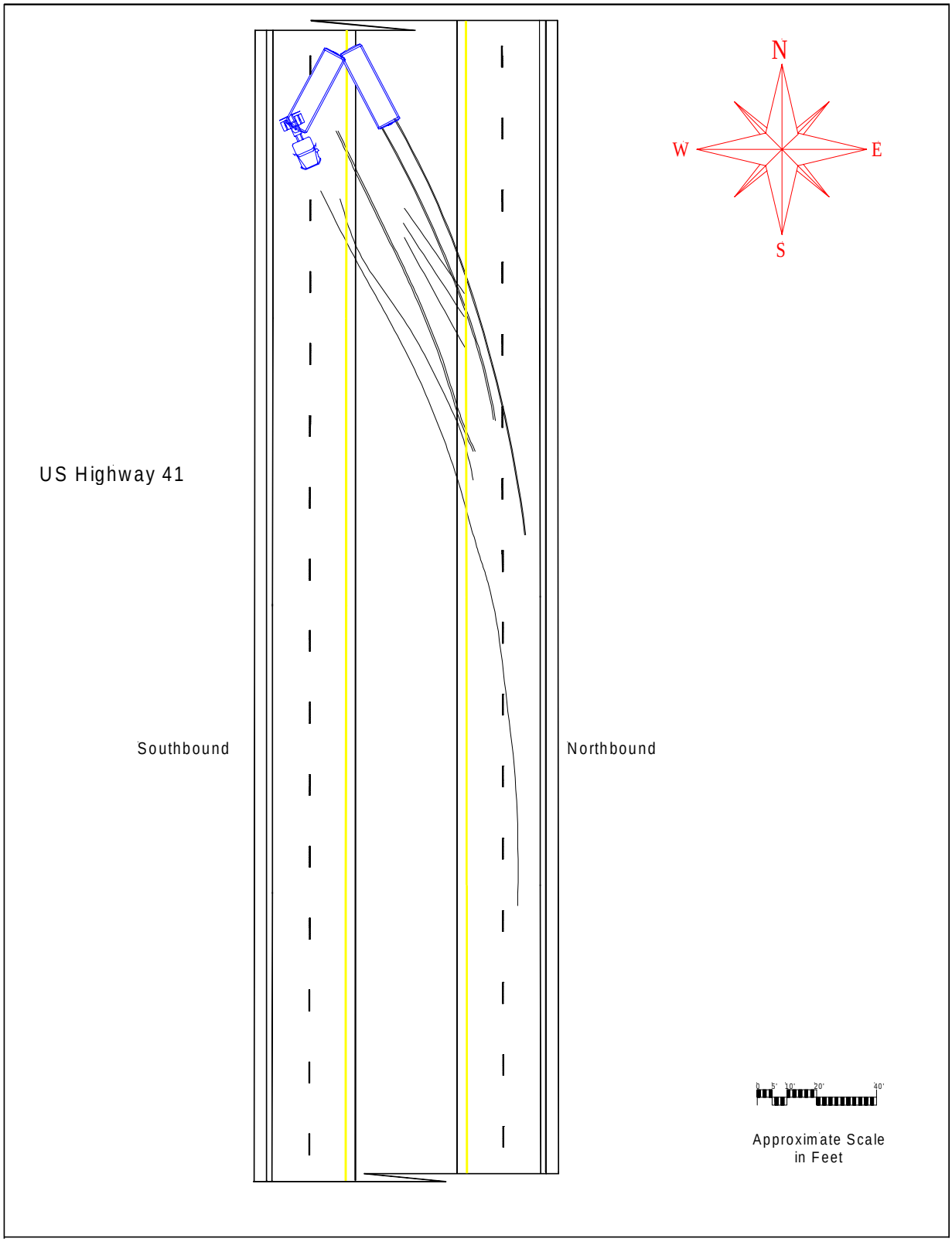

Figure 12 -- Jackknife diagram

In summary, in the early morning of February 12, 1997, near the intersection of US 41 and CTH K, the weather was clear, the temperature was about 16°F, the wind was blowing about 11-12 mph from the west, and the roadway had icy patches. The northbound doubles truck with empty trailers was traveling at the higher end of the speed range of 43 to 58 mph in 7th gear. When the doubles truck's single-drive axle wheels passed over the icy patches, they began to spin, causing the tractor to lose stability. When the driver let off the accelerator, the trailers pushed the tractor into a jackknife. The driver was unable to recover and the doubles truck crossed over the 50-foot grass median into the southbound lanes.

The flatbed truck, traveling southbound on US 41, unsuccessfully attempted to avoid the collision and collided with the doubles truck, lost control, and crossed over the median into the northbound lanes. The northbound passenger van struck and underrode the right front side of the flatbed truck at the landing gear. The refrigerator truck, also traveling northbound, swerved to avoid but nevertheless struck the right rear side of the flatbed truck.

The following is a discussion of the potential countermeasures for the issues identified in this accident.

Driver Countermeasures

Judgment of the Doubles Driver -- The Safety Board evaluated the doubles truckdriver's actions in the context of the sequence of events that led to the accident. The driver recalled that about 15 miles north of the CF yard in Milwaukee, he felt his trailer fishtail slightly, which indicated to him that the roads were not in good condition. He said that he maintained a speed of 50 to 55 mph until he experienced another fishtail at a point further north on the highway. He said that he then reduced his speed to between 35 and 40 mph.

The Safety Board considers that if the doubles driver reduced the speed of his vehicle after he experienced a second temporary loss of traction, he responded appropriately. However, based on the calculated speeds determined by the Safety Board and confirmed by the witness statements, it appears that the driver actually increased his stated speeds until he completely lost control of the vehicle.

The Safety Board considers that the doubles driver exhibited behavior indicative of poor judgment before the accident sequence began. First, moving doubles, by their very nature, are inherently less stable than single trailers, particularly during inclement weather. They tend to develop a lateral motion, or amplitude, that in turn can be affected by the wind and the coefficient of friction. Indeed, Volume 1, Section 7.1 of the January 1997 *Wisconsin Commercial Driver's Manual* advises operators of doubles and triples to exercise caution in adverse conditions. Specifically, the section notes that these units have greater length and additional dead axles to pull, and that they have a greater likelihood of experiencing skids and traction losses.

Second, the presence of patches of ice and snow on the road surface would increase the chance for a loss of control. Section 2.6 of the *Wisconsin Commercial Driver's Manual* states:

> Wet roads can double stopping distances. Reduce speed by about one third (e.g., slow from 55 to about 35 mph) on a wet road. On packed snow, reduce speed by half, or more. **If the surface is icy, reduce speed to a crawl and stop driving as soon as you can safely do so**. [Emphasis added.]

By his own admission, the doubles driver said that road surface conditions appeared to deteriorate the further north he traveled. Nothing indicates that there was any urgency to the trip to return the empty trailers to Menasha. Yet despite the hazardous road conditions, the doubles driver continued traveling north at speeds not conducive to maintaining constant traction. Therefore, the Safety Board concludes that the doubles truckdriver exercised poor judgment in traveling at highway speeds on icy roadways pulling empty trailers.

Training and Experience -- The Safety Board examined the doubles driver's training and experience with regard to operating doubles. The doubles driver had participated in and successfully completed a 1-week (40-hour) course on operating doubles at UPS in November

1995. The UPS course specifically addressed the dynamics of doubles trailers and the operation of doubles in adverse weather, including snow and ice. At the conclusion of the training, the driver demonstrated proficiency in operating doubles and was certified to operate them. While CF does not have its own training program that specifically addresses doubles operations, the firm only hires drivers who have either graduated from an acceptable driving school or who have at least 1 year's experience with comparable equipment. The doubles driver met this CF requirement.

When hired by CF, the driver successfully passed a road test driving doubles and was certified by CF to operate them. Furthermore, the driver had been driving doubles virtually every day since he was hired by CF in October 1996 until the accident; thus, he would have operated doubles for about 4 months in all types of weather. He said that he had driven this particular route about once a week since October 1996 and was comfortable with operating doubles in this area. He had no accidents or incidents involving doubles trailers before the Slinger accident. Although this was the first time that the driver had driven two empty trailers on this route, he had driven empty doubles from Sheboygan to Menasha. Therefore, based on his training and experience, the Safety Board concludes that the doubles truckdriver had received training driving doubles equivalent to the degree of training provided under normal minimum industry practices.

Although the CF driver had received doubles training consistent with industry norms, the training did not ensure that the driver properly recognized and responded to the dangerous circumstances inherent in the combination of vehicle and highway conditions confronting him. While the Safety Board could not determine whether training using a simulator or a skid pad would have influenced the judgment of the CF driver, experience in other transportation modes suggests that simulator training can prepare operators to respond appropriately to hazardous conditions and thus help prevent accidents. Therefore, the Safety Board believes that the FHWA, NHTSA, the American Trucking Associations (ATA), the Motor Freight Carrier Association, and the International Brotherhood of Teamsters should work together to encourage the development and use of simulator-based training for heavy truck operators.

Corporate Culture -- The fact that CF hired a driver with a history of speeding violations to drive doubles trucks might seem to raise concern about the effectiveness of the company's hiring practices in screening out potentially reckless drivers. However, upon closer look, CF cannot be censured for this decision in this circumstance.

The Safety Board's in-depth review of the driver's full driving violation record indicates that CF could not have obtained this complete information through normal channels. Wisconsin's Department of Motor Vehicles database records are normally purged after 5 years, so CF could not have learned of the 1988 and 1989 violations on the driver's record. The driver's June 25, 1993, speeding citation was dismissed after trial and so would not have appeared on his State driving record. The September 1996 and January 1997 violations would not yet have appeared on the driver's record when CF obtained it in October 1996. Consequently, CF could only have known of two violations on the driver's record when the driver was hired, a violation rate which would not have seemed excessive to an examiner familiar with the trucking industry.

CF has a laudable safety record, with an accident rate about half of the industry average. It is CF policy to emphasize the importance of safety, and management has established several programs to ensure that this policy is communicated to CF personnel.

Vehicle Countermeasures

Stability of Doubles -- The Safety Board examined several recent truck accident studies in light of this accident. A 1996 analysis of truck accidents carried out for the OMC by the University of Michigan Transportation Research Institute indicates that most truck accidents occur on dry pavement. A study[59] recently conducted in Indiana found that, compared to

[59] *Accident Analysis and Prevention,* Vol. 29, No. 1, 1997.

single-trailer vehicles, double-trailer vehicles with single-drive axles had fewer crashes on dry and wet pavements (excluding snow, ice, and slush) and fewer crashes involving multiple vehicles. However, this study also showed that doubles were over-represented in crashes on road surfaces with ice, snow, or slush. (The Indiana study excluded accidents on ramps, which minimized the number of rollover accidents included in the study group.)

The over-representation of doubles in crashes involving roadway conditions of ice, snow, and slush is likely due to the special susceptibility of doubles to these environmental factors. Doubles, in general, are more reactive to wind (which is often present under such wintry conditions) than are single-trailer vehicles, because they have more points of articulation, making them more sensitive to sway. Doubles with single-drive axle tractors are also more susceptible to low-friction roadway surfaces, because they have fewer contact points with the road and less effective traction than single-trailer vehicles with dual-drive axle tractors. Therefore, the Safety Board concludes that the greater instability of double-trailer vehicles with single-drive axles renders them more vulnerable to accidents on ice, snow, and slush than single-trailer vehicles with dual-drive axles.

Research has shown that empty or lightly loaded doubles are more susceptible to wind than heavily loaded doubles. One study carried out at the University of Michigan Transportation Research Institute[60] demonstrated the sensitivity of empty doubles and triples to crosswind-induced offtracking and rollover. This study simulated wind gusts of up to 25 mph. The Phase 4 vehicle dynamics model simulations conducted for the Safety Board with regard to the Slinger accident show that, with crosswinds of 0 to 3 mph (and all other things being equal), the empty doubles truck would remain stable. However, when the crosswinds rise to 8 mph, the truck becomes only marginally stable. Therefore, based on these findings, the Safety Board concludes that lightly loaded or empty doubles trucks can be susceptible to even slight crosswinds.

Traction Control -- Jackknife can result from the drive axle's loss of traction caused by locked, retarded, or spinning wheels. Although speed was a significant factor in this accident, the Safety Board sought to determine whether use of a traction control device or system could have ameliorated the wheel spin on the drive axle of the doubles truck sufficiently to have prevented the jackknife. The Board contracted with University of Michigan Transportation Research Institute staff to run Phase 4 vehicle dynamics model simulations with input parameters from the Slinger accident to simulate the effect that a traction control system might have had on it.

The Phase 4 model simulations indicated that, without traction control and under the conditions known about the accident, the doubles truck would have jackknifed at a speed of 58 mph. The known conditions include the prevailing wind and road friction. The wheel spin initiating the jackknife was caused by excess power for the available road friction. The inclusion of a traction control system in the Phase 4 simulations significantly increased the ability of the doubles truck to avoid jackknifing. Although the simulations showed that the tractor instability was not prevented by the traction control mechanism, its use generally diminished the rapidity of the loss of control. Therefore, the Safety Board concludes that, at the speed and under the conditions in which the accident took place, antilock brake and traction control technology would have given the doubles truckdriver more time to respond to the loss of stability.

The Safety Board considers that traction control devices help drivers maintain stability, particularly for single-drive axle vehicles operating with light loads on low-friction roadways. Truck brake manufacturers are currently marketing traction control devices as performance equipment and antilock brakes as safety equipment. Although traction control devices can be added to antilock brake systems at minimal cost, traction control devices are not required.

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[60]MacAdam, Charles, C., "The Crosswind Sensitivity of Unladen Doubles and Triples Combinations and Their Susceptibility to Wind-Induced Offtracking and Rollovers," Supplement to *Vehicle System Dynamics*, Volume 20, August 1991, pp. 432-445.

Because of the safety advantages that traction control devices may contribute to the industry, the Safety Board believes that NHTSA, the FHWA, the ATA, the Motor Freight Carrier Association, and the International Brotherhood of Teamsters should work together to conduct laboratory and truck fleet testing to assess the safety benefits of adding traction control devices to antilock brake systems and should report their findings to the Safety Board. In addition, the Safety Board believes that NHTSA, the FHWA, the ATA, the Motor Freight Carrier Association, and the International Brotherhood of Teamsters should work together to encourage the trucking industry to gain experience with traction control devices through fleet tests. Further, the Safety Board believes that the ATA, the Motor Freight Carrier Association, and the International Brotherhood of Teamsters should notify the trucking industry of the circumstances of the Slinger accident and develop motor carrier guidelines for the operation of empty or lightly loaded multiple-trailer vehicles during inclement weather conditions.

Highway Countermeasures

Adverse Weather -- The Safety Board examined the snow and ice removal procedures followed by the Washington County maintenance personnel. The personnel on duty prior to the accident indicated that the accident area had received two applications of salt and wetting agent. The application rate was above the required State contract level and within the ranges used by other northern States. Therefore, the Safety Board concludes that, although Washington County more than fulfilled the criteria in the WisDOT snow and ice removal contract, its countermeasures did not prevent ice from forming on the roadway.

The Safety Board found several possible explanations as to why these countermeasures were ineffective. The lack of natural windbreaks (evergreen trees and shrubs) exposed the roadway surface to winds, which may have reduced the effectiveness of the salt and wetting solutions. Traffic could have blown the salt and wetting agent off the roadway before they had a chance to melt the ice. The temperature had dropped to around 15°F, a temperature point at which the salt and wetting agent become less effective, and abrasives were not applied to provide traction.

The traditional use of salt and wetting agents after a storm is reactive and costly. The findings of the SHRP[61] project indicate that proactive anti-icing treatments applied before storms can be effective. The project established that an anti-icing program coupled with an RWIS could reduce winter maintenance costs, improve travel conditions, and help protect the environment. Based on these findings, which were subsequently confirmed by field tests,[62] the Safety Board concludes that new adverse weather countermeasures and anti-icing technologies have been shown to be effective, are readily available, and should be aggressively adopted by Wisconsin and other States. The Safety Board is aware that Wisconsin tested three new anti-icing technologies in 1997-98. (The results of the tests were not available for inclusion in this report.) The Safety Board believes that WisDOT should review its policies for snow and ice removal and (1) accelerate the use of new anti-icing technologies, (2) consider the use of abrasives when temperatures drop below 15°F, and (3) take corrective action in open areas where wind could hinder the application and effectiveness of the salt and wetting solutions.

The Safety Board appreciates that the FHWA, AASHTO, and the Transportation Research Board are working together to develop guidelines for snow and ice removal. The guidelines could then be used as a basis to create training materials. The next step would be to provide the materials and training to the government entities that are responsible for ice and snow removal. The Safety Board believes that the FHWA should distribute materials and provide funding through the Local Technology Application Program centers for the training of State and local government officials in new anti-icing technologies.

Median Barriers -- The 1996 AASHTO *Roadside Design Guide* warrants for median

[61] Report No. SHRP-H-385. National Research Council, Washington, D.C., 1994.

[62] *Test and Evaluation Project No. 28: Anti-icing Technology, Field Evaluation Report*, FHWA-RD-97-132, March 1998.

barriers on high-speed, controlled-access roadways that have relatively flat medians consider traffic volumes, median widths, and accident histories. Based on the standards provided in this guide, the ADT and median width on US 41 in the area of the accident indicate that median barriers are not necessary at this location. In addition, a review of the individual accident reports showed that this location did not have a history of cross-median accidents.

The AASHTO *Roadside Design Guide* warrants, however, are based on a 1968 "limited analysis of median crossover accidents"[63] and 1974 research on barrier performance. Like many highway design criteria, the warrants do not address the volume of heavy trucks using the roadway. For the accident area, the 1993 traffic counts show average traffic distributions that include 20 percent trucks. In addition, the warrants do not take into consideration the higher speed limits or changes in the characteristics of the passenger vehicle fleet of recent years. According to NHTSA, the light truck and van weight class that includes sport utility vehicles now constitutes 30 percent of the passenger vehicle fleet and 40 percent of the new car market. Therefore, the Safety Board concludes that current AASHTO median barrier warrants do not take into account the composition and characteristics of the current vehicle fleet. The Safety Board believes that AASHTO and the FHWA should review the median barrier warrants and revise them as necessary to reflect changes in the factors affecting the probability of cross-median accidents, including changes in the vehicle fleet and the percentage of heavy trucks using the roadways.

The Safety Board has previously expressed concern over the incompatibility of existing highway designs with the operating characteristics of trucks, most recently in the White Plains, New York, accident report.[64] The issue becomes more significant as the percentage of trucks in the vehicle fleet increases on the National Highway System (NHS).

On November 27, 1995, the Safety Board issued Safety Recommendation H-95-32, which urged the FHWA to require that the highway geometric design and traffic operations of the NHS be based on heavy truck operating characteristics. In a response dated February 29, 1996, the FHWA stated that current legislation requires a 2.5-percent minimum of innovative barrier on Federal-aid highway projects. The FHWA further indicated that, through implementation guidelines, it will continue to encourage the use of higher-performance median barriers on the NHS. The FHWA stated that most States have built barriers capable of redirecting large vehicles.

Further, the FHWA stated, in a letter dated March 27, 1997, that it is in basic agreement with the Board on this issue, in that consideration must be given to heavy vehicles when developing standards for the NHS. The FHWA stated that, acting on this belief, it is supporting research under the NCHRP and its own research program to develop "the analysis tools and bases for highway standards that address the effects and requirements of heavy vehicles."

In an October 7, 1997, letter to the FHWA, the Safety Board stated:

> Encouraging innovative barriers is a good start in the effort to provide consistent and higher standards for large trucks on the NHS and [the Board] looks forward to other improvements in design that address the operating characteristics of large trucks.

In addition, the Board classified Safety Recommendation H-95-32 "Open--Acceptable Response."

Reporting of Cross-median Accidents -- One of the criteria for determining the need for median barriers in any location is a history of cross-median accidents at that location. Median barriers can prevent and ameliorate accidents, and such barriers might have made a difference in the Slinger accident. Accurate and complete data on crossover accidents are important

[63] *Roadside Design Guide.*

[64] Highway Accident Report -- *Propane Truck Collision with Bridge Column and Fire, White Plains, New York, July 27, 1994* (NTSB/HAR-95/02).

because they help ensure that median barriers are installed where they are needed. Yet most States do not have a cross-median data element on their official accident reporting forms. Consequently, as demonstrated by investigation of the Florida and Wisconsin accidents cited earlier in this report and examination of the FARS data, this information is not readily available.

Because reporting forms typically lack a cross-median data element, individual accident reports must be reviewed or other codes, such as head-on collisions, must be employed to capture cross-median accident data. In addition, as in the Jacksonville, Florida, case, cross-median data may be coded as "other," making it very difficult to separate from unrelated data. Therefore, the Safety Board concludes that cross-median accidents are probably underreported because most accident reporting forms do not have a separate data element for them, and using other reporting elements to capture cross-median accidents may not result in full and accurate accounting.

NHTSA, the FHWA, and the NAGHSR are currently developing the *Guideline for Minimum Uniform Crash Criteria*. The Safety Board believes that, because of the importance of this issue, NHTSA, the FHWA, and the NAGHSR should include a data element for cross-median accidents in the *Guideline for Minimum Uniform Crash Criteria*.

Survivability Countermeasures

Crash Forces -- In many cases, the survivability of a crash is directly related to the crash pulse or acceleration time history of the vehicle(s) during the collision. The most accurate method of determining the crash pulse is use of an accelerometer, or crash pulse recording device. Unfortunately, the airbag ECM on the model of passenger van involved in this accident did not require the storage of a crash pulse, and therefore none was recorded.

The Safety Board could not calculate the crash pulse and delta-v of the passenger van's collision with the flatbed truck. Crash pulse data would have been particularly useful to this accident investigation. An accurate recording of the actual deceleration of the van would have permitted a more complete analysis of the forces experienced by the occupants and the forces they would have experienced had they been appropriately restrained. This information would have allowed investigators to make a more definitive analysis about the potential survivability of the accident for each of the fatally injured passengers.

The Safety Board addressed the desirability of having crash pulse data for vehicle crashes during its Air Bag Forum.[65] On July 1, 1997, the Safety Board issued the following safety recommendation to NHTSA:

> H-97-18
>
> Develop and implement, in conjunction with the domestic and international automobile manufacturers, a plan to gather better information on crash pulses and other crash parameters in actual crashes, utilizing current or augmented crash sensing and recording devices.

NHTSA responded on July 7, 1997, and indicated that it was working with automobile manufacturers to identify crash vehicles equipped with special devices that can record crash pulses and read the crash device recorder. NHTSA also stated that it was developing an Automated Collision Notification (ACN) system designed to reduce the response time for emergency medical assistance. According to NHTSA, the system will have the capability to sense (via onboard accelerometers, in addition to those used for air bag deployment) that the vehicle has been in a collision.

The Safety Board responded on February 12, 1998, that it is "concerned that the provision of the crash pulse recording has been limited in quantity and that it is not clear how the information from the ACN system will be used." Safety Recommendation H-97-18 was classified "Open--Unacceptable Response" because no plan for gathering information on actual crashes with current or augmented crash sensing and recording devices had been presented.

[65] NTSB/RP-97/01.

On-board Recorders -- Another tool in accident investigation and reconstruction is the on-board recorder. On-board recorders are also used by the trucking industry as management tools for carrying out speed control and incentive systems for drivers. Although the Slinger doubles truck had an ECM, it did not have on-board recording devices, which are optional. Consequently, the truck's actual speed at the time of the collision was not readily available.

"Automatic information recording devices" is a safety issue on the Safety Board's "Most Wanted" list. The Safety Board considers that adequate on-board recording devices are necessary in all modes of transportation because information from them can be used to identify safety trends, develop corrective actions, and conduct more efficient accident investigations. Cockpit voice recorders and flight data recorders, or black boxes, have been on commercial airliners for years. Since 1993, event recorders have also been required on trains. Through Safety Recommendations R-96-46 and -47, the Safety Board recommended that the Federal Transit Administration and the American Public Transit Administration develop guidelines for event monitoring/recording devices for rapid transit cars and urge transit agencies to install such devices on new and rehabilitated cars. Regarding marine transportation, the Safety Board has for more than 20 years recommended the use of voyage event recorders for marine accident reconstruction.

The Safety Board has also made recommendations regarding recorders for highway trucking transport. Although the recommendation was primarily aimed at reducing fatigue-related accidents, in 1990,[66] the Safety Board issued Safety Recommendation H-90-28 to the FHWA:

> H-90-28
>
> Require automated/tamper-proof on-board recording devices, such as tachographs or computerized logs, to identify commercial truckdrivers who exceed hours-of-service regulations.

The Safety Board reiterated Safety Recommendation H-90-28 in its 1995 study on truckdriver fatigue,[67] explaining that the intent of the recommendation was to provide a tamper-proof mechanism that could be used to enforce the hours-of-service regulations, rather than relying on drivers' handwritten logs. In a February 1997 response, the FHWA acknowledged that on-board recording devices will eventually be an important tool for monitoring the hours of service of commercial motor vehicle drivers. However, the FHWA stated that "the FHWA position is that the benefits and practicality of on-board recorders must be firmly established before rulemaking ensues." The current status of Safety Recommendation H-90-28 is "Open--Unacceptable Action."

Therefore, because the FHWA has not yet effectively acted on Safety Recommendation H-90-28, the Safety Board believes that the trucking industry associations should advise their members to equip their commercial vehicle fleets with automated and tamper-proof on-board recording devices, such as tachographs or computerized recorders, to identify information concerning both driver and vehicle operating characteristics.

Occupant Injuries and Seat Belt Use -- In any given vehicle collision, three collisions actually take place: the vehicle's collision, the occupant's collision, and the human body's internal collision.[68] The first collision is the vehicle's collision with an external object. But after the vehicle crushes and comes to a stop, the occupant continues to move. Therefore, the second collision is the occupant's collision with objects inside the vehicle, the vehicle's structure, other occupants, or cargo. Then, even after the occupant's body comes to a complete stop, the occupant's internal organs continue to move. Consequently, the third collision is the

[66] Safety Study -- *Fatigue, Alcohol, Other Drugs, and Medical Factors in Fatal-to-the-Driver Heavy Truck Crashes* (NTSB/SS-90/01).

[67] Safety Study -- *Factors That Affect Fatigue in Heavy Truck Accidents* (NTSB/SS-95/01).

[68] *Sudden Impact: An Occupant Protection Fact Book*, NHTSA, DOT HS 807743, July 1991, pp. 4-5.

internal organs' collision with other organs or the skeletal system.

Lap/shoulder belts are vehicle occupants' first line of defense in the second and third collisions of the sequence. Restraints hold the occupants in place, allowing them to stop as the vehicle is stopping, or to "ride down" the collision. Restraints also distribute the forces of rapid deceleration over larger and stronger parts of the body.

The Safety Board examined the passenger van damage, the autopsy reports, and the medical records of the passenger van occupants. The Board found evidence of injury patterns consistent with seat belt use for the driver of the van. In addition, rescue personnel stated that the driver and the right front passenger were belted when the accident occurred. However, the intrusion into the van precluded their survival. The fatal injuries sustained by the driver and right front passenger resulted either from the loss of occupant space because of the intrusion into the van, from the secondary collisions within the vehicle, or from the impact with the flatbed trailer as it intruded into the vehicle.

The Safety Board found no evidence of restraint use by the passengers in the rear of the van. The surviving passenger stated that none of the back seat passengers had been using seat belts. Although the Board found no marks on any other restraint system in the rear of the van, it found plastic transfers from the D-ring on the belt for the left outboard seating position of row 4. The passenger seated directly behind this position (the left outboard seating position of row 5) sustained a partial amputation of the left arm at the shoulder. The Safety Board considers that the plastic transfers from the D-ring found on the belt for the left outboard position of row 4 resulted from this passenger's left arm interacting with that belt and loading it as he moved forward relative to the vehicle during the collision.

The van survivor, who had been seated in the middle of the fourth row, sustained injuries to his legs and his arm. He told the Safety Board that the cargo in the van had been stored several feet in front of him. The interaction between the survivor and the cargo and the interaction of his legs with the interior of the van probably slowed him gradually, allowing him to ride down the collision. As a result, the injuries to his head and chest were significantly less severe than those of the other occupants of the van.

The Safety Board's evaluation of autopsy reports and medical records indicated that the fatal injuries sustained by the passengers in the rear of the van resulted from secondary collisions with the interior of the van. The short distances over which these secondary collisions occurred resulted in greater forces and decelerations being experienced by these passengers than by the vehicle itself. The Safety Board considers that the use of the available lap/shoulder restraint systems in rows 4 and 5 would have reduced such secondary impact forces.

During a collision, a vehicle experiences crushing deformation that lengthens the duration of the impact and substantially decreases the peak and average forces experienced by the undeformed portions of the vehicle. Unrestrained occupants do not benefit from this deformation, as they continue moving until they contact interior vehicle surfaces. Unless some cushion is provided by the vehicle interior, unrestrained occupants can experience deceleration forces many times greater than those experienced by the vehicle. On the other hand, restrained occupants, particularly those properly using lap/shoulder restraint systems, do not move significantly in relation to the vehicle interior; they experience deceleration forces similar to those experienced by the vehicle itself.

In this collision, the forward van structure experienced several feet of deformation during the underride of the van beneath the flatbed trailer. Because the occupants in the rear of the van did not use their restraint systems, they did not benefit from the reduction in peak forces associated with such deformation.

A number of other variables influenced the probability of survival for a belted occupant. These variables include occupant age, health, and position relative to the belt system before the collision; occupant impact with loose objects within the vehicle; and occupant motion relative to the restraint systems. However, the fact that one individual survived this accident

demonstrates that the crash forces the vehicle experienced were not inherently fatal. Although it cannot conclude with certainty that the passengers would have survived had they worn the lap/shoulder belt restraint systems, the Safety Board concludes that the use of the available lap/shoulder belt restraint systems by the occupants of the passenger van would have significantly decreased the severity of their injuries and thereby increased the probability of their survival.

Wisconsin Seat Belt Use Law -- The Safety Board could not determine why the occupants of the rear of the van were not wearing the available restraints. Although he said he knew Wisconsin had a mandatory seat belt law, the survivor did not tell the Board why he and the other passengers in the rear of the van were not wearing the available restraints.

The Wisconsin seat belt MUL is a secondary enforcement law that is enforceable for seating positions with lap/shoulder belts only. Although Wisconsin is one of the few States that allows a court to consider evidence of failure to wear a seat belt, it permits mitigation of only 15 percent of the damages that may be recovered by a plaintiff who failed to wear a seat belt. The Wisconsin seat belt use rate is approximately 6 percent lower than the current national average. Research has shown that States and countries with stricter seat belt use laws have higher seat belt use rates. Consequently, the Safety Board considers that Wisconsin should enact stronger seat belt use laws to increase its seat belt use rate. The Board has previously recommended that Wisconsin and other States enact strong legislation regarding child restraint and seat belt use. In fact, stricter MULs have been on the Safety Board's 1995, 1996, and 1997 "Most Wanted" lists. (See appendix F, Safety Board Recommendations on Mandatory Seat Belt Use Laws, for more details.)

On June 20, 1995, the Board issued Safety Recommendation H-95-13 to the States (and the District of Columbia) that had secondary enforcement of mandatory seat belt laws and the States without MULs. It recommended that these jurisdictions:

H-95-13

Enact legislation that provides for primary enforcement of mandatory safety belt laws. Consider provisions such as adequate fine levels and the imposition of driver license penalty points.

Wisconsin did not respond to Safety Recommendation H-95-13. Following the Air Bag Forum held on July 1, 1997, the Safety Board reclassified Safety Recommendation H-95-13 "Closed--Acceptable Action/Superseded" and issued the following new safety recommendation to the Governors and legislative leaders of the 50 States and U.S. Territories, and the mayor and chairman of the council of the District of Columbia:

H-97-2

Enact legislation that provides for primary enforcement of mandatory seat belt use laws, including provisions such as the imposition of driver license penalty points and appropriate fines. Existing legal provisions that insulate people from the financial consequences of not wearing a seat belt should be repealed. (Supersedes H-95-13.)

Wisconsin has not responded to Safety Recommendation H-97-2. Consequently, the Safety Board reiterates Safety Recommendation H-97-2 to the State of Wisconsin.

Emergency Response

Once a witness had placed a 911 call notifying authorities of this accident, an officer was on scene within 3 minutes and the command vehicle was on scene within about 8 minutes. The Flight for Life helicopter from Milwaukee landed at the scene within 45 minutes, and the first victim from the van was transported by ambulance to an area hospital 59 minutes from the time of notification.

The last victim from the van was not transported by helicopter to a trauma center until 2 hours and 8 minutes after the notification, but much of the delay occurred because medical personnel decided to stabilize

the patient before transporting him. The Safety Board found that the medical personnel acted appropriately in delaying transport of the victim. The Safety Board further considers that the delay did not adversely impact the victim's survival.

The Safety Board also considers that the number of rescue personnel and the amount of equipment dispatched were appropriate for the number of vehicle occupants and the severity of the accident. Therefore, the Safety Board concludes that the emergency response was effective and well coordinated.

CONCLUSIONS

Findings

1. No alcohol use, drug use, fatigue, or vehicle mechanical defects contributed to this accident.

2. At the time and in the vicinity of the accident, the wind was blowing at about 11 to 12 mph from the west.

3. At the time and in the vicinity of the accident, the road had patches of ice.

4. Although the doubles truck was found in 6th gear after the accident took place, it had been traveling at the upper limits of the calculated speed estimate of 43 to 58 mph, and therefore it had been in 7th gear.

5. The initial loss of stability was the result of wheel spin-up.

6. The doubles truckdriver exercised poor judgment in traveling at highway speeds on icy roadways pulling empty trailers.

7. The doubles truckdriver had received training driving doubles equivalent to the degree of training provided under normal minimum industry practices.

8. The greater instability of double-trailer vehicles with single-drive axles renders them more vulnerable to accidents on ice, snow, and slush than single-trailer vehicles with dual-drive axles.

9. Lightly loaded or empty doubles trucks can be susceptible to even slight crosswinds.

10. At the speed and under the conditions in which the accident took place, antilock brake and traction control technology would have given the doubles truckdriver more time to respond to the loss of stability.

11. Although Washington County more than fulfilled the criteria in the Wisconsin Department of Transportation snow and ice removal contract, its countermeasures did not prevent ice from forming on the roadway.

12. New adverse weather countermeasures and anti-icing technologies have been shown to be effective, are readily available, and should be aggressively adopted by Wisconsin and other States.

13. Current American Association of State Highway and Transportation Officials median barrier warrants do not take into account the composition and characteristics of the current vehicle fleet.

14. Cross-median accidents are probably underreported because most accident reporting forms do not have a separate data element for them, and using other reporting elements to capture cross-median accidents may not result in full and accurate accounting.

15. The use of the available lap/shoulder belt restraint systems by the occupants of the passenger van would have significantly decreased the severity of their injuries and thereby increased the probability of their survival.

16. The emergency response was effective and well coordinated.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the doubles truckdriver's lack of judgment in driving too fast for the configuration of his truck under the hazardous highway weather conditions. Contributing to the severity of the injuries and the reduced potentiality for survival was the lack of restraint use by the unrestrained occupants of the passenger van.

RECOMMENDATIONS

As a result of its investigation, the National Transportation Safety Board makes the following safety recommendations:

-- to the Federal Highway Administration:

Work, together with the National Highway Traffic Safety Administration, the American Trucking Associations, the International Brotherhood of Teamsters, and the Motor Freight Carrier Association, to encourage the development and use of simulator-based training for heavy truck operators. (H-98-8)

Work, together with the National Highway Traffic Safety Administration, the American Trucking Associations, the International Brotherhood of Teamsters, and the Motor Freight Carrier Association, to conduct laboratory and truck fleet testing to assess the safety benefits of adding traction control devices to antilock brake systems and report your findings to the National Transportation Safety Board. (H-98-9)

Work, together with the National Highway Traffic Safety Administration, the American Trucking Associations, the International Brotherhood of Teamsters, and the Motor Freight Carrier Association, to encourage the trucking industry to gain experience with traction control devices through fleet tests. (H-98-10)

Distribute materials and provide funding through the Local Technology Application Program centers for the training of State and local government officials in the new anti-icing technologies. (H-98-11)

Review, with the American Association of State Highway and Transportation Officials, the median barrier warrants and revise them as necessary to reflect changes in the factors affecting the probability of cross-median accidents, including changes in the vehicle fleet and the percentage of heavy trucks using the roadways. (H-98-12)

Include a data element for cross-median accidents in the *Guideline for Minimum Uniform Crash Criteria*, which you are developing with the National Highway Traffic Safety Administration and the National Association of Governors' Highway Safety Representatives. (H-98-13)

-- to the National Highway Traffic Safety Administration:

Work, together with the Federal Highway Administration, the American Trucking Associations, the International Brotherhood of Teamsters, and the Motor Freight Carrier Association, to encourage the development and use of simulator-based training for heavy truck operators. (H-98-14)

Work, together with the Federal Highway Administration, the American Trucking Associations, the International Brotherhood of Teamsters, and the Motor Freight Carrier Association, to conduct laboratory and truck fleet testing to assess the safety benefits of adding traction control devices to antilock brake systems and report your findings to the National Transportation Safety Board. (H-98-15)

Work, together with the Federal Highway Administration, the American Trucking Associations, the International Brotherhood of Teamsters, and the Motor Freight Carrier Association, to encourage the trucking industry to gain experience with traction control devices through fleet tests. (H-98-16)

Include a data element for cross-median accidents in the *Guideline for Minimum Uniform Crash Criteria*, which you are developing with the Federal Highway Administration and the National Association of Governors' Highway Safety Representatives. (H-98-17)

-- to the National Association of Governors' Highway Safety Representatives:

Include a data element for cross-median accidents in the *Guideline for Minimum Uniform Crash Criteria*, which you are developing with the National Highway Traffic Safety Administration and the Federal Highway Administration. (H-98-18)

-- to the American Trucking Associations, the Motor Freight Carrier Association, and the International Brotherhood of Teamsters:

Work, together with the Federal Highway Administration and the National Highway Traffic Safety Administration, to encourage the development and use of simulator-based training for heavy truck operators. (H-98-19)

Work, together with the National Highway Traffic Safety Administration and the Federal Highway Administration, to conduct laboratory and truck fleet testing to assess the safety benefits of adding traction control devices to antilock brake systems and report your findings to the National Transportation Safety Board. (H-98-20)

Work, together with the National Highway Traffic Safety Administration and the Federal Highway Administration, to encourage the trucking industry to gain experience with traction control devices through fleet tests. (H-98-21)

Notify the trucking industry of the circumstances of the multiple vehicle crossover accident that took place in Slinger, Wisconsin, on February 12, 1997, and develop motor carrier guidelines for the operation of empty or lightly loaded multiple-trailer vehicles during inclement weather conditions. (H-98-22)

Advise your members to equip their commercial vehicle fleets with automated and tamper-proof on-board recording devices, such as tachographs or computerized recorders, to identify information concerning both driver and vehicle operating characteristics. (H-98-23)

-- to the American Association of State Highway and Transportation Officials:

Review, with the Federal Highway Administration, the median barrier warrants and revise them as necessary to reflect changes in the factors affecting the probability of cross-median accidents, including changes in the vehicle fleet and the percentage of heavy trucks using the roadways. (H-98-24)

-- to the Wisconsin Department of Transportation:

Review your policies for snow and ice removal and 1) accelerate the use of new anti-icing technologies, 2) consider the use of abrasives when temperatures drop below 15°F, and 3) take corrective action in open areas where wind could hinder the application and effectiveness of the salt and wetting solutions. (H-98-25)

-- to the Independent Truckers and Drivers Association, the National Private Truck Council, and the Owner-Operators Independent Drivers Association, Inc.:

Advise your members to equip their commercial vehicle fleets with automated and tamper-proof on-board recording devices, such as tachographs or computerized recorders, to identify information concerning both driver and vehicle operating characteristics. (H-98-26)

Also as a result of its investigation of this accident, the National Transportation Safety Board reiterates the following safety recommendation to the State of Wisconsin:

H-97-2

Enact legislation that provides for primary enforcement of mandatory seat belt use laws, including provisions such as the imposition of driver license penalty points and appropriate fines. Existing legal provisions that insulate people from the financial consequences of not wearing a seat belt should be repealed. (Supersedes H-95-13.)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Chairman

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Member

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Member

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Member

July 24, 1998

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APPENDIX A -- Investigation and Hearing

Investigation

The National Transportation Safety Board was notified of the Slinger, Wisconsin, accident about 11 a.m., February 12, 1997. An investigative team was dispatched with members from the Washington, D.C.; Atlanta, Georgia; Parsippany, New Jersey; Gardena, California; and Arlington, Texas, offices. The team members arrived on the scene at various times during the evening of February 12, 1997. Groups were established to investigate the human performance aspects; the highway, vehicle, and survival factors; and the motor carrier operations.

Participating in the investigation were representatives of the Federal Highway Administration, the Wisconsin Department of Transportation, the Washington County Sheriff's Department, the Slinger Police Department, the Slinger Fire Department, the Wisconsin State Patrol, Consolidated Freightways, Inc., McFaul Transport, Inc., Glandt/Dahlke, Inc., May Fair Rent A Car, Inc., and SIVA Truck Leasing.

Public Hearing or Depositions

No public hearing was held, and no depositions were taken during the investigation.

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APPENDIX B -- Injury Information

Injuries in this accident have been coded according to the revised 1990 Abbreviated Injury Scale of the American Association for Automotive Medicine, which is the standard system of assessing injury severity.

TYPE	Doubles Truck Driver	Flatbed Truck Driver	Van Driver	Van Passengers	Refrigerator Truck Driver	TOTAL
AIS-1 Minor	1	1				2
AIS-2 Moderate						
AIS-3 Serious						
AIS-4 Severe						
AIS-5 Critical				1		1
AIS-6 Unsurvivable			1	7		8
AIS-0 None					1	1
AIS-9 Unknown						
TOTAL	1	1	1	8	1	12

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APPENDIX C -- Roadway Weather Information System

WEATHER DATA TABLE[1]

Date	Time (24 hr. clock)	Status[A]	Chemical Factor[B] %	Surface Temp. (°F)	Sub-Surface Temp. (°F)	Air Temp. (°F)	Dew Point (°F)	Relative Humidity %	Precip. Y/N	Wind Direction/ Speed (mph)
2/11/97	19:38	D	--	25	30	22	15	75	Y	SW/12
	20:05	S/I	0	25	30	22	16	77	Y	SW/10
	20:20	S/I	01	24	30	21	16	81	Y	SW/11
	20:36	C/W	04	24	30	21	17	86	Y	SW/8
	21:07	C/W	11	23	30	21	19	90	Y	SW/14
	22:14	S/I	10	22	30	20	18	93	Y	SW/12
	23:33	S/I	0	23	30	19	18	96	Y	SW/12
2/12/97	00:00	S/I	0	23	30	19	18	96	Y	SW/12
	02:03	S/I	0	22	30	19	18	96	Y	W/10
	02:46	S/I	0	20	30	19	18	95	Y	W/11
	02:54	S/I	0	20	30	18	17	95	Y	W/14
	03:20	S/I	0	18	30	18	17	95	Y	W/9
	03:33	S/I	0	18	30	17	16	95	Y	W/9
	04:01	S/I	0	19	30	17	16	95	Y	W/9
	04:29	S/I	0	18	30	17	16	94	Y	W/12
	04:47	S/I	0	17	30	16	15	94	Y	W/10
	04:55	S/I	0	17	30	16	15	94	Y	NW/10
	05:03	S/I	0	16	30	16	15	94	Y	W/11
	05:52[C]	--	--	--	--	--	--	--	--	--
	06:02	S/I	0	15	30	14	12	92	Y	W/10
	06:03	S/I	0	15	30	14	12	92	N	W/10

A: S = Snow, I = Ice, C = Chemical, D = Dry, and W = Wet.

B: Chemical Factor = percent of brine in solution (salt and wetting agent).

C: Accident occurred at approximately 5:52 a.m.

[1]The Scan-cast pavement sensors and a weather monitoring station are located approximately 10 miles east of the accident site, on U.S. Route 41 near the intersection of U.S. Route 45 and State Highway 60. These values do not imply that similar conditions existed on U.S. Route 41.

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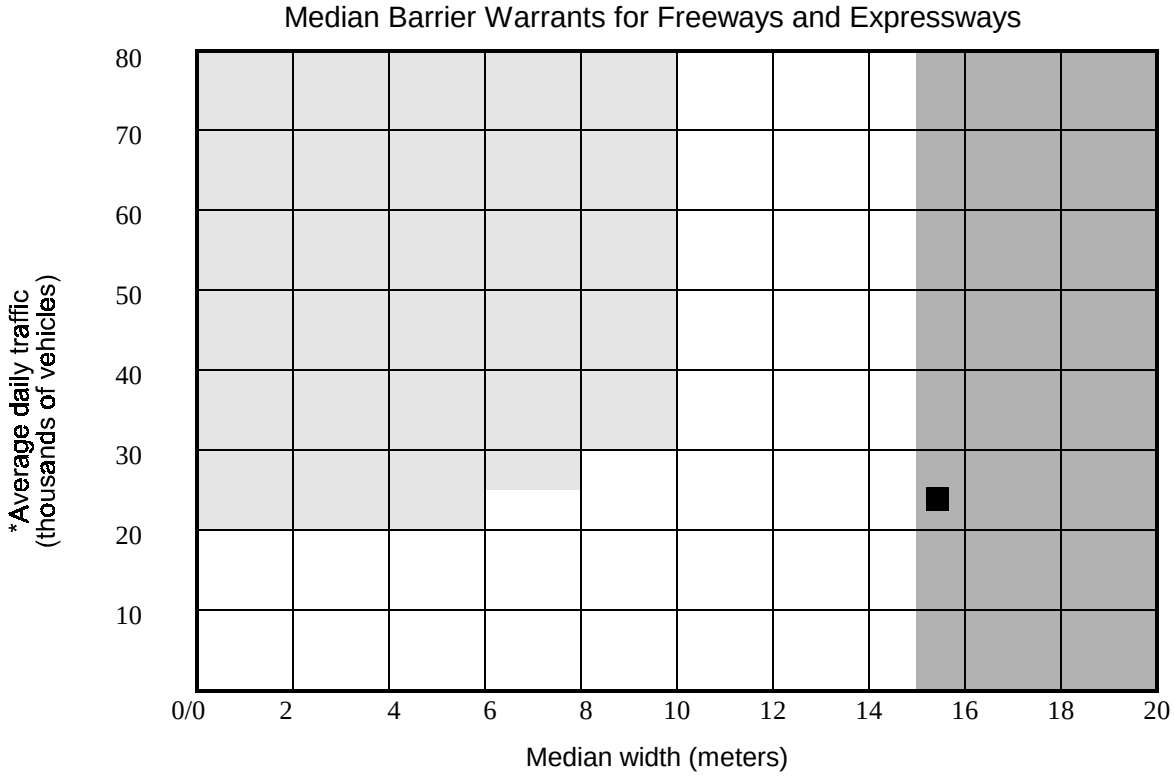
APPENDIX D -- Median Barrier Warrants

According to the American Association of State Highway and Transportation Officials (AASHTO), a median barrier is "a longitudinal barrier most commonly used to separate opposing traffic on a divided highway."[1] Warrants for the installation of barriers are usually based on combinations of average daily traffic (ADT) and median widths that fall within the ranges shown in the table below.



*Based on a 5-year projection.

Light shaded area indicates - evaluate need for barrier

Clear area indicates - barrier optional

Darker shaded area indicates - barrier not normally considered

The median at the accident site was 50 feet wide (15.2 meters) and the ADT was about 25,000 vehicles. This point, marked roughly with the black "square" on the chart above, falls within the shaded area where barriers are not normally considered. AASHTO recommends that where the ADT is less than 20,000 and the median widths are within the optional areas of the chart above, a barrier is only warranted if the area has a history of median crossover accidents. Wisconsin Department of Transportation accident statistics do not show a history of median crossover accidents in the area of the Slinger accident site.

[1] AASHTO, Roadside Design Guide, 1996.

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APPENDIX E -- Safety Board Phase 4 Computer Runs

RUN	DESCRIPTION	RESULT
1	Baseline Accident Run; 58 mph; throttle on, then released; no tractor slip control; driver counter-steer to right; 11 mph wind from west; peak tire/road friction = 0.17, slide = 0.10	Jackknife to left
2	Same as #1, but at 53 mph	Jackknife to left, then right
3	Same as #1, but at 48 mph	Stable
4	Same as #2, but clutch disengaged at throttle release	Jackknife to left, then back to right
5	Same as #1, but clutch disengaged	Slower jackknife to left
6	Same as #1, but peak tire/road friction = 0.2	Stable
7	Same as #6, but no throttle release	Slow development of jackknife to left
8	Same as #1, but slip control max = 0.1 at tractor rear	Jackknife to left then back to right
9	Same as #8, but clutch also disengaged	Similar to #8
10	Same as #8, but truck speed reduced to 53 mph	Stable
11	Same as #10, with no throttle release	Fishtail left then right, then final slow jackknife to left
12	Same as #10, but slip control = 0.2 max on tractor rear	Fishtail left-right-left
13	Baseline #1, but NO crosswind	Stable
14	Baseline #1, but crosswind = 3 mph, no throttle release	Stable
15	Baseline #1, but crosswind = 8 mph, no throttle release	Marginally stable
16	Baseline #1, but initial throttle setting reduced 25%	Jackknife to left and recovery
17	Same as #16, but throttle not released	Jackknife to left
18	Same as #14, but increased throttle setting causing speed pickup	Slow jackknife to left at end of run
19	Same as #18, but slip control max = 0.2 on tractor rear axle	Slow jackknife to left
20	Same as #18, but slip control max = 0.1 on tractor rear axle	Initial fish-tailing, followed by eventual slow jackknife to right as speed increases

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APPENDIX F-- Safety Board Recommendations on Mandatory Seat Belt Use Laws

The following is an excerpt from a July 1, 1997, Safety Board letter, regarding Safety Recommendations H-97-1 through -6, which were issued to the Governors and Legislative Leaders of the 50 States and U.S. Territories, and the Mayor and Chairman of the Council of the District of Columbia.

Seat Belt Use Legislation

According to the National Highway Transportation Administration (NHTSA), lap/shoulder belts, when used properly, reduce the risk of fatal injury to front seat passenger vehicle occupants by 45 percent. Increasing the seat belt use rate is the most effective way of cutting the highway death toll. According to NHTSA, increasing the nationwide seat belt use rate from the present 68 percent to 85 percent would prevent an estimated 4,194 fatalities and 103,518 injuries annually. This reduction in injuries and deaths would result in an economic savings of about $6.7 billion annually. A 90 percent use rate would prevent 5,536 fatalities and 132,670 injuries and save $8.8 billion annually. Seat belts are the most effective means of reducing fatalities and serious injuries when traffic crashes occur; they are estimated to save 9,500 lives in the United States each year.

The Safety Board has previously recommended that the States enact strong legislation regarding child restraint and seat belt use. In 1991, the Board recommended that the 12 States without mandatory restraint use laws (MULs) enact legislation that would require occupants of all passenger cars, vans, and light trucks to use lap/shoulder belt systems in seating positions equipped with such belt systems. In 1995, the Board recommended that the States enact legislation that provides for primary enforcement of mandatory seat belt use laws. Because of the importance of this issue, the Board placed this recommendation on its "Most Wanted" list of safety improvements.[1] Today, 49 States, the U.S. Territories, and the District of Columbia have MULs.[2]

Of the 49 States with mandatory use laws, only 11 States, the U.S. Territories, and the District of Columbia have provisions for primary enforcement, which means that a vehicle can be stopped solely for a seat belt violation.[3] In the other 38 States, the law is a secondary enforcement measure, which means that an officer can cite a motorist for a belt-use violation only if the officer has already stopped the vehicle for another infraction. As a result of the Safety Board's 1996 study on child passenger protection, the Board reiterated the following recommendation to the States without primary enforcement. The recommendation was originally issued in 1995:

> Enact legislation that provides for primary enforcement of mandatory safety belt laws. Consider provisions such as adequate fine levels and the imposition of driver license penalty points. (H-95-13)

In 1996, 82 percent of the States with primary law enforcement had seat belt use rates of 68 percent or higher, but only 27 percent of the States with secondary law enforcement had seat belt use rates as

[1]The purpose of the "Most Wanted" list, which is drawn up from safety recommendations previously issued, is to bring special emphasis to the safety issues the Board deems most critical.

[2]New Hampshire does not mandate seat belt use beyond age 12.

[3]Maryland and Oklahoma passed primary seat belt enforcement laws that become effective on October 1 and November 1, 1997, respectively.

high. Seat belt use rates average about 15 percent higher in States with primary enforcement laws than in States with secondary enforcement laws.

The Safety Board recognizes and commends the States' efforts and the efforts of the highway safety community to encourage the States to address this important issue. However, because of the continued loss of lives on the Nation's highways, and the consequential cost in health care, taxes, and public assistance, States must find additional ways to encourage seat belt use. Experience has shown that strong legislative initiatives, dedicated and highly visible enforcement, and public information campaigns are the most effective methods to increase seat belt use. States and countries where the usage rate has remained high provide valuable insight on which methods work.

Use rates in Australia, Canada, and Germany exceed 90 percent, whereas use rates in many western European countries exceed 80 percent. Seat belt use laws in these countries typically allow primary enforcement and also cover occupants of light trucks and vans in addition to passenger cars. Fines in these countries are generally higher than in the United States, and some jurisdictions assess demerit points against driver licenses for violating seat belt use laws.

The fines in the United States typically range from $10 to $25; two States and the District of Columbia assess a fine of $50 or more. Only the District of Columbia assesses penalty points for seat belt violations.[4] In Australia, violators typically are fined $150 to $200 and receive three demerit points.[5] In addition, the courts can impose fines up to $2,000 and/or 6 months imprisonment. In Canada, violators also receive demerit points and high fines. Europeans are encouraged to wear seat belts because full insurance coverage will not be available if they are involved in an accident in which they are not belted.

Societal attitudes in the United States must change with regard to seat belt use. In other countries, drivers are held legally responsible for their actions. In 29 States and the District of Columbia, however, evidence of the failure to wear a seat belt is inadmissible in a court of law.[6] In seven other States, the law only allows mitigation of a very small percentage – typically 5 percent – of the damages that may be recovered by a plaintiff who failed to wear seat belts.[7] An occupant who fails to wear a seat belt is not exercising reasonable care for his/her own safety. Any person who fails to wear the available lap/shoulder belt should be legally responsible for any enhancement of injuries caused by such failure. It is inconsistent public policy for State governments to be insulating people from the financial consequences of not wearing seat belts at the same time that the Federal government is aggressively trying to increase seat belt use rates. Further, government at all levels incurs significant costs resulting from injuries to unbelted vehicle occupants.[8] Thus, the Safety Board believes that the States, U.S. Territories, and the District of Columbia should enact legislation that provides for primary enforcement of mandatory seat belt use laws, including provisions such as the imposition of driver license penalty

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[4]Effective October 1 and November 1, 1997, the District of Columbia will assess two penalty points and a $50 fine for a seatbelt violation.

[5]The driver license is revoked in Australia when 12 demerit points accumulate.

[6]The 29 States are Alabama, Connecticut, Delaware, Georgia, Idaho, Illinois, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Minnesota, Mississippi, Montana, Nevada, New Mexico, North Carolina, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Texas, Utah, Vermont, Virginia, Washington, and Wyoming.

[7]The seven States and the percentage limitation on mitigation follow: Iowa, 5 percent; Michigan, 5 percent; Missouri, l percent; Nebraska, 5 percent; Oregon, 5 percent; West Virginia, 5 percent; and Wisconsin, 15 percent.

[8]The Federal share of the medical costs of crashes is about 60 percent of total public costs. If all States passed standard enforcement laws and seat belt use increased to 85 percent, Federal taxpayers would save almost $1 billion a year in medical costs. That saving is in addition to the amount States would save. (National Highway Traffic Safety Administration, 1996. *Economic Cost to Motor Vehicle Crashes*, 1994. NHTSA Tech. Rep. DOT HS 808 425. Washington, D.C.)

points and appropriate fines. Existing legal provisions that insulate people from the financial consequences of not wearing a seat belt should be repealed. In view of the foregoing, the Board also reclassifies Safety Recommendation H-95-13 "Closed--Acceptable Action/Superseded" by this new recommendation.

North Carolina has demonstrated that a primary enforcement seat belt law in combination with a dedicated and visible seat belt traffic enforcement program increases restraint use and saves lives; the State reported a reduction of 100 fatalities in the first year following its "Click It or Ticket" occupant restraint enforcement campaign. The Safety Board is aware of several other seat belt enforcement programs in addition to the one in North Carolina.

Seat belt enforcement programs, however, may not be a priority for many law enforcement organizations that are responsible for traffic safety. An active seat belt enforcement program combined with a primary seat belt law has more potential for reducing highway deaths and injuries than most other traffic enforcement programs.

One of the key factors in the success of the North Carolina program is the strong support from Governor Jim Hunt and other elected officials. The Safety Board believes that the Governor of the States and Territories and the Mayor of the District of Columbia should encourage and support efforts by enforcement organizations to conduct dedicated and highly visible occupant restraint enforcement programs that focus on increasing the use of seat belts and child restraints. The Board has asked the U.S. Conference of Mayors, the National League of Cities, the National Association of Counties, and the National Association of Towns and Townships to take the same action.

ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACN	Automated Collision Notification
ADT	average daily traffic
ATA	American Trucking Associations
Caltrans	California Department of Transportation
CDL	commercial driver's license
CF	Consolidated Freightways, Inc.
CFR	*Code of Federal Regulations*
CTH K	County Trunk Highway K
DOT	U.S. Department of Transportation
ECM	electronic control module
EMS	Emergency Medical Service
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
GVWR	gross vehicle weight rating
HMM	Highway Maintenance Manual
LMIS	Lockheed-Martin Information Systems
MTI	McFaul Transport, Inc.
MUL	mandatory use law
NAGHSR	National Association of Governors' Highway Safety Representatives
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
OMC	Office of Motor Carriers
RWIS	road weather information system
SFD	Slinger Fire Department
SHRP	Strategic Highway Research Program
UPS	United Parcel Service
US 41	U.S. Route 41
WCSD	Washington County Sheriff's Department
WisDOT	Wisconsin Department of Transportation