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National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: NOV 27 1995

In Reply Refer To: H-95-32 through -36

Honorable Rodney E. Slater
Administrator
Federal Highway Administration
Washington, D.C. 20590

About 12:30 a.m., on July 27, 1994, a tractor cargo-tank semitrailer loaded with 9,200 gallons of propane (a liquefied petroleum gas) and operated by Suburban Paraco Corporation was traveling east on Interstate 287 in White Plains, New York. The truck drifted across the left lane onto the left shoulder and struck the guardrail; the tank hit a column of the Grant Avenue overpass. The tractor and the semitrailer separated, and the front head of the tank fractured, releasing the propane, which vaporized into gas. The resulting vapor cloud expanded until it found a source of ignition. When it ignited, according to an eyewitness, a fireball rose 200 or 300 hundred feet in the air. The tank was propelled northward about 300 feet and landed on a frame house, engulfing it in flames.

The driver was killed, 23 people were injured, and an area with a radius of approximately 400 feet was engulfed by fire.[1]

The National Transportation Safety Board determines that the probable causes of this accident were the reduction in the alertness of the driver (consistent with falling asleep) caused by his failure to properly schedule and obtain rest and the failure of the management of Paraco Gas Corporation, Inc., to exercise adequate oversight of its driver's hours of service. Contributing to the accident was the design of the highway geometrics and appurtenances, which did not accommodate an errant heavy vehicle. Contributing to the severity of the accident was the vulnerability of the bridge to collision from high-speed heavy vehicles.

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

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Driver's fatigue and carrier's oversight of his hours of service--The Safety Board examined why the driver continued making deliveries without proper rest, the extent of his knowledge of the adverse effects of fatigue, and the company's oversight of his hours of service.

Paraco Gas Corporation, Inc., (PGC) allowed drivers to schedule their own work, thus requiring them to be self-disciplined enough to comply with the hours-of-service rules and to avoid becoming fatigued. Because his truck had broken down for 10 hours, the driver was confronted with a difficult decision. If he rested properly (and in accordance with Federal requirements), he would be unable to complete his scheduled deliveries at his normal or expected time, thus adversely affecting his income. The flat hourly rate he would be paid for the 10-hour breakdown would not fully compensate him for not finishing his deliveries. The Safety Board concludes that he chose to sacrifice his rest in order to complete his deliveries within his normal schedule. The Safety Board also concludes that the company's policy of paying by the load instead of by the hour appeared to encourage drivers to violate hours-of-service regulations.

The Safety Board addressed the issue of method of compensation in the *1995 Fatigue Study*.[2] The Board concluded that "the results of this study suggest a possible link between the method of driver compensation and fatigue-related accidents--an issue which has not been previously addressed in detail." The Board recommended that the FHWA:

> Examine truckdriver pay compensation to determine if there is any effect on hours-of-service violations, accidents, or fatigue. (Class II, Priority Action) (H-95-3)

On June 30, 1995, the FHWA responded to all the safety recommendations made to it in the *1995 Fatigue Study*. Although the response did not directly address Safety Recommendation H-95-3, the FHWA said the following:

> Because the results of research in progress and programed for near-term initiation will significantly add to the present knowledge base on a commercial motor vehicle driver workload and alertness-reducing and alertness-enhancing measure, the FHWA will not be able to act on several of the NTSB's recommendations until after these studies are completed.

Subsequently, on August 21, 1995, the Safety Board noted:

> [the] FHWA's intention to defer action ...indicates a lack of urgency about reducing the incidence of fatigue-related accidents precipitated by truckdrivers. Because the FHWA has not acted in a timely or substantive manner on H-95-1

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[2]*Factors that Affect Fatigue in Heavy Truck Accidents, Volume I: Analysis*, adopted January 18, 1995 (NTSB/SS-95/01).

though -5, these recommendations are classified "Open--Unacceptable Response." The Safety Board urges the FHWA to reconsider its position and to take appropriate action.

None of the research outlined in the FHWA's June 30 letter mentioned examination of methods of compensation and the subsequent effect on safety.

After this accident, the Safety Board discussed the relationship of safety and methods of compensation with several hazardous-materials carriers. One propane carrier indicated that because the shortage of drivers made it difficult to retain safe ones, the company was switching to paying by the hour. Another hazardous-materials carrier said that in September 1992, it had changed from paying drivers by the delivery to paying them by the hour. As a result, the company said, there had been a drastic reduction in accidents of at least 50 percent. The Office of Motor Carriers (OMC) had the following accident statistics for this carrier (DOT #0074278):

Year	Number of Accidents
1991	18
1992	5
1993	0
1994	0

Although other factors may have been involved in reducing the company's number of accidents, the Safety Board believes the change in method of compensation had an effect. Therefore the Safety Board reiterates Safety Recommendation H-95-3.

This driver was young and healthy and may not have recognized the degree of his fatigue. A review of his records showed no evidence of his receiving any training about the effects of fatigue. The test guide for the New York State Department of Transportation commercial driver's license makes the following statements:

> Fatigue (being tired) and lack of alertness are bigger problems at night. The body's need for sleep is beyond a person's control. Most people are less alert at night, especially after midnight. This is particularly true if you have been driving for a long time. Drivers may not see hazards as soon or react as quickly, so the chance of a crash is greater. If you are sleepy, the only safe cure is to get off the road and some sleep. If you don't, you risk your life and the lives of others.
>
> Your body gets used to sleeping during certain hours. If you are driving during those hours, you will be less alert. If possible try to schedule trips for

> hours you are normally awake. Many heavy motor vehicle accidents occur between midnight and 6 a.m. Tired drivers can easily fall asleep at these times, especially if they don't regularly drive at those hours. Trying to push on and finish a long trip at these times can be very dangerous.

The guide does not, however, discuss the effects of reversed work/rest patterns and fragmented sleep. Yet the carrier's scheduling practices required the driver to monitor his own fatigue. The Safety Board concludes that he might have rested before trying to complete his last load had he been trained in understanding the effects of a deficit in sleep and irregular or inverted schedules.

The Safety Board addressed the adequacy of truckdrivers' understanding of the factors affecting fatigue in the *1995 Fatigue Study*. The Board found that many of the truckdrivers in the sample of drivers who had been involved in fatigue-related accidents had not recognized that they needed sleep and had believed that they were rested when they were not. About 80 percent of the drivers involved in a fatigue-related accident rated the quality of their last sleep before the accident as good or excellent. As a result of the study, the Safety Board made the following recommendation to the FHWA, the Professional Truck Driver Institute of America, the American Trucking Associations, Inc., the Commercial Vehicle Safety Alliance, and the National Private Truck Council:

> Develop and disseminate, in consultation with the U.S. Department of Transportation Human Factors Coordinating Committee, a training and education module to inform truckdrivers of the hazards of driving while fatigued. It should include information about the need for an adequate amount of quality sleep, strategies for avoiding sleep loss, such as strategic napping, consideration of the behavioral and physiological consequences of sleepiness, and an awareness that sleep can occur suddenly and without warning to all drivers regardless of their age or experience. (H-95-5)

Considering the existing body of knowledge regarding the effects of fatigue on transportation safety, the Safety Board believes that the FHWA can act on the recommendation. The American Automobile Association, with the FHWA's help, was able to assemble and disseminate a pamphlet on the adverse effects of fatigue. Therefore, the Safety Board reiterates Safety Recommendation H-95-5.

The Safety Board believes that one method of reaching all new commercial truck drivers is the CDL examination. The Safety Board believes that the American Association of Motor Vehicle Administrators should review and augment the CDL manual and test materials to include information on the role of fatigue in commercial vehicle accidents and methods to identify and address fatigue.

Incompatibility of operating characteristics of trucks and highway design--When the truck left the traveled way onto the negatively sloped shoulder and foreslope, its rollover speed was considerably reduced. Calculations based on a 0.26g rollover threshold show that in the center lane, which curved at a 1,522-foot radius and had a 6-percent superelevation, the rollover speed was 85 mph. On the shoulder, with a 1,542-foot radius and a minus 2-percent superelevation, the rollover speed was reduced to 74 mph. However, since the tiremarks on the shoulder and foreslope indicate steering input at a maximum radius of 930 feet, the rollover speed on the shoulder was reduced to 58 mph. Once the truck was on the foreslope, with a superelevation of -12 to -16 percent, the rollover speed was reduced even further, from 36 to 44 mph.

The highway geometry beyond the traveled way, in combination with the tight turning radius of the steering input, reduced the vehicle's rollover speed, resulting in an unstable condition. At highway speeds of 55 to 58 mph, the truck would have traveled 79 to 84 feet per second. The tiremarks left the traveled way 200 feet, or 2.5 seconds, before the truck reached the bridge. Even had there been rumble strips on the shoulder, the driver did not have enough time to perceive, react to, and avoid the hazard. Even if there had been time, once the truck lost stability, the driver could not recover. The Safety Board concludes that the truck exceeded its minimum rollover speed when it left the traveled way, at which point the vehicle lost stability and the driver was unable to recover.

Each design feature that the truck encountered, the pavement drop (3.5 inches), the slope of the ditch (-0.125 to -0.169), and the location of the guardrail, met the minimum AASHTO design guidelines in *A Policy on Geometric Design of Highways and Streets* and in the 1988 *Roadside Design Guide*. Each design feature by itself probably would not have created instability problems for the truck; but encountered together, they created a condition from which the driver could not recover. Because a passenger car has a much lower center of gravity and thus a higher rollover threshold, it probably could have negotiated these design features without stability problems; but this truck, with its high center of gravity and lower rollover threshold, could not. Therefore, the Safety Board concludes that the minimum AASHTO guidelines for the geometric design of highways are not always satisfactory for heavy trucks, especially those with high centers of gravity.

At the accident location, the guardrail was mounted on the backslope of the ditch; thus it did not prevent vehicles from transversing the ditch. According to the 1976 AASHTO *Barrier Guide*,[3] no barrier is required if the steepness of the foreslope is the only consideration. The *Barrier Guide* states that "although specific warrants for barrier protection of ditches do not exist, the designer should recognize their potential hazard. Ditches near the traveled way can be a significant hazard if their cross section[4] cannot be easily traversed by an errant vehicle." The *Guide* also indicates that a median barrier should be placed on the side of

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[3]AASHTO, *Guide for Selecting, Locating, and Designing Traffic Barriers*, Prepared for the FHWA, Washington, D. C., 1976.

[4]The elements of a cross section include, but are not limited to, the sideslope, the right shoulder, the traveled way, the left shoulder, the median, and ditches and drainage.

the greatest slope difference if neither slope requires protection and if the difference in the slope rate is greater than about 0.1.[5]

About 150 feet west of the column, the backslope was about 9 percent. The maximum foreslope up to 132 feet west of the column was 19 percent. The design met the AASHTO guidelines, as did the placing of the guardrail on the north side of the median.

Nevertheless, the placement of the guardrail did not reflect the best engineering practice, since it is usually better to place guardrail on the outside of curves and at the side of the ditch where the slope is greater. Additionally, since there was an upstream hazard in the westbound direction, preceded by a drainage catch basin, it would have been better to put the guardrail on the eastbound side. In this accident, the location of the guardrail was not that important because the guardrail was hit by a truck too heavy for it to redirect. Had a higher performance barrier, such as a 42-inch one, been in place nearer to the edge of the shoulder, or had the slope been relatively flat from the edge of the shoulder, the truck might have been redirected.

The purpose of placing the guardrail beyond the ditchlines might have been to give errant vehicles room to recover. Passenger cars, because of their lower centers of gravity, might have been able to recover in the ditch; however, vehicles with a high center of gravity would not.

A 1978 FHWA publication stated that "Safety priorities suggest that certain guardrail installations are more critical than others and conformance with current data is essential. As an example, guardrails on the outside of curves immediately in advance of severe hazard, or at locations where geometry may compromise barrier performance, should receive priority."[6] This guardrail was on the outside of the curve in advance of the median bridge pier (the hazard), and the slope of the roadway compromised the barrier performance.

The publication also stated that "Safety upgrading ... should consider traffic volumes, barrier accident statistics, degree of deviation from current standards, potential effectiveness of existing barriers, and available resources."[7]

A heavy-truck hazardous-materials accident in an urban area can be catastrophic. Some jurisdictions have designed and constructed highways that exceed the minimum AASHTO guidelines, especially in areas where the number of trucks is high. For instance, the New Jersey Turnpike Authority uses a 42-inch-high concrete median barrier. The Safety Board concludes that highways that are heavily traveled by trucks should be designed for them.

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[5]AASHTO, *Guide for Selecting, Locating, and Designing Traffic Barriers*, pp. 137-138.

[6]FHWA Highway Safety Review--*Report of the Safety Review Task Force to the Federal Highway Administrator*, December 1978, p. 9.

[7]See preceding footnote.

The need for highway design standards to accommodate the operating characteristics of heavy trucks has been recognized. The evolution of the improvements in compatibility is evident in the National Cooperative Highway Research Program (NCHRP) Reports 230 and 350 and in NCHRP Project 22-12.

The Safety Board agrees that heavier vehicles should be tested in accordance with NCHRP 350. The Safety Board believes that it is also important that crash-test studies include the effect of such geometric features as embankment sideslopes and ditches. The studies should include a combination of computer simulations and full-scale crash tests.

The Safety Board recognizes the need for the new performance guidelines in NCHRP Report 350 and the development of objective guidelines for the selection and installation of roadside hardware. Until NCHRP Project 22-12 is complete, designers should consider using 42-inch or 54-inch concrete barriers, which have been used successfully by many agencies, including the NYSDOT and the New York State Thruway Authority, on roads used by trucks. These barriers are already recommended in AASHTO's *Load and Resistance Factor Design* (LRFD) specifications for the protection of structures.

The Safety Board is encouraged by AASHTO's having used a greater variety of design vehicles for its 1990 and 1994 *A Policy on Geometric Design of Highways and Streets.* However, these vehicles are not being used to design safe cross sections. Because cargo tanks roll over more easily and because they often transport hazardous materials, the Safety Board believes that they should be added to the list of design vehicles and that their characteristics, especially their rollover threshold, should be considered when designing cross sections and horizontal curves.

The Safety Board has a long history of championing the need for barriers designed for heavy vehicles. In 1974, a tractor-semitrailer traveling on the New Jersey Turnpike crashed through the guardrail and crushed an automobile, resulting in 9 deaths and 11 injuries. As a result of its investigation, the Safety Board recommended that the FHWA:

> Expedite the portion of the research project, "Advanced Vehicle Protection Systems," that will provide data for the design of new barrier construction and improvements to existing systems. Dynamic impact tests should be made using both intercity buses and heavy trucks. (H-75-11)

The status of the safety recommendation is "Closed--Acceptable Action."

In 1981, a cargo tank, transporting 8,300 gallons of gasoline rolled over while attempting to negotiate a 220-foot-radius right curve on a two-lane approach to a bridge in Allegheny County, Pennsylvania. It slid over a 13-inch-high concrete median barrier and into the path of an oncoming bus. Three persons were seriously injured. The Safety Board recommended that the FHWA:

Expand the performance testing of the New Jersey shaped barrier on curved roadway sections to include crash testing of heavier vehicles with higher centers of gravity, such as 80,000-pound tractor-semitrailers and gasoline tank trucks. (H-83-23)

The FHWA advised the Safety Board that a significant number of performance tests on the New Jersey shaped barriers of varying heights had been conducted and that a 42-inch-high New Jersey shaped barrier had successfully redirected an 80,000-pound tractor-semitrailer with a 64.4 inch high center of gravity at 53 mph. However, these tests were made on tangent and level roadway sections.

The Safety Board also recommended that the FHWA:

Include the testing of heavier vehicles with higher centers of gravity in current high-performance barrier research and development. In particular, encourage the design and development of high-performance barriers that can safely contain or redirect small passenger vehicles and heavier vehicles with higher centers of gravity, such as 80,000-pound tractor-semitrailers and gasoline tank trucks. (H-83-24)

The FHWA replied that a 54-inch-high bridge rail consisting of a 32-inch high New Jersey type barrier topped with a metal rail has successfully redirected an 80,000-pound tractor-semitrailer on a tangent section. A 90-inch barrier with a New Jersey type barrier profile base has successfully redirected an 80,000-pound articulated tank truck on a curved ramp and will probably successfully redirect a similar or smaller vehicle on a tangent roadway section. Safety Recommendations H-83-23 and -24 were classified "Closed--Acceptable Action" on November 19, 1985

In 1984 the Safety Board recommended to the Texas State Department of Highways and Public Transportation:

As part of any major pavement improvement project, provide whenever feasible for the installation of advanced barrier systems on and approaching bridges. (H-84-65)

The recommendation was made as the result of an intercity bus crashing through a bridge guardrail and falling to a creek bank 26 feet below.[8]. Six died and six were injured. Safety Recommendation H-84-65 was classified "Closed--Unacceptable Action." on May 23, 1989.

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[8]See Highway Accident Report--*Trailways Lines, Inc., Bus/E.A. Holder, Inc., Truck, Rear End Collision and Bus Run-Off Bridge, U.S. Route 59, near Livingston, Texas, November 30, 1983* (NTSB/HAR-84/04).

On September 6, 1987, an intercity bus ran off the New Jersey Garden State Parkway at a bridge, struck a guardrail, and overturned.[9] The busdriver and one passenger died. Of the remaining 33 passengers, 32 sustained minor to moderate injuries. The Safety Board recommended that the New Jersey Highway Authority:

> Replace existing steel bridge rail on the Garden State Parkway with 42-inch-high extended New Jersey safety shape bridge rail. (H-88-25)

On August 29, 1989, the recommendation was classified "Closed--Unacceptable Action."

Higher performance barriers are available for redirecting heavy vehicles at highway speeds. Unfortunately, the installation of these barriers has been slow. The requirement in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) for innovative barrier use may speed up their use.

The Safety Board believes that the FHWA should test heavy vehicle impacts with barriers on curves and with cross sections that are not flat to provide additional guidance to the States so that they can better conform to the innovative barrier requirement of ISTEA. It is especially appropriate that the States have this research available as they embark on upgrading the safety features on the National Highway System (NHS).

The roads that will be part of the proposed NHS are used by 70 percent of the heavy-truck traffic, and heavy trucks account for 78 percent of intercity freight revenue. Therefore, since trucks will be a prime user, the Safety Board believes that the NHS should be designed for the types of trucks that will travel on it, especially the portions of the NHS that run through urban areas, where accidents are more likely to have catastrophic consequences. Consequently, the Safety Board believes that the NHS should provide consistent and higher standards for trucks where the truck volumes and speeds warrant.

Bridge vulnerability--The highway cross section and the design and location of the barrier system made the Grant Avenue overpass vulnerable to a heavy-truck collision. The design of the bridge, that is, the four-column pier, made the structure redundant and therefore less vulnerable to collapse.

The NYSDOT has been at the forefront in developing bridge-risk management programs, although its comprehensive bridge-safety assurance program is still under development. After the accident:

> [the] NYSDOT applied the methodology used in their comprehensive bridge safety assurance program and assessed the need for reducing the collision impact damage vulnerability of this bridge. They determined that the bridge did

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[9]See Highway Accident Report--*Academy Lines, Inc., Intercity Bus Run-Off Roadway and Overturn, Middletown, New Jersey, September 6, 1987* (NTSB/HAR-88/03).

have a vulnerability to failure based on an extreme hit or event that might occur. Their assessment would have translated into a recommendation for installation of a high performance Jersey shaped barrier in the area of the bridge. This work would have been considered when the bridge was put on the Capital Program.[10]

The Safety Board has addressed the topics of bridge vulnerability to collision and of bridge-risk assessment in several recent reports about its accident investigations.[11] Highway bridge vulnerability to collision from high-speed heavy vehicles was addressed in the report about the Evergreen, Alabama, accident.

In May 1993, a tractor-semitrailer that was carrying cement was traveling south on I 65 near Evergreen when it left the road, traveled along the embankment, overran a guardrail, and collided with one column of a two-column bent of an overpass. Two spans of the overpass collapsed onto the semitrailer and the southbound lanes of the interstate, sending a cloud of cement dust into the air. An automobile and a tractor-semitrailer, also southbound, then collided with the collapsed spans. The driver of the truck loaded with cement sustained serious injuries; the drivers of the other vehicles were killed.

In its report about the accident, the Safety Board concluded that the columns were vulnerable to a high-speed heavy-vehicle collision because they were within the 30-foot clear zone and had only W-beam guardrail protection. The Board noted that not all State highway departments assess bridge structures and their vulnerability to high-speed heavy-vehicle collision and subsequent collapse.

The Safety Board recommended that the FHWA :

Request States to identify and assess bridges that are vulnerable to collapse from a high-speed heavy-vehicle collision with their bridge columns and develop and implement countermeasures to protect the structures. (H-94-5)

In cooperation with the American Association of State Highway Transportation Officials, ensure that the bridge management program guidelines include information on evaluating which bridges are vulnerable to high-speed heavy-vehicle collision and subsequent collapse. (H-94-6)

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[10]July 21, 1995, letter to the Safety Board from the NYSDOT's acting director of the commercial vehicle safety program.

[11]See Highway Accident Report--*Tractor-Semitrailer Collision with Bridge Columns on Interstate 65 near Evergreen, Alabama, on May 19, 1993* (NTSB/HAR-94/02); Highway-Marine Accident Report--*U.S. Towboat CHRIS Collision with the Judge William Seeber Bridge, New Orleans, Louisiana, May 28, 1993* (NTSB/HAR-94/03); and Railroad-Marine Accident Report--*Derailment of Amtrak Train No. 2 on the CSXT Big Bayou Canot Bridge Near Mobile, Alabama, September 22, 1993* (NTSB/RAR-94/01).

On August 11, 1994, the FHWA responded to the recommendations. About Safety Recommendation H-94-6 the FHWA said, "we feel that we have provided the State highway agencies with sufficient publications to provide the recommended guidance and request that this recommendation be considered closed." In a January 12, 1995, letter, the Safety Board classified Safety Recommendation H-94-6 "Open--Acceptable Response."

In the same August letter, the FHWA said about Safety Recommendation H-94-5:

> We feel this problem can best be addressed by including it as part of our regular bridge management process. We plan to alert our field offices of the potential hazard of high-speed heavy vehicle collisions with bridge piers and to recommend they include this assessment as part of their bridge management process. . . .[the] National Bridge Inventory (NBI) includes data on bridge underclearance obstructions (e.g., piers and abutments) including the distance of the obstruction from the edge of the roadway. This data is used to determine an appraisal rating for underclearnace adequacy and in calculating a sufficiency rating. Both ratings are used in setting priorities for bridge replacement and rehabilitation under the Federal bridge program.

On January 12, 1995, the Safety Board replied that it was concerned about the FHWA relying on NBI data. The Board believes that it is not possible to tell from the NBI data whether a lateral clearance measurement is based on the distance to a bridge support or on the distance to a concrete barrier. Based on the summary of responses to bridge questionnaire about bridges that the Safety Board sent to the 50 States,[12] most States could not determine the number of columns in a pier from their inventory. Without such information, it is difficult to assess relevant site and structure characteristics. The information is also critical to measuring the vulnerability of a bridge to collision and collapse.

In its reply, the Safety Board noted that the FHWA did not agree with the Safety Board's recommendation that countermeasures be taken for any bridge that is vulnerable to collision and collapse. The Board pointed out that it had not, however, recommended that countermeasures be taken for every vulnerable bridge. Rather, the Board had asked that each bridge's vulnerability be determined and that countermeasures, if necessary, be developed as part of the risk assessment of each vulnerable bridge. Because of its concerns, the Board classified, Safety Recommendation H-94-5 "Open--Acceptable Response," pending further response.

On April 28, the Safety Board received a copy of an April 12 memorandum from the Chief of the Bridge Division to the Regional Federal Highway Administrators and the Federal Lands Highway Program Administrator. The memorandum explained Safety Recommendations H-94-5 and -6 and the FHWA's position, which had not changed.

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[12]See reference in preceding footnote to Evergreen report.

According to the memorandum, the Safety Board was advocating "a program to retrofit all existing structures that may be vulnerable or slightly vulnerable..." The Board is not advocating such a program at all. The Board believes that the States should systematically evaluate the vulnerability of their highway bridges to collision and collapse from heavy vehicles (trucks, barges, ships) and protect those that are in the most need. However, the Board believes that the FHWA should provide guidance by developing risk assessment models.

The memorandum also states, "There is not sufficient accident data on high-speed heavy-vehicle collisions with bridge piers to justify the development of separate evaluation guidelines for this type of accident." The Safety Board is aware that there may not be many high-speed heavy-vehicle collisions with bridges. However, the Safety Board is also aware that when there is such a collision, the results can be catastrophic.

After the White Plains accident, the Safety Board investigated another heavy-truck collision with a bridge column.[13] About 3:00 a.m. (local time) on August 8, 1994, a tractor-semitrailer loaded with coils of steel was westbound on I-30 near Hooks, Texas. It swerved to the left, crossed the left lane, traveled into the median parallel to the roadway behind the guardrail, and collided with the east column of a bridge. The bridge then collapsed. Two people in the truck were killed.

On July 17, 1995, the FHWA again asked that Safety Recommendations H-94-5 and -6 be closed. In discussing Safety Recommendation H-94-5, the FHWA said that it had never intended to utilize the NBI database for determining lateral clearances to bridge supports. The FHWA said:

> [it believes that] the NBI database is simply used to determine an appraisal rating for underclearance adequacy and in calculating a sufficiency rating for setting priorities for bridge replacement and rehabilitation under the Federal bridge program. The States will use existing bridge records, which includes as-built plans, in their assessment of a bridge's vulnerability to collapse from high-speed heavy-vehicle collision from supports. Bridges that are determined to be vulnerable will have countermeasures appropriately implemented in accordance with the States' comprehensive programs to improve bridge safety and serviceability. The FHWA does agree with the appropriate implementation of countermeasures, if necessary, for vulnerable bridges as determined through a State's bridge management process.

The FHWA further indicated that "The proposed action has been taken and no additional action by the FHWA is required at this time."

The NYSDOT's assessment of the Grant Avenue bridge shows the value of a comprehensive bridge safety assurance program. Unfortunately, in this case the bridge was

[13]See Highway Accident Brief No. DCA-94-MH-009, June 6, 1995.

assessed after the accident. The Safety Board recognized the forward thinking NYSDOT comprehensive bridge safety assurance program in the New Orleans accident report.[14] The White Plains and Hooks accidents are additional examples of what can happen when a bridge is vulnerable to collision and collapse. The Safety Board still believes that the FHWA should exercise its oversight responsibility and request that the States identify and assess the bridges that are vulnerable to collapse from a high-speed heavy-vehicle collision. Therefore, the Safety Board has reclassified Safety Recommendation H-94-5 "Open--Unacceptable Response" and reiterates the recommendation.

In the July 17 letter, the FHWA said that it had referred to Transportation Research Board Special Report 214 and the AASHTO *Roadside Design Guide* in its April 12, 1995, memorandum to the field offices. The FHWA said it believed that "more States will use the AASHTO LFRD document as they become more comfortable with the new methods presented in it." The FHWA said it planned no additional action. Since the Safety Board believes that these publications will provide the necessary guidance to the States, the Board has classified Safety Recommendation H-94-6 "Closed--Acceptable Alternative Action."

As a result of the Evergreen accident, the Safety Board also recommended that AASHTO:

> In cooperation with the Federal Highway Administration, ensure that the bridge management program guidelines include information on evaluating which bridges are vulnerable to high-speed heavy-vehicle collision and subsequent collapse. (H-94-7)

The Safety Board understands that this recommendation has been forwarded to AASHTO's Highway Subcommittee on Bridges and Structures for evaluation and response. Pending the subcommittee's adoption of guidelines for the evaluation of bridges that may be vulnerable to high-speed heavy-vehicle collision and collapse, Safety Recommendation H-94-7 was classified "Open--Acceptable Response."

Highway and railway bridge vulnerability and risk assessment for extreme events was discussed in the New Orleans and Mobile accident reports.[15] In 1993, a towboat maneuvering in a dense fog struck and displaced the Big Bayou Canot railroad bridge near Mobile, Alabama. Shortly afterward, a train struck the displaced bridge and derailed. Forty-two passengers and five train crewmembers were killed; 103 passengers were injured.

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[14]See Highway-Marine Accident Report--*U.S. Towboat CHRIS Collision with the Judge William Seeber Bridge, New Orleans, Louisiana, May 28, 1993* (NTSB/HAR-94/03).

[15]See preceding footnote for information about New Orleans accident. See Railroad-Marine Accident Report--*Derailment of Amtrak Train No. 2 on the CSXT Big Bayou Canot Bridge Near Mobile, Alabama, September 22, 1993* (NTSB/RAR-94/01).

As a result of the investigation, the Safety Board recommended that the Secretary of Transportation:

> Convene an intermodal task force that includes the Coast Guard, the Federal Railroad Administration, the Federal Highway Administration, and the U.S. Army Corps of Engineers to develop a standard methodology for determining the vulnerability of the Nation's highway and railroad bridges to collisions from marine vessels, to formulate a ranking system for identifying bridges at greatest risk, and to provide guidance on the effectiveness and appropriateness of protective measures. (I-94-3)
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> Require that the Federal Railroad Administration and the Federal Highway Administration, for their respective modes, use the methodology developed by the intermodal task force to carry out a national risk assessment program for the Nation's railroad and highway bridges. (Class II, Priority Action) (I-94-4)

In a February 2, 1995, letter the Secretary of Transportation indicated that the task force had been formed and had adopted the basic risk assessment methodology described in the 1983 National Research Council study *Ship Collisions with Bridges, The Nature of the Accidents, Their Prevention and Mitigation.*[16] The Safety Board responded on April 24, 1995, that it was pleased with the task force's progress and had classified Safety Recommendations I-94-3 and -4 "Open--Acceptable Response."

Cargo tank integrity--The Safety Board has previously addressed its concerns about a cargo tank full of compressed gases failing catastrophically in an accident. In 1975, the Safety Board investigated a highway accident in Eagle Pass, Texas,[17] which involved the catastrophic failure of a tank carrying 8,748 gallons of LPG. The tank separated from the tractor, struck a concrete head wall, and ruptured, releasing the LPG. Fifty one people were burned in the ensuing fire; and of the 51, 16 died.

As a result of its investigation, the Safety Board recommended that the DOT:

> Initiate a research program to identify new approaches to reduce the injuries and damages caused by the dangerous behavior of pressurized, liquefied flammable gases released from breached tanks on bulk transport vehicles (I-76-5).

In 1978, the Research and Special Programs Administration (RSPA) contracted for research[18] in this area, and the Board classified the recommendation "Closed--Acceptable Action."

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[16]National Academy Press, Washington, D.C., 1983.

[17]See Highway Accident Report-*Surtgias, S.A., Tank-Semitrailer Overturn, Explosion, and Fire, near Eagle Pass, Texas, April 29, 1975* (NTSB-HAR-76-4).

[18]Contract DOT-RC-82039, September 26, 1978.

In 1979, after a railroad derailment in Crestview, Florida,[19] that resulted in the failure of several rail tank cars carrying liquefied compressed gases, the Safety Board recommended that RSPA:

> Expand current research into 'new approaches for controlling pressurized liquefied flammable gas releases' from breached tanks on bulk transport vehicles to include control of pressurized liquefied nonflammable ammonia and chlorine gas releases. (I-79-12).

In 1991, RSPA advised the Safety Board that the research program to find new approaches for controlling pressurized gas releases had been canceled several years earlier. RSPA noted that the research had not yielded any viable alternatives to railroad shelf-couplers, headshields, and thermal protection, all of which had proven effective in preventing product release. RSPA also noted that further research was not justified and requested that the recommendation be classified "Closed--Acceptable Alternative Action."

In an April 3, 1992, letter to RSPA, the Safety Board agreed that shelf-couplers, headshields, and thermal protection had dramatically improved safety when installed on rail tank cars and had reduced the number of catastrophic failures of pressurized tank cars. However, the Safety Board reminded RSPA, Safety Recommendation I-79-12 was an intermodal recommendation, The Board noted that RSPA had not addressed new approaches for controlling pressurized gas releases from breached highway cargo tanks. To further support the recommended research, the Safety Board told RSPA about the following highway accident investigations that involved the failure of cargo tanks carrying LPG.

Date	**Location**	**Burn Injuries**	**Fatal Burn Injuries**
April 29, 1975	Eagle Pass, Texas	51	16
April 6, 1987	Lawrenceville, New Jersey	7	0
December 23, 1988	Memphis, Tennessee	23	9
January 20, 1992	Crawford, Mississippi	4	3

In the Lawrenceville and Memphis accidents, the front heads of the cargo tanks failed after they struck bridge structures. In the Crawford accident, the front head failed after the it struck another vehicle.

[19]See Railroad Accident Report--*Louisville & Nashville Railroad Company Freight Train Derailment and Puncture of Hazardous Materials Tank Cars, Crestview, Florida, April 8, 1979* (NTSB-RAR-79/11).

In the April 3 letter, the Safety Board again urged RSPA to do the recommended research. RSPA did not respond. Since there was no indication that RSPA had taken action to conduct the recommended research, on June 29, 1994, the Safety Board classified Safety Recommendation I-79-12 "Closed--Unacceptable Action."

On February 4, 1992, the Safety Board adopted a special investigation report on cargo tank rollover protection.[20] The report addressed the need to evaluate the forces that act on cargo tanks during rollover accidents and the need to establish performance standards for rollover protection devices based on analysis of those forces. As part of the special investigation, the Safety Board found that NASA had used computer analysis to improve the crashworthiness of cargo tanks used to transport rocket fuels. Special design features were incorporated into the cargo tank configuration to protect the tank in the following kinds of impact: a 55-mph frontal collision with an unyielding surface; a 55-mph lateral impact from another tractor-trailer weighing 80,000 pounds; and a rollover and 18-foot fall from an overpass.

The accident in White Plains again demonstrates the destructive potential of a cargo tank carrying flammable compressed gases when it catastrophically fails during a highway accident. The Safety Board is concerned about the adequacy of minimum construction requirements that allow a front tank head to be 33 percent thinner than the tank barrel. In rollover or jackknife accidents, the front head is vulnerable to collision with fixed objects. Therefore, the Safety Board concludes that the front head on a cargo tank is vulnerable to being damaged and subsequently releasing the cargo.

The Safety Board has previously recognized the effectiveness of headshields in reducing tank head punctures in train derailments and the efforts of NASA to design a front head impact limiting system for highway cargo tanks it uses to transport rocket fuels. The Safety Board could not determine whether it is reasonable to design tank heads that could have withstood the impact forces involved in this accident. The Safety Board believes that the FHWA and RSPA should research methods and develop standards to improve the crashworthiness of front heads on cargo tanks used to transport liquefied flammable gases and potentially lethal nonflammable compressed gases.

The National Transportation Safety Board therefore issues the following safety recommendations to the Federal Highway Administration:

> Require that the proposed National Highway System provide consistent and higher standards for large trucks. (Class II, Priority Action) (H-95-32)
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> Conduct research with cargo tanks (80,000 pounds) to evaluate the safety performance of roadside barriers and highway geometrics, such as embankment

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[20]See Hazardous Materials Special Investigation Report, *Cargo Tank Rollover Protection*, February 4, 1992, (NTSB/SIR-92/01).

sideslopes and ditches, and change the standards accordingly. (Class II, Priority Action) (H-95-33)

Require any Federal-aid project involving bridges to use the 1994 *Load and Resistance Factor Design* guidelines for the protection of structures and the design of piers. (Class II, Priority Action) (H-95-34)

Cooperate with the Research and Special Programs Administration in studying methods and developing standards to improve the crashworthiness of front heads on cargo tanks used to transport liquefied flammable gases and potentially lethal nonflammable compressed gases. (Class II, Priority Action) (H-95-35)

Cooperate with the American Association of Motor Vehicle Administrators and the American Trucking Association to review and augment the commercial drivers license manual and test materials to include information on the role of fatigue in commercial vehicle accidents and methods to identify and address fatigue. (Class II, Priority Action) (H-95-36)

Also, the National Transportation Safety Board reiterates the following safety recommendations to the Federal Highway Administration:

Request States to identify and assess bridges that are vulnerable to collapse from a high-speed heavy-vehicle collision with their bridge columns and develop and implement countermeasures to protect the structures. (H-94-5)

Examine truckdriver pay compensation to determine if there is any effect on hours-of-service violations, accidents, or fatigue. (H-95-3)

Develop and disseminate, in consultation with the U.S. Department of Transportation Human Factors Coordinating Committee, a training and education module to inform truckdrivers of the hazards of driving while fatigued. It should include information about the need for an adequate amount of quality sleep, strategies for avoiding sleep loss, such as strategic napping, consideration of the behavioral and physiological consequences of sleepiness, and an awareness that sleep can occur suddenly and without warning to all drivers regardless of their age or experience. (H-95-5)

Also, the Safety Board issues Safety Recommendation H-95-37 to the Research and Special Programs Administration, Safety Recommendation H-95-38 to the New York State Department of Transportation, Safety Recommendation H-95-39 to the American Association of State Highway and Transportation Officials, Safety Recommendation H-95-40 to the American Association of Motor Vehicle Administrators, Safety Recommendation H-95-41 to the American Trucking Associations, Inc., and Safety Recommendations H-95-42 and -43 to Paraco Gas Corporation, Inc.

The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations H-95-32, -33, -34, -35 and -36 in your reply. If you need additional information, you may call (202) 382-6813.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT and GOGLIA concurred in these recommendations.

Jim Hall

By: Jim Hall
Chairman