



Log H-565A

National Transportation Safety Board

Washington, D.C. 20594
Safety Recommendation

Date: June 3, 1992

In reply refer to: H-92-34 through -45

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The number of fatalities that occurred in highway work zones increased from 489 in 1982 to 780 in 1988. Concurrently, total spending on highway construction increased from about \$32 billion to about \$52 billion. The Nation's interstate system, for the most part, has been completed. As the infrastructure ages, the number of maintenance and construction zones to repair and to replace sections of the network can be expected to increase. Further, growth in traffic volume has required that roadway capacities be increased to provide a more desirable level of service to motorists; thus construction for this reason can also be expected to increase. The available data indicated that unless additional efforts were made to reduce work zone accidents, the number of fatalities would continue to increase. Because of these factors, the National Transportation Safety Board became increasingly concerned about the adequacy of traffic safety in work zones and initiated a study in 1988 concerning work zone related accidents. More than 40 accidents were investigated during the next 2 years, and previous work zone accidents investigated by the Safety Board were reviewed.

In July 1990, as the review of the accident cases neared completion, the Safety Board conducted a major investigation of a work zone accident near Sutton, West Virginia. Eight persons were killed in the accident, and five vehicles were either destroyed or severely damaged. In its statement of probable cause, the Safety Board determined that contributing to the cause of the accident was the less than optimal work zone control devices and procedures used at the site. The accident underscored the Safety Board's concern regarding safety in work zones, and several safety recommendations were issued to the West Virginia Department of Transportation and the Federal Highway Administration to improve work zone safety.

Additional investigations of work zone accidents were conducted in 1990 and 1991, as they occurred. A review of these accidents and the Sutton, West Virginia, accident raised additional work zone safety issues that are discussed in the Board's study.¹

¹ National Transportation Safety Board. 1992. Highway Work Zone Safety. Safety Study NTSB/SS-92/02. Washington, D.C.

Accident Data

Concern has been expressed in the industry about the accuracy of work zone related data. With respect to fatalities, the Fatal Accident Reporting System (FARS) does not, for example, distinguish between persons driving highway maintenance vehicles within work zones and other drivers who crash in work zones while traversing the work zone site. A 1991 study² by the National Institute for Occupational Safety and Health recommended that data collection be adjusted to enable this distinction, primarily because countermeasures for these two types of crashes are different. The Safety Board concurs and believes that the NHTSA should revise the reporting of fatalities to make this distinction.

A 1987 study³ by the American Association of State Highway and Transportation Officials (AASHTO) recommended that "All States should assure their accident data systems are capable of providing sufficient information to monitor the accident experience of work zones within their State."

Because of the concern expressed in the above referenced studies, Safety Board staff selectively reviewed State data and the report forms used by States to determine how States document or code accidents that occur in work zones. The review revealed some discrepancies between State data and FARS data. For example, in 1989, the State of North Carolina reported that 16 fatalities occurred in work zones, but the FARS data indicated that 3 fatalities occurred in work zones in the State. For the same year, the State of Minnesota reported that 11 fatalities occurred in work zones, compared to 16 fatalities according to FARS data. In 1990, the FARS data indicated that 11 fatalities occurred in work zones in the State of West Virginia, while the State reported 14 fatalities.

NHTSA staff involved with the FARS data indicated that some differences in the number of fatalities reported by FARS and the States may exist because only fatalities that occur within 30 days after the accident are included in the FARS data. However, NHTSA staff also acknowledged that the discrepancies could very likely be caused by the various ways States document and code work zone related accidents. On some State forms, there are no categories to document accidents occurring in work zones. In preparing the FARS data, NHTSA's analysts in these States would have to interpret the narrative of the accident found on the State form to determine if the accident was work zone related.

² Landen, Deborah; Kisner, S. 1991. Occupational fatalities in highway work zones: fatal accident reporting system, 1987-1988. Washington, D.C. National Institute for Occupational Safety and Health, Division of Safety Research.

³ American Association of State Highway and Transportation Officials-- Standing Committee on Highway Traffic Safety. 1987. Summary report on work zone accidents. Washington, D.C. April.

Section 402 of the Intermodal Surface Transportation Efficiency Act of 1991⁴ provides for:

...annual reports to the Secretary [of the DOT] on the efforts being made by the States in reducing deaths and injuries occurring at highway construction sites and the effectiveness and results of such efforts. The Secretary shall establish minimum reporting criteria for the program. Such criteria shall include, but not be limited to, criteria on deaths and injuries resulting from police pursuits, school bus accidents, and speeding, on traffic-related deaths and injuries at highway construction sites and on the configuration of commercial motor vehicles involved in motor vehicle accidents.

The above legislation provides an excellent opportunity to achieve uniformity in the documentation of work zone related accidents. The Safety Board has been informed by NHTSA officials, however, that some States are streamlining their accident report forms to reduce the time required to fill out the form because of budgetary constraints. Such action, in the Safety Board's view, appears contrary to the intent of Section 402. Moreover, the Safety Board believes that there is a need for more reliable data on work zone accidents and that the NHTSA and the FHWA should review all State forms and select the data elements that comprehensively document work zone accidents. The States should be encouraged to incorporate these data elements into the States' accident report forms.

During the course of this study, the Safety Board attempted to document exposure data with respect to work zones to compare accident rates in work zones with accident rates on roads not under construction. No such data exist. The only measure of the amount of work zone activity is the number of dollars spent for construction. Various studies in the past have cited the lack of exposure data for work zone accidents. One of the recommendations of the previously cited 1987 AASHTO study was that "the Committee [AASHTO Standing Committee on Highway Traffic Safety] should work with states to provide some measures of exposure for work zone accidents...." A 1990 study prepared by the Minnesota Department of Transportation cited "the need for a measure of exposure...."⁵ FHWA officials indicated to the Safety Board that collection of work zone exposure data, which would be a relatively expensive project, has been proposed but never approved for funding within FHWA.

The Safety Board acknowledges that exposure data for some moving maintenance activities, such as painting or mowing, would be difficult to document because of the short-term duration of the activities. However, the

⁴ Legislation signed by the President on December 18, 1991, that provides authorizations for highways, highway safety, and mass transportation for the next 6 years.

⁵ Minnesota Department of Transportation, Standards Unit, Office of Traffic Engineering. 1990. Work zone accident analysis for calendar year 1989. November.

Safety Board believes that exposure data for long-term construction sites on the interstate system, for example, should be documented, particularly in view of the large percentage of construction work zone accidents that occur on the interstate system. The 1990 FARS data indicated that over 80 percent of the fatal accidents in work zones occur in construction work zones (and only 20 percent in the other categories of work zones), and that almost 30 percent of the fatal accidents in work zones occur on the interstate system. Given the expected increase of construction and maintenance on the interstate system, the Safety Board urges the FHWA to develop a program to collect exposure data for construction zones on the interstate system. Such data would enable the FHWA and State transportation officials to measure more precisely the effects of work zones on accident rates and the treatments needed to reduce accident rates.

Two-Lane, Two-Way Operations

In October 1990, construction work began on a 10-mile section of Interstate 20 about 20 miles east of Birmingham, Alabama. The construction included the replacement of a bridge and a lane widening project. To perform the work, a two-lane, two-way operation (TLTWO) was set up, which required lane reductions and a median crossover to the eastbound lanes.

The crossover surface was asphalt. The crossover was delineated with orange and white reflectorized barrels on the right and a yellow 4-inch-high asphalt island on the left. Reflectorized orange and white 12-inch-high rubber posts were mounted in the center of the asphalt island every 10 feet. The distance from the beginning of the crossover to the end of the work zone was about 1,000 feet. The temporary raised asphalt island functioned as a lane divider throughout the two-lane two-way operation.

On April 27, 1991, a 1985 Chevrolet S-10 pickup truck was traveling eastbound in the construction zone, and a 1986 Nissan Pulsar was traveling westbound. The driver of the Nissan lost control of the vehicle, and it traveled across the raised asphalt island into the eastbound lane where it collided with the eastbound pickup. According to the police report, the pickup truck was estimated to be traveling at 45 mph at the time of the collision and the Nissan at 60 mph. Both drivers and a passenger died in the accident.

About 7 p.m. on May 3, 1991, a westbound Honda passenger car, occupied by its driver and a passenger, entered the same construction zone. An eastbound Mazda passenger car, occupied by its driver and a passenger, also entered the construction zone at the opposite end traveling at an estimated speed of 45 mph. A witness, who was traveling eastbound behind the Mazda, observed the Honda traveling at an estimated 60 mph. As the Honda entered the transition to the one-lane westbound roadway, it crossed over the 4-inch-high asphalt island and collided head on with the Mazda. After impact, the Honda and the Mazda rotated off the right edge of the travelway, and the Honda erupted in flames. The driver and passenger of the Honda were fatally injured, and the driver and passenger of the Mazda were seriously injured. Both vehicles were destroyed by the collision and subsequent fire.

This construction zone was in place from October 1990 through May 1991. As part of its investigation of the accident that occurred on May 3, 1991, Safety Board staff reviewed computer records to determine the number of accidents in this area during the time the construction zone was in place. The review revealed at least five additional accidents in which vehicles crossed the median (island) in this area.

The Safety Board has addressed the issue of TLTWOs in the past. For more than a decade, the Safety Board has expressed concern about the lack of positive separation⁶ of opposing traffic in work zones.

On August 22, 1979, a westbound tractor-semitrailer sideswiped an eastbound tractor-semitrailer and then struck an eastbound motor home on a two-lane, undivided roadway in a 9-mile-long construction zone on I-80 about 30 miles northwest of Laramie, Wyoming. The driver and codriver of the westbound tractor-semitrailer were killed. Six of the seven persons in the motor home were ejected and killed; one person was partially ejected and seriously injured. Based on its investigation, the Safety Board concluded that the westbound truck struck the eastbound truck and the motor home at speeds of 68 mph and 58 mph, respectively.

In its report of that accident investigation, the Safety Board concluded that "the accident history at this location indicates that accident rates, especially fatal accident rates, increase significantly when an interstate highway is switched from a four-lane, divided operation to a two-lane, two-way operation during construction work." The Board's report expressed concern about the FHWA's efforts at the time to address two-lane, two-way operations on high-speed, high-volume highways.

On September 17, 1979, 3 1/2 weeks after the Laramie accident, the FHWA issued an emergency final rule (FHWA Docket No. 79-31) entitled "Traffic Safety in Highway and Street Work Zones; Separation of Opposing Traffic." The emergency final rule would have amended 23 CFR 630 and was to have been effective immediately.

In response to the FHWA's emergency final rule, some State transportation agencies began to modify their traffic control plans to emphasize the use of single-lane closures, rather than TLTWOs, because of the prohibitive cost of positive barriers. Recognizing the States' concern, the FHWA on October 16, 1980, published a notice of proposed rulemaking (NPRM) to amend the emergency final rule. The NPRM was intended to give flexibility to allow the use of separation devices other than positive barriers throughout the TLTWO, including transitions, when conditions such as time and length of exposure, type of traffic, and the type of facility warranted.

⁶ For the purpose of this study, positive barrier or positive separation of traffic refers to the use of concrete barriers to separate traffic, notably the New Jersey type barrier.

About 9 months later, on July 22, 1981, about 5:50 a.m., a 1978 van occupied by seven persons was traveling eastbound on the Ohio Turnpike in a construction zone near Cleveland, Ohio, where two-way traffic was operating in the eastbound lanes. The posted speed for the construction zone was 50 mph. Shortly after the van, which was traveling about 55 mph, entered the construction zone, it drifted into the westbound lane and forced an oncoming westbound car off the roadway onto the median shoulder. The van continued about 400 feet in the opposing traffic lane and collided nearly head on with a GMC tractor-semitrailer traveling westbound at an estimated speed of 45 mph. The van driver and five passengers in the van were killed, and one passenger was seriously injured. The driver of the tractor-semitrailer received minor injuries.

The Safety Board determined that the probable cause of the accident was the failure of the van driver to maintain his vehicle within the proper traffic lane. Contributing to the cause of the accident was the lack of positive separation of opposing traffic in the construction work zone. As a result of its investigation of the Cleveland accident, the Safety Board, on March 30, 1982, urged the FHWA to "promptly adopt the final rule changing the Manual on Uniform Traffic Control Devices (MUTCD) to incorporate the provisions of the "Emergency Final Rule, 23 CFR 630.101" (Safety Recommendation H-82-8). The Safety Board continued to believe that two-way operations on one roadway of a normally divided highway should be permitted only when other methods were determined to be infeasible.

On May 20, 1982 (less than 2 months after the Safety Board issued Safety Recommendation H-82-8), the FHWA published a final rule that, in essence, weakened the emergency rule that was published 3 years earlier. The final rule permits TLTWOs only after other available methods of traffic control have been carefully considered. The emergency rule permitted TLTWOs only when other methods of traffic control were determined to be infeasible. The FHWA stated in the rulemaking that as a result of experience with the use of separation devices in TLTWOs, the FHWA had determined that there may be instances in which a properly separated TLTWO could be preferable to other feasible types of traffic control in work zones. As stated in the Federal Register at the time the final rule was published, "The FHWA has decided not to stipulate further traffic control design requirements in this situation.... This will allow greater flexibility to develop traffic control detail tailored to the particular circumstances on each project. This amendment is intended to place the primary responsibility for determining the appropriate traffic control details for each project on the State and local highway agencies."

On January 10, 1992, the FHWA published an advance notice of proposed rulemaking in the Federal Register regarding proposed amendments to Part VI of the MUTCD. Part VI addresses traffic controls for street and highway construction, maintenance, utility, and emergency operations. These proposed revisions to the MUTCD contain a discussion of TLTWOs. The first paragraph in the proposed revisions mirrors the opening paragraph found in the Traffic Control Devices Handbook. The wording of the remaining three paragraphs in the proposed revisions duplicates the original wording of the emergency final rule issued in 1979. Although the proposed revisions to the MUTCD suggest a

stronger position on this issue by the FHWA, comparable to the position taken in 1979, the Safety Board remains concerned that TLTWOs can still be implemented on the interstate system without positive separation of opposing traffic.

Through its accident investigation experience and data collection activities, the Safety Board is aware that not all States use positive separation of opposing traffic when TLTWOs are implemented on the interstate system. For example, asphalt medians are used to divide TLTWOs in Michigan, Louisiana, and North Carolina; tubes are used in Louisiana and Kentucky; and cones are used in Kentucky and Florida. Further, a 1990 study noted that North Carolina, Florida, Ohio, and Pennsylvania have used a 12- to 18-inch-wide by 4-inch-high asphalt median with reflectorized yellow paint and orange tubes with reflectorized white collars spaced at 50-foot intervals as a divider for TLTWOs when the average daily traffic (ADT) count is less than 30,000.⁷ The study also noted that "The medians are generally not recommended...where the traffic volume is high, for example, where the ADT is greater than 50,000." The Roadside Design Guide discusses the use of a temporary raised island and cautions, "Presently, since there is limited operational experience with the temporary raised island [4-inch-high asphalt median], there is not a consensus on the traffic and geometric conditions that warrant its use. Until there is more operational experience with the device, it should only be used on roadways with speeds of 45 mph or less except when recommended by an engineering study."

With posted speed limits of 55 mph and 65 mph on the interstate system and with traffic often exceeding those limits, it may be unreasonable to expect to achieve speed reductions to 45 mph or below in work zones. In fact, the MUTCD states that "traffic movement should be inhibited as little as practicable" and that "reduced speed zoning should be avoided as much as practicable." Given these conditions, the Safety Board strongly believes that if TLTWOs are implemented on a normally divided highway, positive separation of opposing traffic must be achieved. The use of cones, drums, tubes, or temporary asphalt medians will not achieve the desired separation. The MUTCD and the Traffic Control Devices Handbook should be revised accordingly.

Although the prevailing view is to minimize speed reductions through work zones on the interstate to prevent speed differentials, the Safety Board has some concern that the currently used positive barriers are not designed to provide the level of protection needed for large commercial vehicles traveling through work zones at speeds as high as 55 mph and 65 mph. The concrete barrier in some cases would probably have limited effect in preventing accidents of commercial vehicles at these speeds. Consequently, the FHWA should determine if a combination of efforts, such as speed reductions coupled with onsite enforcement and positive barriers, may be needed at work zones when commercial vehicles are a relatively large percentage of the ADT.

⁷ Cottrell, B. H., Jr. 1990. Temporary asphalt medians for two-lane, two-way operation. Transportation Research Record No. 1258.

Truck-Mounted Attenuators

About 9 a.m. on September 26, 1989, four State of Illinois Department of Transportation maintenance trucks began a pavement striping operation, traveling north in the right northbound lane of I-39 near Ogle County, Illinois, at a speed estimated by one of the truckdrivers to be 20 mph. The paint striping machine was being pulled by the lead truck. The last truck, a 1987 Ford 8000, was equipped with a truck-mounted attenuator (TMA), which is a type of crash cushion mounted typically on the rear of a State transportation vehicle.

About 10:50 a.m., a 1986 Mack tractor, traveling in the right northbound lane and pulling a 1970 Heil dry bulk trailer loaded with dry concrete (78,000 pounds), overtook the painting operation on a straight section of roadway and struck the rear of the TMA-equipped Ford 8000 truck at a speed estimated by the driver of the Mack truck to be 55 to 60 mph. Another truckdriver following the Mack truck indicated that the driver of the Mack truck may have been traveling at 65 mph. The Mack truck crushed and overrode the TMA on the rear of the Ford truck and pushed the Ford truck across the left northbound lane and into the median of I-39.

Most likely because the TMA absorbed a substantial amount of the impact forces, the driver of the Mack combination vehicle was not injured. The driver of the Ford truck received minor injuries (cervical neck strain, scalp abrasion, abrasion/contusion on his right calf) and was treated and released from a local hospital.

On the morning of March 19, 1989, the California Department of Transportation was conducting a trash removal/sweeping operation on I-5, in Downey, California. The vehicles involved in the trash removal/sweeping operation included (from front to rear) a trash truck, two dump trucks, two sweepers, and two shadow trucks. Both shadow trucks were equipped with TMAs on the rear, flashing arrow board signs, and a white and black warning sign that read "Sweeper Ahead."

About 6:30 a.m., while the sweeping operation was being conducted in the lane adjacent to the median, traveling at a speed estimated by the driver of the last truck in the operation to be 3 mph, a Dodge Omni traveling north on I-5 ran into the TMA on the rear of the last truck in the sweeping operation. According to the driver of the Omni, he had been traveling about 55 mph before applying his brakes, but was unable to stop before impacting the TMA.

The Dodge Omni sustained crush damage across the front to a maximum depth of 2 feet. The TMA sustained severe crush damage; there was no damage to the shadow truck. Based on the damage to the TMA, the estimated speed of the car at the time it struck the TMA was between 30 and 40 mph.

Neither the driver of the Dodge Omni nor the driver of the shadow truck was injured as a result of the accident. Both drivers were restrained with lap/shoulder belts. Although the Safety Board has some concerns that

advance warning signs were not being used in the above two examples of slow moving maintenance operations and believes that the lack of severe injuries can be attributed, in part, to the fact that occupant restraints were used in one case, the benefits of using truck-mounted attenuators in slow moving, maintenance operations are apparent.

The angle or offset at which a TMA is struck may affect the effectiveness of the TMA to mitigate injuries. One example follows:

On May 17, 1989, the Texas Department of Highways and Public Transportation was painting pavement stripes on I-20 eastbound near Sweetwater, Texas. About 3:05 p.m., maintenance personnel positioned a 1985 GMC 7000 truck astraddle the right edgeline about 1/2 mile west of the area being painted. The truck was equipped with a Hex-Foam TMA on the rear and a flashing arrow board mounted about 6 feet above the ground.

Shortly after the truck equipped with the TMA was positioned astraddle the right edgeline, a 1989 Ford F250 pickup truck, traveling about 65-67 mph in the right eastbound lane, skidded 10 feet and then impacted the left side of the TMA. The pickup truck then struck the left side of the GMC truck. The TMA was crushed about 12 to 18 inches along the entire 7-foot-long left side, and the metal backup plate was pushed inward about 2 feet. There was about 12 inches of contact damage along the right side of the pickup truck, and the hood, door, and roof were crushed into the passenger's seating area.

The passenger of the pickup truck, who was restrained with a lap/shoulder belt, was killed. The driver of the pickup truck, who was also restrained, received moderate injuries. Most likely because of the angle at which the TMA was impacted, the effectiveness of the TMA to mitigate injuries was substantially reduced.

The manufacturer of the Hex-Foam TMA warns TMA users in its training session not to position a truck with a TMA halfway on the roadway or straddling a lane. Positioning a truck with a TMA partially in one lane, according to the manufacturer, increases the chances of a vehicle impacting only part of the crash cushion. Further, a representative of the company that manufactures the Hex-Foam TMA stated that his company believes that additional testing is warranted to address severe offset impacts that can occur on the highway, particularly the interstate system. According to the representative, "We have formally proposed [a] fourth crash test to the NCHRP [National Cooperative Highway Research Program] Report 230 rewrite panel. The impact should be 0° on the nose, with a 2.5-foot offset. Any offset beyond this creates occupant risk 'G' levels that exceed current guidelines. We are not sure current TMA models can pass this severe of an offset impact, but we feel the issue must be addressed." FHWA officials have proposed revisions to Report 230 that would encourage optional testing of TMAs at 62 mph and at an offset impact.

The Safety Board encourages additional testing, including impacts at various angles and offsets. The Safety Board has learned that manufacturers of TMAs are conducting research to determine if TMAs can be improved to withstand impact forces in excess of 45 mph. TMAs currently are not designed

for crashes in which the speed differential exceeds 45 mph. The above accidents illustrate that moving work/maintenance zones are often performed on divided highways where the speed limit is not reduced from the normal posted speed limit of 55 or 65 mph, and because of the relatively low speeds at which the moving/maintenance operations are performed, major speed differentials are created.

While encouraging additional testing and research of TMAs, the Safety Board also believes that an analysis of the effects of using TMAs in high-speed environments should be conducted. Problems may be introduced that could result in a degradation of safety to motorists and drivers of TMA-equipped vehicles. A trade-off analysis of the benefits and shortcomings of using TMAs in high-speed environments (in excess of 45 mph) is necessary. The FHWA is the appropriate agency to conduct or sponsor, in conjunction with industry, the research and analysis.

The statement by the manufacturer of the Hex-Foam TMA--that it warns users of TMAs not to position a truck with a TMA astraddle or partially in a lane--raises additional concerns regarding the adequacy of guidance currently available on the applicable uses of TMAs. Although the manufacturer's statement may be sound advice, there appears to be little additional information to support or refute such a position, despite the ever increasing use of these devices by State departments of transportation in the last few years.

Because of the limited guidance available on the use of TMAs, researchers at the University of Tennessee Transportation Center in 1989 conducted extensive interviews with highway agency personnel from five States involved in maintenance and construction work zone activity. The interviews were to be the basis for developing a set of guidelines on the use of TMAs. The results of the interviews indicated that the most common application of TMAs was for protection of workers and motorists in moving work zones. Those interviewed, however, voiced strong support for more frequent use of TMAs on barrier vehicles in stationary operations. Based on the information gathered, the researchers developed suggested priorities for the application of TMAs.

In their conclusions, however, the researchers cautioned:

Two limitations on the significance and suggested use of the guidelines are acknowledged by the research team. First, the project was not a research project spelled with a capital "R." Such an effort would have involved the collection and analysis of data which are not readily available, at a cost measured in \$100,000s (well beyond the budget of this project) over a period of time measured in years. Second, the guidelines in the present format are most appropriately used as a policy formulation and budgeting tool. Further refinement and simplification will be required.

The Safety Board's investigations of work zone accidents over the last several years revealed that the severity of several accidents could have

been substantially reduced had TMAs been used on barrier vehicles at stationary work zone sites.

Notwithstanding the work by the University of Tennessee Transportation System Center, the Safety Board is concerned that the use of TMAs in various work zone environments has not been sufficiently addressed in the guidance and reference materials routinely used by state and local transportation officials. According to the FHWA, because a TMA is not a traffic control device, the MUTCD and the Traffic Control Devices Handbook are not the appropriate manuals in which to discuss the applicable uses of TMAs. According to FHWA and AASHTO officials, the Roadside Design Guide would be the appropriate document in which to incorporate guidance on the applicable uses of TMAs in short-term moving/maintenance operations and long-term stationary construction sites. Although the Safety Board recognizes that additional tests and research are needed to determine the effectiveness of TMAs when impacted at an angle or offset and when used in situations where the speed differential exceeds 45 mph, the Board believes that sufficient information is currently available to provide some guidance on the various applications of TMAs. Accordingly, the Safety Board urges AASHTO to incorporate such guidance into the Roadside Design Guide. The Safety Board also believes that even though the TMA is not considered a traffic control device and, consequently, the applicable uses of TMAs would not be appropriate in the MUTCD, a reference to the Roadside Design Guide concerning the uses of TMAs would be appropriate in the MUTCD and the Traffic Control Devices Handbook.

One figure in the proposed revisions to the MUTCD illustrates trucks equipped with TMAs, one of which is straddling the pavement edgeline, as optional in a mobile operation on a multilane road. Because the effects of impacting TMAs at various angles and offsets are currently being researched and given the warning of one manufacturer not to position a truck with a TMA astraddle or partially in a lane, the Safety Board believes that the FHWA should revise the figure in the proposed revisions to the MUTCD to eliminate the depiction of vehicles equipped with TMAs positioned astraddle pavement edgelines.

Also of concern to the Safety Board is that drivers of vehicles equipped with TMAs may not be provided adequate protection in terms of restraints and headrests. In the moving maintenance operation of the State of Illinois Department of Transportation during September 1989, the driver of the vehicle that struck the TMA was not injured. However, the driver of the State department of transportation vehicle that was equipped with a TMA did receive minor injuries, including cervical neck strain, scalp abrasion, and abrasion/contusion on his right calf. The investigation of the accident revealed that the State vehicle was not equipped with a headrest and that the seatbelt was being worn loosely at the time of the accident. The Safety Board believes that because of the likelihood of rear-end collisions, vehicles equipped with truck-mounted attenuators need to be equipped with lap/shoulder restraints and headrests to provide drivers the maximum protection possible.

In a manual developed by one manufacturer of TMAs, safety instructions address the use of seatbelts and headrests for the occupants of trucks

equipped with a TMA. The Safety Board is aware that some State highway departments recognize the need to provide protection to the drivers of trucks with TMAs. California, for example, installs headrests and lap/shoulder restraints on vehicles equipped with TMAs. The Safety Board is concerned, however, that recognition of the need to provide the driver with adequate protection to mitigate injuries may not be widespread, as the above accident suggests. The FHWA and AASHTO should encourage State highway departments to incorporate these safety features into the specifications for the purchase of new vehicles and to retrofit existing vehicles.

Flagging

The issue of flagging at work zone sites was most recently addressed by the Safety Board in its report of the Sutton, West Virginia, accident.⁸ The flagger at the accident site was positioned 200 to 210 feet ahead of the area where the work was being performed. The MUTCD states, "Flagger stations shall be located far enough in advance of the work site so that approaching traffic will have sufficient distance to reduce speed before entering the project. This distance is related to approach speed and physical conditions at the site; however, 200 to 300 feet is desirable." As previously noted, the FHWA is revising Part VI of the MUTCD, which includes flagger placement. Consequently, as a result of its investigation of the Sutton accident, the Safety Board recommended that the FHWA:

H-91-30

Revise Section 6F-5 of the Manual on Uniform Traffic Control Devices to establish recommended distances for posting flaggers at work zones based on the legal speed limit approaching the zone.

The FHWA did not concur with the Board's Safety Recommendation H-91-30. In its letter of September 20, 1991, the FHWA stated that "the recommended distances for posting flaggers at work zones are adequately covered in the MUTCD and that these distances exceed the stopping sight distances for the range of legal speed limits which are encountered at work sites." The FHWA also referred to the MUTCD provision regarding placement of an "Advance Flagger Sign" at a distance of 500 feet in advance of the flagger placement point.

The Safety Board did not agree with FHWA's position and in a letter dated January 22, 1992, stated:

...the provisions of Section 6F-5 of the MUTCD should be revised by either deleting the sentence concerning "desirable" distance from the MUTCD or including in the MUTCD a detailed matrix table based on various speeds and stopping distances. Because of the

⁸ "Multiple Vehicle Collision and Fire in a Work Zone on Interstate Highway 79 Near Sutton, West Virginia, July 26, 1990" (NTSB/HAR-91/01).

institution of high speed limits (65 mph) on certain highways, such a revision will enhance motorist safety....

The Safety Board urged the FHWA to reconsider its position and classified Safety Recommendation H-91-30 as "Open--Acceptable Response," pending FHWA's further review of the Board's comments.

The Safety Board's investigation of accidents in conjunction with this safety study revealed several instances in which the placement of the flagger appeared inadequate given the various conditions at the work site. In the accident that occurred near Effingham, Illinois, on June 15, 1988, the flagger was located about 100 feet beyond the pavement grinder to move cones as the pavement grinder continued down the interstate highway, rather than the distance of 200 to 300 feet in front of the operation as recommended by the MUTCD and the Flagger's Handbook of the Illinois Department of Transportation.

The accident near Effingham, Illinois, also highlights the issue addressed in the report of the Sutton, West Virginia, accident: that flaggers should be in a position to warn workers of approaching danger, such as out-of-control vehicles. The farther a flagger is placed ahead of the actual work area, the more difficult it becomes to warn workers in the zone of an erratic vehicle's approach. As a result, the Safety Board urged the FHWA to "add a section to the MUTCD encouraging or requiring the use of audible warning devices, such as horns, by work zone flaggers to alert highway workers of the approach of an erratic vehicle" (Safety Recommendation H-91-31). The FHWA responded positively stating that it would consider adding information to the new Part VI of the MUTCD regarding the intent of the Board's safety recommendation. As a result, Safety Recommendation H-91-31 is currently being held in an "Open--Acceptable Response" status.

About 1:30 p.m. on September 19, 1989, a 1987 Toyota pickup truck and a 1984 GMC utility pickup truck were northbound on State Route 22 near New Lebanon, New York. The vehicles were traveling through a maintenance work zone during rain. The speed limit was 55 mph. The Toyota driver was stopping for a flagger standing in the roadway when the GMC driver approached from the rear, applied brakes, slid on the wet pavement, and crashed into the rear of the Toyota. Neither driver was seriously injured.

In the area of the accident, State Route 22 goes through mountainous terrain with many curves and grades. There was a 0.3-mile tangent followed by a hillcrest and a curve about 150 feet before the accident location. The flagger would have been visible to approaching traffic for only about 150 feet. A "One Lane Ahead" sign and a "Flagman Ahead" sign were located on the shoulder of State Route 22 about 4 miles and 3 miles, respectively, before the flagger's location.

On April 17, 1989, the New York State Department of Transportation began a moving road patching operation on State Route 3 near Harrietstown, New York. The westbound lane was closed for the repair work, and the eastbound lane was controlled by two flaggers. About 2.5 miles west of this location, a "Work Area" sign and a "Flagman Ahead" sign were placed on the shoulder of

the roadway. The area is rural and the terrain is mountainous. The eastbound lane descended an 11-percent grade for about 590 feet approaching the work area.

About 1:40 p.m., a GMC flatbed truck was eastbound on Route 3. The posted speed limit was 55 mph. As the truck crested a hill, a flagger was waving an eastbound 1989 Mazda to stop. As the Mazda was slowing to a stop, the GMC truck, which was braking, swerved to the left, began to overturn, and struck the Mazda in the rear. The Mazda was pushed forward and to the right 62 feet into a cable guardrail on the shoulder. The restrained truckdriver and the restrained front occupants of the Mazda were not injured; the unrestrained occupant in the rear seat of the Mazda suffered moderate injuries.

After cresting the hill, the truckdriver had a view of the flagger for about 450 feet. With a posted speed limit of 55 mph on a descending grade, the distance was insufficient to enable the driver to react, reduce speed, and stop short of the traffic ahead. Given the topography of the area, the flagger should have been located at the crest of the hill or an additional flagger should have been placed at that location.

The above two accidents illustrate that further guidance is needed on the placement of flaggers at work zone sites. Because these accidents suggest that factors in addition to the legal speed limit approaching the work zone should be considered in establishing recommended distances for posting flaggers at work zones, Safety Recommendation H-91-30 is being placed in a "Closed--Unacceptable Action/Superseded" status. A new recommendation is being issued to the FHWA to revise the MUTCD to provide more detailed information on such factors as posted speed limits, actual vehicle speeds, commercial vehicle deceleration rates, road conditions, and topography in determining the placement of flaggers at work zone sites. Because of current technology, the need for the flagger to warn workers vocally of impending danger is no longer a factor that has to be considered in determining the location of flaggers.

Human Performance Factors

A highway work zone presents a unique challenge to an inattentive or otherwise impaired driver. The Safety Board concluded in its report of the Sutton, West Virginia, work zone related accident discussed previously, that fatigue-induced inattention, exacerbated by an inadequate and unbalanced diet the day of the accident, caused the truckdriver to fail to heed warning signs and to slow the truck in time to avoid the collision.

The Safety Board further stated in its report of that accident:

The traffic control devices in the work zone at the accident site were in substantial compliance with the MUTCD and West Virginia guidelines. The Safety Board believes that these guidelines, concerning signing and other work zone safety features, provide more than adequate advance warning for a vigilant driver, but may be inadequate for an inattentive or otherwise impaired driver.

As a result of its investigation of the Sutton accident, the Safety Board issued the following safety recommendations to the Federal Highway Administration:

H-91-27

Conduct research to determine: (a) what characteristics of work zone traffic advisories work best to counter driver inattention, and (b) how to provide more readily understandable displays of critical information. Use the results of this research to design better and more meaningful work zone traffic advisories.

H-91-29

Encourage the use of the "design driver" concept, which assumes that some drivers are impaired or inattentive, in designing work zone safety features and signing.

Several accidents investigated by the Safety Board as part of this safety study support the subject of the above recommendations. Examples follow.

About 4:30 p.m. on November 3, 1989, a 1988 Lincoln sedan with two occupants was stopped in the open left lane of two westbound lanes as a result of traffic congestion in a work zone on I-90, near Blooming Grove, Wisconsin. A 1986 Mercury Lynx 4-door sedan with three occupants was stopped behind the Lincoln. A 1979 Freightliner tractor, pulling a trailer loaded with 25,557 pounds of paper cups, approached the stopped vehicles from behind, jackknifed, and then struck the Mercury. As a result of the impact, the Mercury rotated 180° and then struck the Lincoln. The truckdriver and the occupants of the Lincoln were not injured. The occupants of the Mercury received serious injuries.

The construction zone was 3 miles long and involved the resurfacing of the westbound lanes. The construction zone was set up in July 1989, and work was expected to continue through November 1989. Signs indicating construction ahead began at milepost 145.5. (The accident occurred 2.6 miles after the first sign at milepost 142.9.) At milepost 144.5, a message board indicated that the right lane ahead was closed. Three additional sets of signs followed (one sign of each set on each side of the roadway) indicating the distance to the lane closure. The taper for the lane closure began at milepost 143.25, and two flashing arrow panels were located at milepost 143.0.

The driver of the combination vehicle was cited by the Wisconsin State Patrol for (1) inattentive driving, (2) false entries in his daily log book, and (3) operating in excess of the hours of service regulations. The driver had been keeping two daily log books and had been on duty for 71 hours in the 8 days before this accident. A postaccident inspection of the combination vehicle by the Wisconsin State Police Motor Carrier Safety Officer found no equipment violations.

About 4 a.m. on August 14, 1989, a loaded tractor semitrailer was eastbound on I-84 near Sterling, Pennsylvania. The truck was traveling in a 4.7-mile-long construction zone in which the right lane was closed and traffic was channeled to the left lane. At two bridge locations, concrete barriers were used to further reduce the left lane. The barrier extended 5.5 feet into the left lane, reducing the left lane to a width of about 7 feet. Pre-construction pavement markings had not been obliterated. To pass through the work area on the bridge safely, drivers of combination vehicles had to move left and pass through the work area with the left wheels of their vehicles traveling on the 4-foot-wide shoulder between the left edgeline and the bridge parapet wall. As the truck was approaching the second bridge location (about 2.5 miles into the zone), the truck struck the tapered section of the concrete barrier near the centerline, veered left, struck the guardrail, and mounted the bridgerail. After traveling on top of the bridgerail for 96 feet, the truck crossed over the rail and dropped 63 feet to the creek embankment below, landing on its roof. The driver was killed.

A truckdriver following the accident truck stated that the truck had been swerving on the roadway for about a mile and traveling between 40 and 50 mph. A truck in front of the accident vehicle observed the swerving and tried to radio on the citizen band to wake up the driver. The posted speed limit in the zone was 55 mph. However, there were advisory speed plates that reduced the advisory speed to 35 mph in 5-mph increments.

During the afternoon following the accident, the Pennsylvania Department of Transportation began making improvements at both bridges in the work zone to provide motorists increased visibility of the lane closure and better guidance through the narrow, shifted left lane. A flashing arrow panel and a line of vertical panels with yellow lights was placed in the right lane ahead of the tapered concrete barrier. The existing yellow edgeline was obliterated and a wider lane was established by installing a temporary, taped yellow edgeline at the outer edge of the 4-foot-wide left shoulder. Raised pavement reflectors were installed to highlight the entrance of the widened left bridge lanes. Similar reflectors were installed on the inner walls of the barriers and bridge parapets to guide motorists through the bridge. In addition, regulatory 35-mph speed limit signs were erected. Had these additional work zone safety devices been in place before August 14, 1989, they might have effected changes in the performance of the fatigued driver and the accident might have been averted.

About 4:40 a.m., on June 26, 1989, a 1989 Freightliner tractor pulling a semitrailer loaded with 44,100 pounds was traveling westbound through a work zone on I-70 in Bond County, Central Township, Illinois. Interstate 70 had two lanes in each direction; however, only one lane in each direction was open at the time of the accident because of an ongoing resurfacing operation. About 5.4 miles into the work zone and about 4.2 miles after the roadway had narrowed to one lane (left lane), the truck crossed into the closed right lane and struck three type I barricades that were located on the lane line at intervals of 200 feet. The truck crossed the closed right lane and entered the milled north shoulder, going over a pavement edge dropoff, which

measured between 6.4 and 8 inches. The truck traveled about 232 feet along the shoulder and struck an unoccupied pavement profiler that was parked on the milled north shoulder. The truck ignited, and the truck and profiler burned in the resulting fire. The driver and codriver were killed.

Based on information contained in the driver's log book recovered from the wreckage, an Illinois State Police Motor Carrier Safety Officer determined that the driver had violated the 10-hour driving rule. The driver was in excess of the 10-hour limit by 3 hours 40 minutes at the time of the accident.

Although in most cases, the signs and layout of the work zone met the recommended practices described in the MUTCD, the use of additional work zone safety devices and procedures that alert the various senses may have effected changes in the performance of the above fatigued drivers.

Considerable research has been done on older drivers and the need to compensate for deteriorating faculties that result from the aging process. The results of this research on the aging driver population should have application to drivers in general and specifically for drivers in work zones that are fatigued, inattentive, and under the influence of alcohol or drugs. The following work zone accident illustrates this issue.

About 2 p.m. on April 26, 1989, a 1985 Dodge sedan, occupied by a 77-year-old driver and two passengers, ages 70 and 74, were southbound in a construction zone on the New York State Thruway in South Nyack, New York. In this area of the construction zone, the left lane was closed and the two other lanes were open. The Dodge was traveling in the left open lane (center lane) in the area of milepost 16.8 when it veered to the left, went between traffic cones delineating the left side of the second lane, crossed the closed third lane, and crashed into the rear of a dump truck that was stopped on the left shoulder. The three occupants of the Dodge were killed, and the truckdriver reportedly received minor injuries.

A faded dashed white line ran diagonally for about 200 feet from the left edge of the center lane, across the left lane and onto the shoulder, intersecting the position where the dump truck was parked. A solid yellow line also ran diagonally for about 200 feet from the edge of the closed left lane, across the shoulder and intersected a dirt area in the work zone near the center barrier. The faded white line and the solid yellow line appeared to be parallel to each other. There were no skid marks prior to impact.

The reason the driver changed lanes so abruptly is unknown. The autopsy indicated that the driver did not have heart failure before the crash. Although it is possible the driver may have been distracted or incapacitated in some other manner before the crash, it is also possible that the varying barrel and traffic cone pattern may have confused the elderly driver and he chose to follow the remnants of old lane markings that led into the truck. Any driver could have been confused by the remnants of old lane markings; however, the older driver may not be able to react as quickly to conflicting traffic cues.

The Safety Board continues to believe that there is a need to alert and educate all drivers about the effects of fatigue and a need to prevent commercial vehicle drivers from exceeding the hours of service regulations and maintaining double log books. The Board's position on these issues is well documented.⁹ Nevertheless, the Safety Board also believes that research should be pursued to explore design changes in the work zone area that will protect the inattentive or slightly impaired driver. The FHWA has concurred with the thrust of the Safety Board's Safety Recommendations H-91-27 and -29, discussed previously, and is currently conducting research in this area.

Having reviewed the wording of Safety Recommendations H-91-27 and -29, the Board believes that there is some overlapping with respect to the intent of these two safety recommendations and that the Board can more succinctly define the full range of drivers that we attempted to address in these recommendations--those drivers with somewhat degraded sensory perceptions, whether the degradation is from inattentiveness or impairment. Therefore, the Safety Board is superseding H-91-27 and -29 with a new recommendation urging the FHWA to conduct research to develop design changes in work zones that will aid drivers with degraded sensory perceptions resulting from aging, inattentiveness, or impairment. As previously recommended, the FHWA should use the results of this research to design better and more meaningful work zone traffic advisories and safety features. Because of the expected increase in the construction and maintenance activities on the Nation's interstate system in the next few years, the increase in highway funding, and the increasing number of older drivers, the Safety Board encourages the FHWA to make the necessary resources available to fulfill the intent of the Board's recommendations as quickly as possible.

Six accidents investigated by the Safety Board in conjunction with this study involved alcohol. In four of the accidents, the blood alcohol content (BAC) level was above .212 percent, and in the fifth it was at .182 percent. The Safety Board recognizes that with drivers' BACs at these high levels, very little, in terms of improved traffic control advisories, can be done to protect against the driver. Rather than attempt to improve designs to protect against drivers at these high impairment levels, the Safety Board continues to believe that every effort should be made to keep these drivers off the roads. It is unrealistic, however, to expect to eliminate alcohol entirely from the driving environment. For the legally drinking driver or the slightly impaired driver whose sensory perceptions are somewhat degraded and whose reaction time slows, the type of design changes discussed above should have a favorable impact.

Compliance With Existing Guidelines

Accidents investigated in conjunction with this safety study revealed several instances in which the traffic control techniques and devices were

⁹ "Fatigue, Alcohol, other Drugs, and Medical Factors in Fatal-to-the-Driver Heavy Truck Crashes" (NTSB/SS-90/01).

clearly not in compliance with existing guidelines. The lack of compliance raises concern about the adequacy of monitoring and reviewing traffic control plans by State department of transportation officials and the adequacy of the FHWA's emphasis on recurring problems. In addition to the lack of compliance with flagging guidelines, as evidenced in the Effingham, Illinois accident on June 15, 1988, two specific problems--pavement edge dropoffs and the obliteration of conflicting pavement markings--highlight this concern.

The MUTCD addresses the issue of conflicting pavement markings. "Conflicting pavement markings shall be obliterated to prevent confusion to vehicle operators....The intended vehicle path should be clearly defined during day, night, and twilight periods under both wet and dry pavement conditions." The Traffic Control Devices Handbook provides similar guidance, stating: "Inappropriate markings should be removed to eliminate any misleading cues to drivers under all conditions of light and weather."

Despite this guidance, the investigation of the South Nyack, New York, accident, in which the 77-year-old driver suddenly veered into the closed left lane and crashed into the rear of a dump truck, revealed that all preconstruction pavement markings had not been obliterated. Although the reason for the driver's sudden maneuver to the left lane is unknown (all occupants of the vehicle were fatally injured), it is possible that the old pavement markings caused the driver to become confused and the driver followed the old pavement markings when he veered to the left.

The investigation of the Sterling, Pennsylvania, accident on August 14, 1989, in which the driver of the combination unit was killed, revealed that old pavement markings had not been obliterated. The preconstruction yellow edgeline was not obliterated and may have confused the already fatigued driver about the exact location of lanes.

The FHWA has addressed this issue in the past. In a memorandum dated January 7, 1988, FHWA headquarters encouraged regional administrators to "Monitor projects to assure that both temporary and permanent pavement markings and signing are properly applied and removed in work zones. Inappropriate traffic control devices are still being left in place. Division offices should review the States' policies, procedures, and projects."

The previously mentioned Roadside Design Guide developed by the AASHTO Task Force for Roadside Safety provides guidance on the need to protect uncompacted shoulders and pavement edge dropoffs. In addition, the FHWA has recognized this problem over the years. In December 1986, the FHWA addressed the issue in a memorandum to regional administrators based on observations during field reviews. This "information was to provide guidelines to States in the development of their own dropoff policy. Any dropoff is considered hazardous, but those greater than 2 inches, left overnight, and immediately adjacent to traffic have a high accident potential." Again in 1987, the FHWA encouraged its regional and division offices to work with States in the development and implementation of policies for pavement edge dropoffs.

Despite this guidance, accidents investigated by the Safety Board in conjunction with this study indicate that the problem continues to exist.

About 10:14 p.m. on September 14, 1989, a 1988 Ford truck tractor in combination with two trailers was northbound on two-lane, two-way U.S. Highway 63 near the northern limits of Portia, Arkansas. The driver stated that as he was approaching oncoming traffic, his right tires went off the pavement. The combination vehicle traveled off the right edge of the asphalt onto a soft shoulder that was under construction. After the combination vehicle traveled about 300 feet along the shoulder, the rear trailer broke loose and rolled onto its right side. The trailer received moderate damage. The driver was not injured.

The contractor had been doing shoulder work on both sides of the travelway on the 1.4-mile project, even though Arkansas highway construction specifications stated that "shoulder material shall not be cut from the edge of the pavement on both sides of any section open to traffic." The shoulder material was a soft clay material, and in some areas of the project, the shoulder was 12 inches below grade. Because of rain on the day of the accident, the shoulders in the accident area were soft and muddy.

About 1 hour after the above accident, a second truck tractor in combination with one semitrailer, also traveling northbound, was being directed around the accident scene. As the combination vehicle was being directed to the left side of the travelway, the truck went off the edge of the asphalt onto the muddy shoulder. As the driver attempted to turn back to the right, the combination unit rolled onto its left side.

On August 3, 1989, construction work was being performed on 2.5 miles of State Highway 28, a two-lane highway, near Distant, Pennsylvania. The construction work involved building up the roadway and adding a passing lane. A "Road Construction 1/2 Mile" sign was the first sign to warn motorists of the construction ahead. In the next 1/2 mile, there were 10 signs posted on the shoulder of the southbound lane: a regulatory sign, 4 warning signs, and five construction signs. The first three construction signs marked the distance to the construction zone. The next sign read "Be Prepared to Stop," and the last sign indicated the start of construction. The speed limit approaching and through the construction zone was 55 mph.

Approaching the construction zone southbound, the southbound lane and northbound lane were 10.25 feet wide and 12 feet wide, respectively. Within the construction zone, the southbound and northbound lane widths were 7.67 feet and 13 feet, respectively. Within the first 20 feet of the construction zone, there was a 5-inch dropoff on the outside edge of the southbound lane. Over a distance of 20 feet, the 5-inch dropoff increased to 6.5 inches onto an 8-inch-wide ledge. There was another dropoff of 6.5 inches at the outside of the ledge for a total dropoff of 13 inches from the pavement surface. No signs were posted to warn of the dropoffs or reduced lane width for the southbound lane, and pavement markings were not added to delineate the reduced southbound lane width.

About 5:15 a.m., on August 3, 1989, a southbound truck, with its lights on, loaded with 2,000 pounds of liquid nitrogen, was approaching the construction zone. Upon entering the construction zone, the southbound truck went off the pavement. The right front tire rode on the 8-inch-wide ledge (a 6.5-inch dropoff) while the right rear tires rode outside of the ledge (a 13-inch dropoff). After travelling a short distance, the truck came back onto the pavement, crossed the southbound and northbound lanes and hit a drainage culvert on the east side of the roadway. The truck then rolled over 360 degrees and came to rest in the ditch. The truckdriver sustained a broken leg.

The above accidents suggests that States are not adequately monitoring work zone projects to determine if contractors are complying with existing guidelines. The problem may well be a financial one, in that adequate funding is not available for the review and monitoring process. However, more emphasis needs to be placed on these problem areas by FHWA division offices and State transportation officials. The FHWA reviews annually each State's work zone traffic safety program and conducts on-site reviews of work zone projects. The States, however, are ultimately responsible for their or their contractors' compliance with existing guidelines. The Safety Board believes that AASHTO, in cooperation with the FHWA, should develop a program to enhance compliance with existing guidelines regarding work zone safety features. The States may need to allocate a percentage of the funding for projects for monitoring and compliance purposes.

Safety Programs

From 1972 to 1982, 20 California Department of Transportation (Caltrans) workers were killed in construction work zones. As a result, in 1982, Caltrans initiated an educational program entitled "Give 'Em a Brake" that provided information on work zone safety through the use of billboard space, public service advertisements on radio and television, presentations to driving classes, bumper stickers, and posters. From 1982 to 1987, five Caltrans employees were killed, and according to Caltrans, California experienced a major reduction in the number of employee fatalities, injuries, and lost work days by 1989.

All but nine States have initiated work zone safety programs similar to the "Give 'Em a Brake" program since 1982 when California implemented its program. The programs initiated by the States vary from limited efforts, such as occasional news releases and public service announcements, to full year-round campaigns that involve the development of videos and educational programs for high schools, incorporation of work zone safety in driver education programs, improved traffic control devices and advisories, and onsite use of police officers for enforcement purposes. The emphasis with most of the States' programs when first implemented was to educate motorists about the dangers in work zones in order to protect the workers. Some State programs now focus on the need for drivers to recognize the dangers work zones create for motorists and have incorporated engineering, enforcement, and educational activities into their programs.

Although various agencies and associations, including the FHWA and AASHTO, have encouraged the development of work zone safety programs, no agency or association has taken the lead to direct a nationwide work zone safety program. The variation and range of work zone safety programs at the State level and the expected increase in construction and maintenance work zone activity in the coming years suggests that a uniform program at the national level, analogous to Operation Lifesaver, the rail/highway grade crossing program, is needed. The FHWA and AASHTO are the appropriate agencies to take the lead in developing a national program that should address engineering, enforcement, and education. To adequately address these three areas of the program, the participation of other organizations should be enlisted, including the National Highway Traffic Safety Administration, the National Safety Council, the American Automobile Association, the American Trucking Associations, Inc., the International Association of Chiefs of Police, the American Road and Transportation Builders Association, the Associated Builders and Contractors, Inc., the American Traffic Safety Services Association, the American Association of Motor Vehicle Administrators, the International Bridge, Tunnel, and Turnpike Association, the National Association of Governor's Highway Safety Representatives, the Highway Users Federation for Safety and Mobility, and the Professional Truck Driver Institute of America. Funding for enforcement and education programs could be provided by a percentage of FHWA's apportionments to States for highway construction.

Therefore, as a result of this safety study, the National Transportation Safety Board recommends that the Federal Highway Administration:

Review, in conjunction with the National Highway Traffic Safety Administration, all State accident report forms, select the data elements that comprehensively document work zone accidents, and encourage the States to incorporate these data elements into their accident report forms. (Class II, Priority Action) (H-92-34)

Develop a program to collect exposure data for construction work zones on the interstate system. (Class II, Priority Action) (H-92-35)

Conduct research, in conjunction with industry, to determine the effectiveness of truck mounted attenuators when struck at various angles and offsets and at speeds in excess of 45 mph, and analyze the safety benefits and shortcomings of using truck-mounted attenuators in such high-speed environments. (Class II, Priority Action) (H-92-36)

Eliminate in figure TA-35, "Mobile Operation on Multilane Road," in the proposed revisions to the Manual on Uniform Traffic Control Devices, the depiction of vehicles equipped with truck-mounted attenuators positioned astraddle pavement edgelines. (Class II, Priority Action) (H-92-37)

Encourage, in cooperation with the American Association of State Highway and Transportation Officials, State highway departments to (1) incorporate headrests and lap/shoulder restraints into the specifications for the purchase of new vehicles given that the vehicles may at times be equipped with truck-mounted attenuators and (2) retrofit existing vehicles used for that purpose. (Class II, Priority Action) (H-92-38)

Revise the Manual on Uniform Traffic Control Devices to require positive separation of opposing traffic when two-lane, two-way operations on one roadway of a normally divided highway are implemented on the interstate system and incorporate this information into the Traffic Control Devices Handbook. (Class II, Priority Action) (H-92-39)

Revise the Manual on Uniform Traffic Control Devices to provide guidance on the placement of flaggers at work zone sites based on factors such as posted speed limits, actual vehicle speeds, commercial vehicle deceleration rates, road conditions, and topography. (Class II, Priority Action) (H-92-40)

Conduct research to identify design changes in work zones that will aid drivers with degraded sensory perceptions resulting from aging, inattentiveness, or impairment. Use the results of this research to design better and more meaningful work zone traffic advisories and safety features. (Class II, Priority Action) (H-92-41)

Develop, in cooperation with the American Association of State Highway Transportation Officials, a program to enhance compliance with existing guidelines regarding work zone safety features. (Class II, Priority Action) (H-92-42)

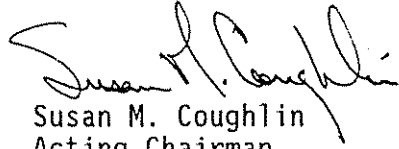
Develop, in cooperation with the American Association of State Highway and Transportation Officials, a national work zone safety program that integrates substantive enforcement and public information and education efforts. Enlist the support of those organizations and associations that can provide expertise in the areas of engineering, enforcement, and education. (Class III, Longer Term Action) (H-92-43)

Refer, in the Manual on Uniform Traffic Control Devices and the Traffic Control Devices Handbook, to the guidance on the applicable uses of truck-mounted attenuators to be incorporated in the Roadside Design Guide. (Class II, Priority Action) (H-92-44)

Determine if a combination of efforts, such as speed reductions coupled with onsite enforcement and positive barriers, may be needed at work zones when commercial vehicles are a relatively large percentage of the average daily traffic. (Class II, Priority Action) (H-92-45)

Also, as a result of this safety study, the Safety Board issued safety recommendations to the National Highway Traffic Safety Administration and the American Association of State Highway and Transportation Officials.

Acting Chairman COUGHLIN, and Members LAUBER, HART, HAMMERSCHMIDT, and KOLSTAD concurred in these recommendations.



By: Susan M. Coughlin
Acting Chairman