Log R-677A
I-108

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: AUG 11 1998

In reply refer to: R-98-43 and I-98-3

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More than 4,000 accidents have occurred at the Nation's grade crossings each year from 1991 through 1996. Many of the accidents at active crossings have involved highway vehicle drivers who did not comply with train-activated warning devices installed at the crossings. This failure to comply often includes driver actions resulting from a deliberate decision, such as driving around a lowered crossing gate arm or ignoring flashing lights. Drivers at passive crossings are not provided warnings from train-activated devices; consequently, they must rely on a system of grade crossing signs and pavement markings, passive devices, that are designed to warn drivers only of the presence of a crossing. No element of this passive system changes, however, to alert drivers to an oncoming train. Further, the effectiveness of the passive system is influenced by characteristics of the physical layout of the crossing, such as an adequate view of the area surrounding the crossing (sight distance) and roadway alignment, that affect the information given to an approaching motorist regarding an upcoming hazard.

According to the Federal Railroad Administration (FRA), there were 4,054 accidents in 1996 that involved highway vehicles at grade crossings; 54 percent (2,208) of those accidents, occurred at passive grade crossings. About 60 percent of the fatalities from all grade crossing accidents in 1996 (247 of 415 fatalities) were at passive grade crossings.

The cost to eliminate or upgrade passive grade crossings is very high. According to the General Accounting Office, the average cost of adding lights and gates in 1995 was $150,000 per grade crossing. The total cost to upgrade the 96,759 passive crossings on public roadways would be about $14 billion. Gates and lights do not completely eliminate the hazards present at crossings, and, therefore, sole reliance on them would reduce but not eliminate all the fatalities. The ultimate solution from a safety standpoint would be a standard grade separation, which usually involves construction of bridges or overpasses and costs an estimated $3 million per crossing. The large number of passive grade crossings, the high percentage of fatalities that occur at passive grade crossings, and the cost to eliminate or upgrade passive grade crossings prompted the Safety Board to conduct a study to identify some of the common causes for accidents at passive grade crossings, and to identify less costly remedies to improve safety at passive crossings not scheduled for closure or upgrade.[1]

For this study, the Safety Board investigated 60 grade crossing accidents that occurred between December 1995 and August 1996. The Safety Board selected for study accidents involving a collision between a train and a highway vehicle occurring at a passive grade crossing, wherein the highway vehicle was sufficiently damaged to require towing. The sample of accidents is not intended to be statistically representative of the entire population of accidents at passive grade crossings during the study period, but rather to illustrate a range of passive grade crossing accidents.

In May 1997, the Safety Board convened a 2-day public forum in Jacksonville, Florida, to gather information about issues affecting safety at passive grade crossings. Witnesses included experts from the railroad industry; law enforcement; research groups; Operation Lifesaver; and Federal, State, and local government agencies. Those involved in grade crossing accidents, both highway vehicle occupants and traincrews, testified about their personal experiences. In addition, representatives from Canada and Italy discussed passive grade crossing issues and experiences in their countries.

Detecting a train at a passive crossing and making the correct decisions about whether a highway vehicle should stop at the crossing or could cross the tracks safely before the train arrives is a complex task that has confronted the Nation's motoring public for decades. The task is affected by the driver's ability to (1) detect the presence of the crossing, (2) detect the presence of a train, and (3) accurately gauge the train's speed and arrival time at the crossing. The task is further complicated by the driver's attention at a crossing, which as shown in the Safety Board's study, can be affected by what that individual expects to see. The Safety Board concludes that a driver's decision to look for a train may be adversely affected by the driver's familiarity with and expectations at a specific passive grade crossing and the driver's experience with passive crossings in general. Also, as shown in the Board's study, the train horn—one of only two active signals given to a driver to alert the driver that a train is present—is effective as a warning only if the driver recognizes it as a train horn. The Safety Board, therefore, further concludes that in some circumstances, audible warning devices on trains fail to meet their objective of alerting motorists to an oncoming train because of highway vehicle design and environmental factors.

Despite the complexity of the task, the approach to passive grade crossing safety has remained relatively unchanged over the years. The current approach includes providing a sight distance triangle for an approaching motorist to see a train and installing a railroad crossing advance warning sign, pavement markings, and a crossbuck sign, where appropriate. The accident sample in the Safety Board's study illustrates that this approach has been inadequate in many instances.

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[1] National Transportation Safety Board. 1998. Safety at passive grade crossings. Volume 1: Analysis. Safety Study NTSB/SS-98/02. Washington, DC.

To eliminate the continuing problems encountered by the motoring public at passive crossings, the Safety Board concludes that a systematic and hierarchic approach to improving passive grade crossing safety is needed, an approach that does not depend primarily on the ability of the driver approaching the crossing to see an oncoming train The hierarchic approach includes grade separation and closure, installation of active warning devices, improved signage, and intelligent transportation systems technology. The approach includes immediate and long-term measures. This letter is limited to a discussion of (1) the need for the railroads to ensure that the U.S. Department of Transportation (DOT) crossing identification number is posted at every crossing and (2) the intelligent transportation systems technology.

DOT Crossing Identifier

Where possible, Safety Board staff compared data in the FRA inventory database (GCIS) on crossings involved in the study accidents with the data collected by investigators at the time of the accident. To search the database, staff needed the DOT crossing identifier, the unique ID number assigned to each crossing. According to the FRA, "[e]very crossing in the United States, including public, private and pedestrian, both at grade and grade separated shall have a crossing inventory number assigned and recorded in the National File." Further, the FRA recommends that this unique number "be displayed on both sides of the track at each and every crossing;"[2] that is, every crossing should be posted with its number. About one-third (19) of the study accident crossings in the Board's sample did not have the number posted, and 2 had incorrect numbers posted (cases 12 and 61).[3] In one case (case 61), for example, the railroad company owning the crossing had recycled signposts from another crossing and left the old ID numbers intact on the posts.

The DOT crossing ID number was created and set in place so that the various local authorities, State and Federal agencies, and the railroads would all have a common method by which to refer to a particular crossing. The DOT crossing ID number enables a county highway engineer, for example, to more easily communicate with a railroad about a crossing at which there will be work crews. More importantly, if used correctly, this number enables local police to notify railroads of trouble at a specific crossing, or the railroad to identify to local emergency response personnel exactly where a grade crossing accident has occurred. Any of this communication, some of it directly related to safety, would have been impossible at one-third of the crossings in the study sample. The Safety Board is concerned, given the number of crossings with a missing or incorrect ID number in the study sample, that ID numbers may be missing or incorrect at many other crossings throughout the system. The Board therefore believes that the FRA, the Association of American Railroads (AAR), and the American Short Line and Regional Railroad

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[2] Federal Railroad Administration, Office of Safety. 1996. *Highway-rail crossing inventory instructions and procedures manual.* Washington, DC. (p. 2-5).

[3] In 17 of these 21 cases, the Board found the appropriate number by looking at track charts or private crossing agreements, or someone at the railroad was able to provide it. At 4 of these 21 crossings (cases 32, 37, 57, and 58), the Board performed searches in the database using more general information, such as railroad name, State, and County names; this general search succeeded in identifying only 1 of the 4 crossings (case 32).

Association should encourage the railroads to ensure that the DOT identification number is properly posted at all grade crossings

Improved Signage

The Safety Board's study suggests the need for a system-wide approach that provides for uniformity of signage at passive crossings and instructs the driver what action is needed while providing the driver adequate time to react accordingly

Despite concerns about the use of stop signs at passive crossings, the Safety Board believes that the benefits of stop signs at passive crossings outweigh the concerns Foremost, in the Safety Board's opinion, is the need for a system-wide approach that provides consistent information and instruction to the driver. Installation of stop signs at passive crossings accomplishes this objective. Specifically, (1) the action required by a stop sign is well understood by drivers, (2) a driver stopped at a crossing has more time in which to detect an approaching train, and (3) sight distance along the tracks when viewed from a stop line is generally adequate, according to study accident data In the Board's 60 cases, sight obstructions existed for a driver stopped at the crossing in only 10 cases; in comparison, there were 33 cases in which the visibility was limited on the approach to the crossing By placing a stop sign at a passive crossing, a clear, unambiguous message is sent to the driver so that the driver knows both where the crossing is and what action must be taken. Further, the presence of a stop ahead sign, required by the Federal Highway Administration's (FHWA) *Manual on Uniform Traffic Control Devices* (MUTCD) before a stop sign at a grade crossing, warns the driver in advance of what action is needed. Requiring the driver to stop at passive crossings can eliminate some of the problems created by limited sight distance or other physical characteristics such as skewed angle of intersection along the roadway approach

The decision to install a stop sign, according to the 1993 guidance document developed by the FHWA and the FRA, is based on a determination of risk and is reasonable from a systems planning approach The Board's study data, however, suggest that, given the level of risk present at all passive grade crossings, wider use of stop signs would increase safety Rather than using engineering studies to determine that a stop sign is needed at a crossing, the Board believes that a more reasonable approach is for the States to use traffic engineering studies to determine why a stop sign **should not** be placed at a crossing Thus, the Board questions the need to limit the use of stop signs based on the 1993 guidance provided by the FHWA and the FRA The Safety Board concludes that installation and enforcement of stop signs at passive grade crossings would provide consistent information, instruction, and regulation to the motoring public and would improve the safety of the Nation's passive grade crossings. The Board recognizes that the FHWA and the FRA believe that the use of stop signs at certain crossings may increase the risk to the traveling public; for example, crossings where there is a steep ascending grade on the approach to or through the crossing However, the Safety Board is recommending that the States install, within 2 years of receiving Federal funding, stop signs at all passive grade crossings unless a traffic engineering analysis determines that installation of a stop sign would reduce the level of safety at a crossing Crossings where conditions are such that the installation of stop signs would reduce the level of safety should be upgraded with active warning devices or should be eliminated.

Intelligent Transportation Systems

The FHWA's MUTCD indicates that stop signs should be an interim measure until active warning devices can be installed. The Safety Board concurs that stop signs are an interim measure and believes that a long-term solution to eliminating passive crossings and reducing collisions between highway and rail vehicles will be through the use of intelligent transportation systems (ITS) that will be able to alert the motorist to the presence of a train.[4]

Subcomponents of ITS that are applicable to grade crossings include in-vehicle safety advisory and warning systems (IVSAWS) that use modern telecommunications technology to broadcast a warning to specially equipped highway vehicles.[5] The IVSAWS consist of a device to detect the presence of a train (this may be a transmitter on the locomotive, or a detection circuit at trackside), that sends a signal to a transceiver at the grade crossing, which, in turn, sends a signal to the receiver on the highway vehicle.

The IVSAWS are not intended to serve only as a warning about trains. The ultimate objective of this part of the ITS program and the organizations developing the technology is to design a system to warn drivers about numerous dangers on the roadway. When fully implemented, the IVSAWS could warn drivers about such things as the approach of police or emergency vehicles, the presence of a stopped school bus, and the approach of a train at a crossing. Given this multiple functionality, it will be necessary to enable the driver to determine easily which hazard to look for. Guidelines and specifications for appropriate visual displays and audible messages are currently being developed.

The automobile manufacturers, recognizing that they will play an integral role in the implementation of systems like IVSAWS, are active to different degrees in the development of the equipment and the standards. For example, several manufacturers are members of the Intelligent Transportation Society of America (ITS America), the umbrella organization established by Congress in 1991 to coordinate development and deployment efforts in ITS. Participation in ITS America permits the automobile manufacturers to keep informed of developments related to roadway and trackside equipment and to participate in the standards development committees. The Safety Board is encouraged by the efforts made by the automobile manufacturers to keep themselves aware of ITS developments and urges their active participation in all aspects of the development process.

ITS applications cost far less than installing lights and gates and will also convert passive crossings into active crossings. For the train detection and transmitting equipment for IVSAWS at each crossing, most cost estimates are below $5,000 per crossing, and all cost estimates are

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[4] ITS is a cooperative effort between government and private entities to integrate modern computer and communications technology into the transportation infrastructure. Its purpose is to test and to develop technology, and to establish standards for enabling uniform application of that technology throughout the Nation. (Information on the role of the Federal Government in ITS was obtained on February 4, 1998, from the Web site of the DOT's ITS Joint Programs Office: http://www.its.dot.gov/qa.web2.htm.)

[5] Some of these systems are also referred to as "vehicle proximity alerting systems" (VPAS).

below $10,000 per crossing[6] As noted earlier, it costs about $150,000 per crossing for standard warning devices. Depending on the cost of the ITS infrastructure, it is likely that the cost of ITS technology will be less than that for standard active warning devices. The Safety Board supports efforts to encourage development of ITS applications.

Unlike the gates and lights, however, the IVSAWS require, as a rule, a direct cost to the driver of each highway vehicle, who must either purchase and install an aftermarket device or pay extra for the system installed in a new car. Because the system will work best when every vehicle on the road carries the receiver, the practicality of these devices will depend on their near-universal availability in highway vehicles. Currently, estimated prices for the receivers range from about $50 up to $250.[7] The Safety Board recognizes that once the in-car technology is available, it will take 15 to 20 years before all vehicles on the road are equipped with the technology.

The Safety Board believes that interim ITS solutions may also be possible, such as signs or signals that can alert a motorist to the presence of a train without depending on expensive track circuitry. Less complex ITS applications have been proposed by the FHWA for use at grade crossings, including variable message signs and roadside beacons activated by wireless communications signals emitted by train detection equipment.[8] One proposed solution being tested by the Burlington Northern Santa Fe and the Union Pacific railroads is to utilize Global Positioning System tracking and computer projections to accurately determine a train's actual speed and position, and radio frequency satellite communications to activate whatever variable message signs or roadside beacons are installed at crossings in time to give motorists sufficient warning of the train. The grade crossing component of this project is being tested by the Texas Transportation Institute on the Pacific Northwest high speed rail corridor.[9] Equipment that communicates with the crossing warning devices has been successful in laboratory tests and will be field-tested in the summer of 1998, according to personnel at the Institute. Cost estimates for the grade crossing equipment are not yet available

Other systems are being tested as a part of the Transportation Research Board's Innovations Deserving Exploratory Analysis (IDEA) program. For example, two proposed systems use different radar technologies to detect the presence and the speed of an approaching train, and then activate the warning devices. In the case of one of the radar systems just mentioned, the final contract is being completed, and therefore testing has not commenced. In the

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[6] The cost for the ITS infrastructure (global control and communications technology to be used everywhere) is not included in these estimates.

[7] One proposed system piggybacks its warning device onto the vehicle radio, and any extra cost is hidden from the consumer.

[8] Federal Highway Administration. 1997. Highway rail intersections. Standards Requirements Package 12. (Prepared by the Architectural Development Team, Lockheed Martin Federal Systems, Rockwell International.)

[9] Roop, Stephen. 1997. Specific applications of ITS to grade crossings. In: Intelligent transportation systems and their implications for railroads: Proceedings, Joint FRA-ITS America Technical Symposium; 1997 June 4-5; Washington, DC. DOT/FRA/ORD-97/11; DOT-VNTSC-FRA-97-8. Washington, DC: U.S. Department of Transportation, Federal Railroad Administration. Washington, DC: VI-1 to VI-7 (page VI-1).

case of the other radar system, field testing will be conducted during the summer of 1998, and a viable product is expected by September.[10]

The Safety Board concludes that IVSAWS and other ITS applications proposed have the potential to reduce accidents and injuries at passive grade crossings by alerting drivers to an oncoming train. They appear to be less costly and more effective than installation of active warning devices for passive grade crossings. Initial testing of five IVSAWS was completed by the FRA in 1995, and two of the systems tested were determined to merit further testing, which was scheduled to begin early in 1998.[11] At the time the Board prepared its report of the current safety study, however, the testing had not yet been scheduled. Two States are currently funding tests of two different IVSAWS at railroad grade crossings independent of the DOT. In addition, several other IVSAWS have been developed, including systems in Italy and in portions of the United States, that warn drivers about several different highway hazards, such as hidden driveways and construction zones; the Italian system is already in use in more than 50,000 highway vehicles.[12] Given that several systems have proven effective and the potential of ITS to reduce accidents at passive crossings, the Safety Board believes that efforts to test and implement these systems should be a high priority. Therefore, the Safety Board is recommending that the DOT (1) develop and implement a field test program for IVSAWS, variable message signs, and other active devices, and then (2) ensure that the private entities who are developing advanced technology applications modify those applications as appropriate for use at passive grade crossings. Following the modifications, the DOT should take action to implement use of the advanced technology applications. Because of the multimodal nature of this technology, the Safety Board believes that it would be prudent for the modal administrations—including the National Highway Traffic Safety Administration, the FHWA, and the FRA—and the modal associations—including the American Association of State Highway and Transportation Officials, the Association of American Railroads, the American Short Line and Regional Railroad Association, and the American Public Transit Association—to participate and cooperate fully with the ITS development.

Some ITS applications utilize technologies already in existence. For example, a representative of an automobile manufacturer has informed Safety Board staff that vehicles with a remote control door lock/unlock feature are already equipped with short-range receivers, a technology that could be adapted to suit the purposes of IVSAWS. The current generation of proposed IVSAWS includes systems that make use of radios currently on the market, and one that uses well-established radar detector technology. This means that the process of adapting and testing current technologies is faster than a process in which fundamentally new technology must be developed. However, each of the proposed systems uses a different radio frequency and utilizes different message codes to indicate the presence and type of hazard; if all are viable, there is a potential for implementation of different systems in different regions of the country. Should this become true, motorists could not rely on the warning from the system in their vehicle when traveling from one region to another. There is a need, therefore, for the establishment of national

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[10] Telephone conversation with staff of the Transportation Research Board, ITS-IDEA Program, May 8, 1998.

[11] Telephone conversation with the FRA project manager, January 27, 1998.

[12] Briefing for Safety Board staff on May 20, 1997, by representatives of the Italian manufacturer, Electronic Security Systems Equipment Generation International Corporation.

standards for radio frequencies to be used, auditory alerts, and specific message codes to be sent. The DOT, rather than imposing standards, is, in conjunction with ITS America, supporting, guiding, and funding the efforts of five standards development organizations in determining the standards for all ITS applications. According to information provided by the DOT, however, these standards are not yet in place for ITS at grade crossings, nor has any timetable been established for publishing these standards.[13] In fact, it has not yet been determined which standards need to be developed,[14] and until they are developed, there is no guarantee that any ITS system would be uniformly applied across the Nation. The Safety Board concludes that in order to achieve the greatest safety at passive grade crossings as quickly as possible, standards for ITS applications must be established in a timely manner. The Safety Board is recommending that the DOT establish a timetable for the completion of standards development for ITS applications at highway–rail grade crossings and act expeditiously to complete the standards.

Therefore, the National Transportation Safety Board recommends that the American Short Line and Regional Railroad Association:

> Encourage your member railroads to ensure that the U.S. Department of Transportation identification number is properly posted at all grade crossings. (R-98-43)
>
> Participate and cooperate fully with the development of intelligent transportation systems that will be able to alert drivers to an oncoming train at passive grade crossings. (I-98-3)

Also as a result of this study, the Safety Board issued recommendations to the U.S. Department of Transportation, the Federal Railroad Administration, the National Highway Traffic Safety Administration, the Federal Highway Administration, the States, Operation Lifesaver, Inc., the American Association of Motor Vehicle Administrators, the American Automobile Association, the Professional Truck Drivers Institute of America, the Advertising Council, Inc., the American Association of State Highway and Transportation Officials, the Association of American Railroads, and the American Public Transit Association.

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[13] Telephone conversation with the standards program manager at DOT's ITS Joint Program Office, June 8, 1998.

[14] Telephone conversation with the director of systems integration, ITS America, May 18, 1998.

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility ". . . to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any actions taken as a result of its safety recommendations and would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations R-98-43 and I-98-3 in your reply.

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

By: Jim Hall
Chairman