Innovative Passive Device Studies and Demonstrations Currently Being Conducted in the United States and Canada

EUGENE R. RUSSELL

In the late 1960s a flurry of new warning devices were proposed to improve conspicuity, or driver awareness, or understanding, or all three at railroad-highway crossings. A period of little or no activity in regard to these devices followed, probably because the emphasis in the 1970s and 1980s was on upgrading grade crossings to active warning devices on a priority basis. Most high-volume grade crossings have now been upgraded; however, thousands of passive grade crossings on low-volume roads exist where expensive active devices cannot be justified on a cost-effective basis. Thus, low-cost, innovative devices that are more effective have drawn renewed interest that will likely continue throughout the 1990s. Most of the devices presented are too new to be reported in the published literature. Most are in the early development stage and some have yet to be proven or studied adequately. However, the argument is presented that if a successful effort is to be made in the area of low-cost, innovative devices for low-volume grade crossings, a coordination of effort is needed, starting with an awareness of these as-yet fragmented studies. Brief backgrounds of innovative devices and discussion of recent efforts include the Conrail device (Ohio and Kansas); new retroreflective materials (Arizona, Minnesota, Vermont, and Nebraska); retroreflective trackside objects (Arizona); a proposed 3M/BN passive warning sign; a proposed adaptation of the variable aspect signs to be used at grade crossings; a Texas study to enhance the effectiveness of the current, standard crossbuck; a human factors study being conducted at the FHWA Turner Fairbank research facility; a Canadian study of new sign systems at passive crossings using intermediate signs; and a before and after study of the effects of an Operation Lifesaver media blitz on driver behavior at crossings.

In the 1960s considerable activity focused on finding innovative devices for passive railroad-highway grade crossings or the approaches thereto. Some devices were intended to increase conspicuity but most were intended to give the driver more information (e.g., differentiating between active and passive crossings, indicating the angle of the crossing, or providing a more meaningful symbol to aid driver understanding). Then a lapse of several years in these efforts followed. This was probably because of the emphasis on upgrading hazardous crossings on a priority basis through a massive, federally funded program that provided categorical grant money for this purpose.

Now that this highly successful federal program has resulted in upgrading the high-priority grade crossings, attention is once again being focused on improving low-volume crossings where low highway or train traffic does not justify the cost of active warning devices. Thus, the emphasis is once again on finding effective, low-cost, innovative devices to improve safety at low-volume grade crossings.

Many of these devices are too new to be reported in the literature. Most are in the early development phase, and some have yet to be proven or studied. If a successful effort is to be made in this area, coordination of the overall effort is needed. As a first step to a more coordinated effort, a wider audience of researchers, developers, manufacturers, public officials, and the general public needs to be aware of several isolated studies and demonstrations currently underway in the United States.

GENERAL REVIEW OF INNOVATIVE DEVICES FOR PASSIVE GRADE CROSSINGS

The most recent comprehensive summary of innovative devices for passive grade crossings that have been proposed or studied is contained in a COMSIS Corporation report on driver behavior at rail-highway crossings (*1*). Some of the material in this first section is paraphrased from the COMSIS report with references as cited in the report. This material provides a very brief background as a setting for presenting current studies.

Advanced Warning Sign

Railroad advance warning signs are generally considered to be well-understood indications of a grade crossing ahead (*2–5*). However, considerable evidence exists that beyond good, general recognition, traffic-control devices at grade crossings are not well understood (i.e., drivers often have poor comprehension of their exact meaning and of the proper action required) (*3,6–8*). Ruden, Wasser et al. believed that because the railroad advance warning sign was round, whereas most others are diamond-shaped, it could cause confusion (*9*). His study team developed three new signs, all presenting some version of an "RxR" symbol on a yellow, diamond-shaped field.

As early as 1968, NCHRP Report 50, one of the most comprehensive reviews of the grade-crossing safety factors,

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Department of Civil Engineering, Kansas State University, Seaton Hall, Manhattan, Kans. 66506-2905.

recognized a need for signs that could help drivers more clearly understand the action expected at a particular grade crossing (*10*). The report suggested a variety of advance warning signs, all using diamond-shaped sign fields that met three important criteria:

1. The sign better met drivers' sterotypes regarding warnings,
2. The sign had more meaningful content, and
3. The sign provided improved information content by discriminating between active and passive crossing sites.

This author believes that a need for signs meeting the third criterion still exists. That is, the proper action expected of drivers approaching a grade crossing and the consequences of taking inappropriate action differ at passive and active crossings. A driver approaching a passive crossing has a heavier responsibility than at an active crossing. At a passive crossing the driver must determine if a train is at or near the crossing and whether it presents a danger. In rural areas it is sometimes difficult (and almost impossible at night) to determine, at a safe distance from the grade crossing, whether it is an active crossing because the only difference is an unlit pair of flashers.

Schoppert and Hoyt proposed passive signs that diagrammatically showed the crossing angle (*10*). At a passive grade crossing, the angle of crossing is important. If the grade crossing is skewed, there is one quadrant in which a driver must execute a more definitive (over the shoulder) head movement to see if there is danger. In these cases, with the current, standard sign at night, it is not at all clear where to look. For example, at a sharply skewed grade crossing, a driver could conscientiously look to the right (at a 90° angle) and see no evidence of a train (headlight), whereas one could be approaching from over the driver's right shoulder (at about 135°) and not be seen.

Crossbuck Sign

Drivers generally recognize the standard crossbuck and know that it marks a grade crossing. Because no comparable sign is encountered in normal highway driving, not all drivers fully understand the crossbuck's meaning or what action is required to ensure their safety. In terms of driver action it really means "yield to a train when present," but this message may not get across to the general driving public.

The COMSIS report reviewed a number of studies conducted to improve the crossbuck sign (*3,4,9*). Signs with and without wording, with black letters on white background, blank signs with a red border, and blank yellow signs with a black border were tested (*4*).

Another study compared a blank white version with either a 2-in. red or 2-in. black border (*5*). Subject recognition of the worded crossbuck was 100 percent. In recognition studies of blank versions, the percentage correct (recognition) ranged from 70 to 83 percent. The COMSIS report concluded that, "Despite these problems [some biases were noted in the studies] it appears that the crossbuck itself has meaning to many subjects, even without the wording" (*1*).

Schoppert and Hoyt suggested that the crossbuck be incorporated into a larger sign field and that the field be an inverted triangular field (*10*). The larger field provides better target value, and the inverted triangle is similar to the standard yield sign, which would presumably convey the message to yield.

This author believes that the standard crossbuck shape has sufficient conspicuity and recognition to mark a crossing. Promoting proper action would be better accomplished through increased education (e.g., drivers' education in high school or Operation Lifesaver programs). The crossbuck's effectiveness could also be enhanced through additional information from the advanced warning sign, such as differentiating active and passive grade crossings, indicating the crossing angle, or providing additional information on or near the crossbuck, such as with a standard yield sign or an added message. Additional word messages or a unique sign or symbol on the crossbuck post itself may also be helpful.

The COMSIS report reviewed many studies that mostly relate to increased conspicuity of advance signs, crossing signs, or combinations. The use of red and white within signs to improve conspicuity was suggested by Ruden (*2,4,11*). The use of the unique standard shapes of grade crossings, round advance warning and crossbuck, is sometimes considered an advantage for drawing attention, although at other times it is questioned because it violates driver expectancy about warning sign characteristics. One study found wide differences in driver recall of visually similar signs, and its author argued that the degree of risk or demand presented by the sign message was the major factor (*12*).

This author suggests that an analysis of the literature indicates most innovative devices should either improve understanding or be directed toward specific hazards or demanding situations.

Illumination

Although not necessarily new and innovative, illumination of a grade crossing is a low-cost improvement and could effect significant reductions in night accidents where vehicles run into trains occupying the crossing. Russell and Konz studied grade-crossing illumination extensively and found (pre-1980 data) that the incidence of vehicles striking trains rose from 23 percent of all vehicle-train collisions during the day to 46 percent at night (*12–16*). Accident data from 1986 to 1987 show an increase from 22 percent during the day to 33 percent at night (*1*). The data from both periods reflect a greater percentage of night accidents in which vehicles run into trains, indicating both the drivers' difficulty of seeing trains when approaching unilluminated crossings at night and the difficulty of becoming alerted to the crossing itself and determining whether it is active or passive (i.e., being able to see signals in the inactivated mode). It is this author's experience from extensive night driving on midwestern low-volume roads that recognizing inactive flashers at night is very difficult.

Russell and Konz recommended a minimum of two lights, one on each approach (*12*). They also recommended an average of 2 ft-c of light on the side of the train (*12*). Russell, Konz, and Mather have tried to promote the concept that lighting standards should relate to a minimum amount of light on the side of trains.

Mather has promoted the use of illumination in Oregon and has conducted several demonstrations at Oregon grade crossings. He essentially followed the recommendations for an average of 1 ft-c on the side of the train. Mather has also developed some suggested guidelines for light type, type of luminaire cutoff, height, and location.

DEVICES CURRENTLY BEING USED, PROMOTED, OR DEVELOPED

A range of devices are currently being used, promoted, developed, or demonstrated as low-cost devices at low-volume grade crossings. Most are based on the concept of more effective retroreflective materials that provide greater conspicuity at night and give drivers more awareness of the crossing itself, signs, or devices at the crossing or the presence of a train. Devices that the author has investigated through personal contact are discussed.

Conrail Device

The Consolidated Rail Corporation (Conrail) has formed a joint labor-management group to investigate safety at railway-highway grade crossings. One effort of the group has been development of a modified crossbuck. The Conrail crossbuck consists of a three-panel, retroreflective and reflecting device to be installed on the post below the crossbuck sign (Conrail shield) and used in conjunction with various new crossbuck designs consisting of standardized, 90° blades with standard wording, but of different color combinations. The latest design consists of red letters on a silver background, all of high-intensity retroreflective materials with a 2-in. strip of silver material on the back of each blade.

The Conrail shield has a triangular, three-dimensional configuration. It has alternating stripes of red and silver with 2-in. mirror strips between the red and silver (Figure 1). The retroreflective material is "activated" by automobile headlights on the approach or by the headlight of an approaching locomotive. The mirror strips also reflect light from the train towards the approaching driver. Because of these latter two attributes, its developers refer to it as a self-triggering device (M. Joyce, unpublished data).

The Conrail crossbuck is being tested in Ohio and Kansas (K. Hinshaw and J. M. Molitoris, unpublished data). Conrail's goal is to amend the standard crossbuck nationwide (at passive grade crossings). This will require its acceptance in the *Manual of Uniform Traffic Control Devices* (MUTCD), a process that would start with a successful product evaluation and demonstration project.

Ohio Studies

Areas of concern that will be studied or demonstrated in Ohio include driver response to the Conrail crossbuck and behavior testing, data evaluation, and cost-benefit methodology. The Ohio Department of Transportation (ODOT) is evaluating the Conrail crossbuck, along with other low-cost, innovative devices at passive crossings. They intend to promote a corridor project across northern Ohio. The objectives of the study are as follows:

1. To verify that the existing crossbuck may or may not be operating at its intended level of effectiveness as a passive crossing control device in both daytime and nighttime conditions,
2. To verify that the Conrail crossbuck has the visual impact (e.g., visibility and reflectivity) it is intended to have relative to the existing crossbuck,
3. To analyze and document familiar and unfamiliar driver behavior as it is affected by the existing crossbuck compared to the Conrail crossbuck,

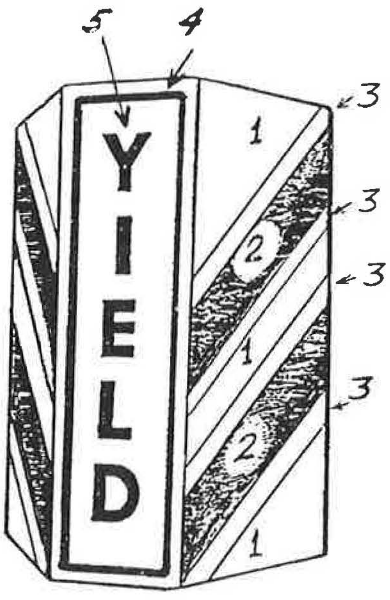

FIGURE 1 Conrail shield.

Dimensions:

Front Panel, 9" x 38"
Side Panels, 12" x 38"
Yield Panel, 8" x 37"
Red Strips, 4 1/4" x 16 1/2"
Mirror Strips, 1 1/2" x 16 1/2"

Key:

1. Silver
2. Red
3. Mirror strips (total 15% of surface)
4. Red border (1/2")
5. Red letters on silver background
   letter height = 6"

4. To evaluate and document familiar and unfamiliar driver behavior relative to both the standard and Conrail crossbuck under both daytime and nighttime conditions,
5. To compare and document visibility of the standard crossbuck versus the Conrail crossbuck under daytime and nighttime conditions with a train approaching and traveling through the crossing,
6. To evaluate and document the process, costs, and benefits of amending the MUTCD and implementing the Conrail crossbuck, and
7. To consider and comment on alternative modifications to the crossbuck or other passive crossing control signs or devices and compare effectiveness, costs, and benefits.

The anticipated benefits of the Ohio study include the following:

1. An improved safety environment at railroad-highway intersections,
2. A nationwide reduction in crashes, injuries, and fatalities at railroad-highway intersections, and
3. A relatively low-cost, high-benefit grade crossing improvement.

Kansas Demonstration Project

The FRA worked with two universities (Kansas State University and the University of Kansas), three major railroads (the Atchison, Topeka, and Santa Fe Railway Company, the Burlington Northern Railroad, and the Union Pacific Railroad), and the Kansas Department of Transportation in developing support, a funding package, and a contract for demonstrations at six grade crossings, two on each of the three railroads.

Six rural grade crossings were selected to demonstrate four specific low-cost warning devices plus two combinations of the four. The six systems were matched up with the six grade crossings. The six systems are listed in Table 1. Figure 2 shows a schematic sketch of the installation of the Conrail device with roadside delineators. The research and evaluation plan described here will be used for each grade crossing system.

The variables to be recorded and analyzed in the field are as follows:

1. Speed of approaching vehicles will be taken at three points on the approach—one in the approach and two near the beginning and end of the nonrecovery zone on each approach. A standard radar gun will be used by a hidden or inconspicuous observer.
2. Deceleration rates will be calculated from the speeds and time to traverse the zone.
3. The point of brake light applications will be observed on each approach.
4. Head movements made by drivers in the approach zone will be observed and recorded during daylight hours.
5. Traffic counts will be recorded by hand during the observation periods.

TABLE 1 Devices To Be Used in the Six Studies, as Proposed

Study No.	Description
1	Modified Canadian Crossbuck (not approved; an additional study No. 3 was substituted)
2	YIELD sign (with YIELD AHEAD)
3	Roadside delineators on approaches and delineators or retroreflecting material on crossbuck post
4	Conrail Shield
5	Combination of studies Nos. 3 & 4 Conrail Shield and roadside delineators on approaches and delineators or retroreflecting materials on crossbuck post
6	Combination of Studies Nos. 2, 3 & 4 Conrail Shield, YIELD sign (with YIELD AHEAD), roadside delineators or retroreflecting material on approach and retroreflecting material on crossbuck post

Three observation periods will be conducted: one before and two after periods. The first after study will be about 2 months after installation of the experimental devices and the second after study will be approximately 6 months later. Each observation period will last approximately 1 week. Data will be collected on 3 weekdays. Each day will be divided into a day (light) period and night (dark) period. The day period will be from 2:30 p.m. to 5:30 p.m. (or when the setting sun causes a problem, if prior to 5:30 p.m.). The night period will be from 9:00 p.m. to midnight. The 2:30–5:30 p.m. period corresponds to rural, peak traffic flow. There is practically no rural traffic after midnight.

After the study has been completed, data will be analyzed for any statistically significant changes. Pictorial history (i.e., slides, video) and subjective analysis of the demonstration will also be included in the analysis.

The final step will be to restore the innovative devices and restore the grade crossing to standard condition in conformance with the MUTCD.

Retroreflective Trackside Objects

The Arizona Corporation Commission expressed interest in alternatives to costly lighting systems at crossings in suburban areas.

The primary concept of the devices used in Arizona was that night visibility can be enhanced by a high-intensity, retroreflective material. In addition, the reflective material provides flicker as a train passes between drivers' headlights and the high-intensity, retroreflective devices on the far side of the track. The Arizona Department of Transportation (ADOT) received FHWA permission to install these devices at 15 grade crossings paid for with regular grade crossing funds (M. Mariscal, unpublished data).

ADOT conducted tests of retroreflective material on all four quadrants of three grade crossings. Poles were 4 in. × 48 in. with round tops and retroreflective panels on each side. Retroreflective tape was put on the crossbucks. Subjective analysis of this test (i.e., field observation and video) indicated the devices would be somewhat effective (M. Mariscal, unpublished data).

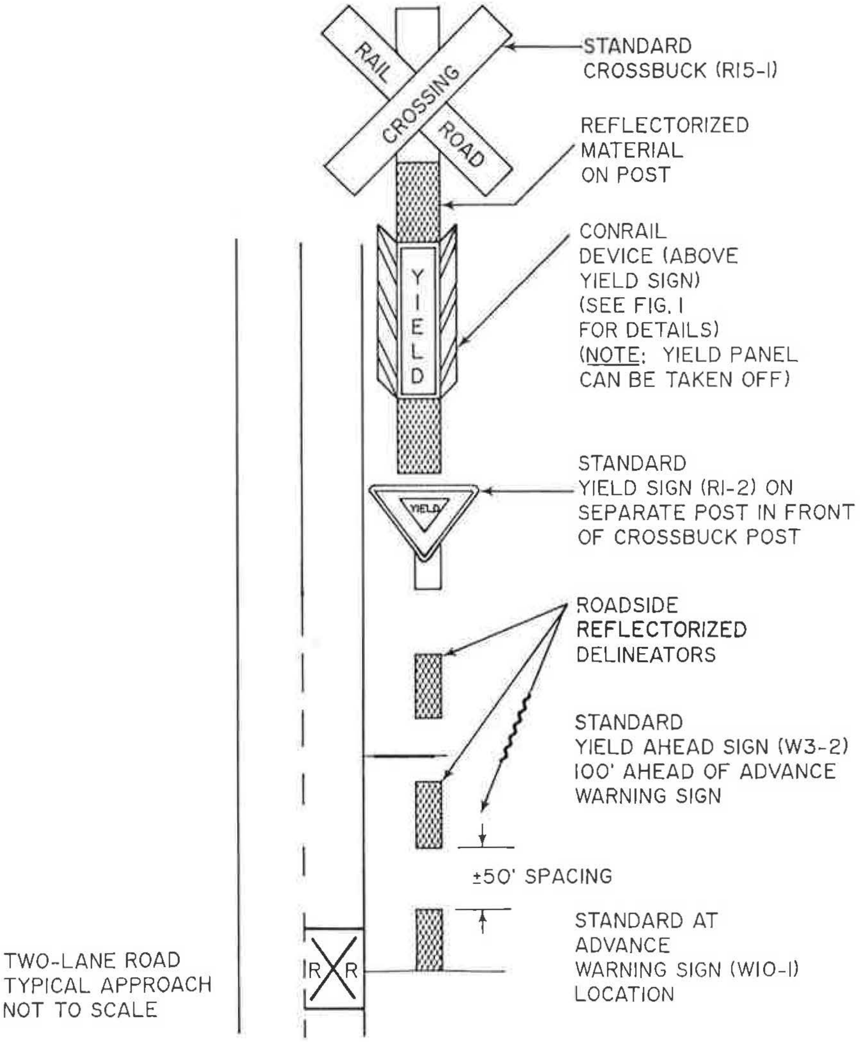

FIGURE 2 Schematic of Conrail shield, delineators on approach, and reflectorized crossbuck post (from Study 5).

A second test was conducted in April 1989 at Fort Rock Road, west of Seligman. Poles were 8 by 48 in. with two 8-in. and 48-in. retroreflectorized panels. Additional 8-by-48-in. panels were installed on the backs of the crossbucks. Subjective analysis by field observation and video indicated this device was very effective (M. Mariscal, unpublished data).

In spring 1991, FHWA approved the use of these retroreflective devices at 16 locations on mainline crossings. The railroads will install the devices at their cost, estimated at $280 per crossing, with FHWA paying 90 percent (M. Mariscal, unpublished data).

During these latest tests, ADOT personnel will spend one day stopping drivers to see what they think of the crossing devices.

Diamond-Grade Retroreflective Material

3M Corporation is promoting the use of diamond-grade, retroreflective material on standard crossbucks and posts. This diamond-grade material is being used in Nebraska at selected grade crossings and will be used at grade crossings in the state of Minnesota (E. Tompkins, unpublished data). Diamond-grade material has about three times the reflective rating of engineering-grade material and about two times the reflective rating of high-intensity, retroreflective material. It should increase the visibility of crossbucks at night. When used on the far side of the tracks, it should enhance the flicker effect when compared to engineering-grade retroreflective material. The state of Texas has recently made a decision to use diamond-grade retroreflective material at grade crossings (H. Richards, unpublished data).

3M/BN Passive Warning Sign

Burlington Northern (BN) Railroad has been involved in a research and development project with 3M to develop what they call a "passive warning sign." The warning sign appears to light up when a train approaches a crossing because the light from the locomotive headlight is captured by the sign and then redirected 90° outward toward the oncoming vehicular traffic (Figure 3). The patented optical system designed by 3M uses no mirrors, but rather thin-film Fresnel lenses to control the light (J. LeVere, unpublished data).

The face plate of the sign that the motoring public sees may contain any message or color. A three-quarter size model with a red "X" front panel was demonstrated at the Kansas DOT Annual Railroad Conference (J. LeVere, unpublished data). The proposed size of the sign would be 60 in. high by 12 in. wide by 12 in. deep. It would be mounted on the crossbuck post.

The passive warning sign would be most effective at night but less effective at dawn and dusk. It would have little or no special effectiveness during the day. However, it could be designed with an effective, nonilluminated, daytime warning message.

Solar-Powered Illumination

Recent advances in technology allow illumination by photovoltaic (solar) panels and batteries, and activation by telescopic switches that can sense the headlight of an approaching train (J. LeVere, unpublished data). The illumination is train-activated; that is, the telescopic switches activate light, 50-watt, quartz-halogen flood lamps, four mounted on wooden poles on each side of the track. The lights remain on for 10 min, operated by battery power, then shut off until activated again by the next train.

The experimental system BN is testing (at a grade crossing on Vermilion Road near Longmont, Colorado, since November 5, 1990) consists of the following main subsystems (J. LeVere, unpublished data):

- Photovoltaic modules and charge controllers,
- Maintenance-free lead acid batteries,
- Eight 50-watt quartz-halogen flood lamps mounted on wooden poles, and
- Telescopic switches and relay control system.

The solar panels charge a 24-volt bank of batteries on each pole. The system will provide about 2 hr of continuous operation. If trains take longer than 10 min to clear the crossing, the time will have to be adjusted.

Other Low-Cost Retroreflective Devices

An FHWA memorandum summarized research that involved the use of existing, low-cost retroreflective devices at a nonsignalized crossing to focus the driver's attention when a train is present (*17*). A number of devices had been installed at rural grade crossings and evaluated at night with a train trav-

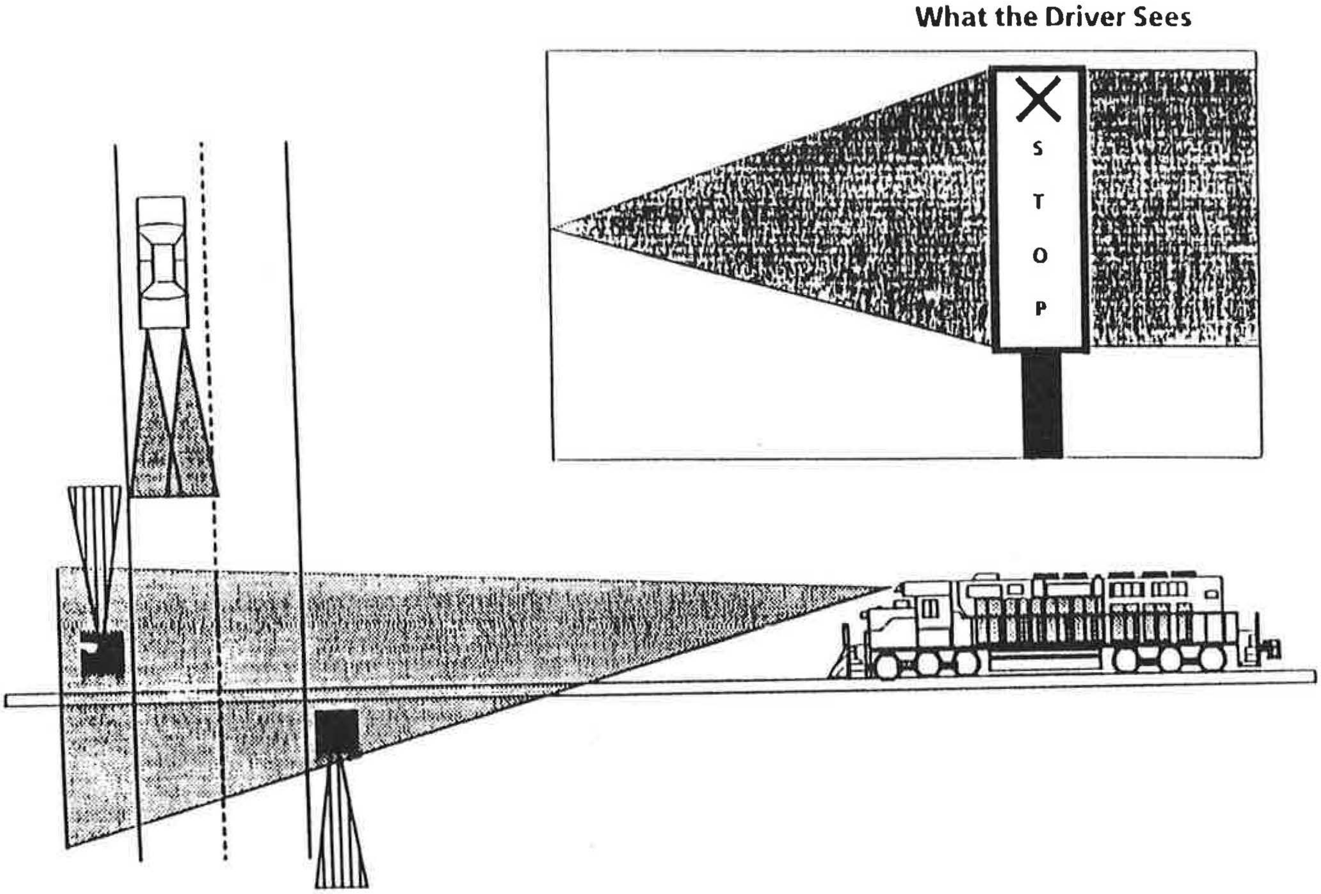

FIGURE 3 Schematic of the BN/3M passive warning sign (Source: BN Systems).

eling through the crossing. A list of these devices is shown in Table 2. Based on a subjective evaluation by the contractor, two of the devices were the most promising: multiple retroreflectorized panels installed in all four quadrants of the grade crossing and retroreflective material installed on the backs of crossbucks (*17*).

The test devices were installed at three Vermont Railroad Company crossings in Vermont on both the near side and far side of the crossings. The near side devices were intended to help draw attention to the crossbuck and the crossing; the far side devices were supposed to create flicker as the rail cars and wheels passed in front of them and thus to accent train movement.

The subjective evaluation of effectiveness was done by noting the following:

- Degree of greater visibility,
- Distance from the crossing at which the devices were visible,
- Durability,
- Vandal-resistance, and
- Installation cost.

Both types of devices tested were visible at 200 to 300 ft in advance of the crossing. Experience with the off-the-shelf, retroreflective panels indicates that they are both durable and relatively inexpensive (*17*).

The FHWA memorandum includes some guidelines on the use of these retroreflective devices:

> When improving the visibility of the railroad crossing, high efficiency retroreflective material should be used on the backs of crossbucks and sign supports and on both side of panels. Panels on two-way roads should use white/silver retroreflective material, while panels on one-way roads should have yellow retroreflective material on the left side and white/silver on the right side. Whenever white is specified as a sign color, it includes silver-colored retroreflective coatings or elements that retroreflect white light. (*17*)

Variable-Aspect Signs

The principle of a variable-aspect sign (VAS) is that, although it is a stationary, passive sign, when used in pairs of panels, they appear to move or alternate between dark and light in opposite phases as an approaching driver's angle of view changes (C. J. T. Young, unpublished data). Possible changes include changes in message, changes in colors, changes in shape (such as an arrow that alternates between two lengths and appears to "jab" in one direction). They can be designed as "enhancers" to increase the effectiveness of existing signs by adding panels that appear to flash as the driver approaches. The design of the VAS that gives the moving or flashing effect is described below:

> The dynamic effect of the VAS is produced by placing a special image surface behind an assembly of parallel, cylindrical lenses. The VAS is constructed in two parts, with a front facing lens system and a backplate which contains the image surface of the sign. An intervening air space separates the lens structure from the image surface. The lens system is made up of clear plastic strips molded and polished to allow high display resolution and quick reversal of two images. The image surface is constructed to allow easy design and substitution of word and symbol messages in any combination of figure-ground colors. VAS can use any colors that can be used in other signs, and they can include retro-reflective surfaces. Its construction is related to an arrangement that has been used for viewing stereoscopic pictures, but it has been further developed and much extended by Outlook Engineering Corporation to be applicable to highway signs. (C. J. T. Young, unpublished data)

One use of VAS that has been suggested is at a rail-highway grade crossing. Possible displays include a pair of "blinking" panels added to the highway advance warning sign and a VAS

TABLE 2 Devices Installed and Evaluated (*17*)

The devices installed and evaluated included the following:

1. Three-inch retroreflector buttons attached to highway delineator posts.
2. Retroreflective material installed on the back of crossbucks and their support posts. The retroreflective material consisted of 4-inch wide, encapsulated lens sheeting tape.
3. A 3-inch by 9-inch aluminum plate covered with an encapsulated lens sheeting attached to a highway delineator post. Multiple 4-inch by 6-inch plates mounted on delineator posts were also evaluated.
4.[a] A multiple retroreflectorized panel installed in all four quadrants of the railroad crossing. The posts were covered with encapsulated lens sheeting on both sides.
5. Combinations of retroreflector buttons and rectangular aluminum retroreflectorized plates.
6. Standard pavement markers.
7. Retroreflector buttons attached to the cross ties.

[a] System number 4 consisted of impactable, curved delineator panels, 3 inches wide x 4 feet high, placed to optimize visibility between boxcars and train wheels. The concave side faced the near side of the approach; the convex side faced the far side of the approach. No fewer than three of these panels were used at a grade crossing.

crossbuck with blades that alternate between black and white (C. J. T. Young, unpublished data).

ADDITIONAL STUDIES IN PROGRESS

Texas

The objective of a Texas study is to enhance the effectiveness of current MUTCD standard crossbuck and advance warning signs (passive devices) at railroad-highway grade crossings (D. Fambro, unpublished data). The improvements to the standard passive warning devices are intended to improve safety and effectiveness while being relatively low-cost (i.e., less expensive than active warning devices) (*18*).

To accomplish the objectives the Texas researchers will

- Conduct a state-of-the-art review of current and past studies and practices,
- Conduct a workshop with Texas grade-crossing experts to select candidate warning devices or improvements to test, and
- Test the candidate warning devices or improvements in both controlled and real-world environments (*18*).

The candidate devices initially identified are as follows:

- Stop and Yield signs,
- Crossbucks with double blades and backblades,
- The Canadian crossbuck,
- The Conrail device,
- The BN/3M device,
- Various reflective devices,
- Illumination, and
- Flashing lights (other than standard, active flashers).

The candidate devices were selected by a panel of experts from the State Department of Highways and Public Transportation (SDHPT), Texas Transportation Institute (TTI), and FRA. Delphi techniques were used to identify the candidate devices as well as to select attributes of controlled, convenient sites and to identify parameters to be studied in a human factors evaluation.

Human factors experts will use focus groups to develop a questionnaire about scenes showing the new devices. This part of the study will narrow the candidate list. Those devices that the focus groups determine to be the most effective will be installed in the field at several locations throughout Texas. It is expected that up to 200 crossings may have the new or improved systems installed.

Two systems will receive priority in the Texas studies: the standard crossbuck with system improvements and the modified Canadian crossbuck (*18*).

Canada

In Canada, a study will look at the effectiveness of having an intermediate warning sign located between the advance warning sign and the crossbuck. The intermediate sign would give a driver additional information about the crossing that should contribute to taking the proper action.

The Canadian Ministry of Transportation is conducting the study of passive grade crossings to examine the following (E. Duran, unpublished data):

- The differences between daytime and nighttime driver behavior,
- The effect at grade crossings of restricted sightlines that result from sight restrictions in any quadrant, and
- The effectiveness of a new signing system for passive grade crossings.

The new passive signing system will include a series of intermediate warning signs between the advance warning sign and the crossing. For example, an approach might have a series of three intermediate signs: Restricted Visibility, Be Prepared to Stop, and Stop Before Crossing (E. Duran, unpublished data).

The sites will be low-volume roads with at least one quadrant with restricted sight distance, good sight distance down the tracks in both directions for a stopped driver, and conditions that minimize the chance of creating a hazard to drivers (E. Duran, unpublished data).

The data collected will be vehicle approach speed, brake light application, and a video recording of driver action. These data will be collected before and after improvements are made.

The results of the study are expected to identify driver behavior at night, demonstrate the importance of clearing sightlines at grade crossings, and determine the behavioral effectiveness of new intermediate advisory or warning signs (E. Duran, unpublished data).

FHWA Turner Fairbank

A human factors-type lab study is being conducted at the FHWA Turner Fairbank research facility. Subjects are being shown slides or photographs of various crossbuck modifications in traditional research tests used by research psychologists. These tests are designed to test the impact that a particular sign has on a subject, particularly the sign's conspicuity or ability to get the subject's attention and the subject's understanding of the sign (B. Alicandri, unpublished data).

Determining the conspicuity and driver's understanding of the modified Canadian crossbuck are two aspects of the study. All signs and modifications being studied are generated by a special computer graphics package from which a slide or a photograph is produced.

Minnesota

The governor of Minnesota recently signed into law an act relating to the transportation needs of the state that included a provision to conduct a study of railroad-highway grade crossing safety improvements in the state. The study will include the following:

1. A method of determining the relative benefits of grade-crossing warning and improvements to the railroad, to the road authority, and to the public, and cost guidelines;
2. Funding sources for grade-crossing warning and improvements;

3. Grade-crossing safety research needs;
4. Recommendations for statutory changes to improve grade-crossing safety;
5. The adequacy of existing and proposed methods of grade-crossing safety, including train visibility, signal and warning device design, a public reporting system for malfunctioning warning devices, improved systems of crossing warnings, and recommendations for additional funds for rail crossing safety education; and
6. Methods for establishing statewide priorities for grade-crossing safety and for implementing these priorities (*19*).

Iowa

A study of the effect of an Operation Lifesaver media blitz is being conducted in Iowa (K. Brewer, unpublished data). Although this is not a study of an innovative device, the importance of education should not be overlooked when looking for low-cost improvements in grade-crossing safety.

The objective of the research is as follows:

> . . . to observe and record driver behavior at a selected sample of railroad highway grade crossings before an Operation Lifesaver campaign, and to estimate the significance of any change in driver behavior that may be attributed to the conduct of the Operation Lifesaver campaign. (*19*)

The study will concentrate on a set of grade crossings that includes a different level of traffic warning devices such as gates, signals and crossbucks, and advance warning signs. The locations chosen represent a mix of land use types and different railroad environments.

During the "pre-blitz" (before) study, driver action at and approaching grade crossings was observed for four 4-hr periods. The following variables were recorded:

- Approach speed,
- Crossing speed,
- Driver attention ("looking behavior"),
- Obedience or disobedience to any traffic warnings, and
- Time elapsed between the automobile crossing the track and the train's arrival (if a train was on the approach during the driver's approach) (*19*).

The Operation Lifesaver media blitz included a grade-crossing investigation course for the police department, more than eight different school presentations, and several business/industry presentations. Posters were hung at business locations and information was put in employee pay envelopes.

Community awareness media activities included a radio station's newsmaker show, public service announcements in the local newspaper, 16 billboard locations, a display at a police chiefs convention, a public education display at the local mall, and a contest at the mall.

After data will be taken at the crossings immediately following the media blitz. It is anticipated that if Operation Lifesaver is an effective public information campaign, one or more of the variables measured will show positive changes from the precampaign results to the postcampaign results. If improvements are recorded in driver behavior, another follow-up field study will be performed 4 to 5 months later to determine if any long-term effects occurred in driver improvements.

CONCLUSIONS

This author offers the following personal conclusions. Two major problems exist today at passive crossings. First is identification of the crossing both in regard to its existence and recognition that it is a passive crossing, particularly at night. Second is full understanding of the crossing's significance (i.e., that full responsibility for safe passage over a passive crossing rests with the driver). To deal with these problems, this author believes that greater conspicuity is needed, particularly at night, but that greater conspicuity itself needs to be associated with something unique that will come to be associated with passive crossings. Greater emphasis is also needed on education of drivers about their responsibilities at passive crossings. Finally, additional information is needed to assist drivers to carry out their responsibilities safely.

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