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Positive-Guidance Demonstration Project at a Railroad-Highway Grade Crossing

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A rural railroad-highway grade crossing used exclusively by local drivers was selected for a positive-guidance demonstration project. Initially, and throughout the project, the crossing was controlled by STOP signs because of sight-distance restrictions. The project first upgraded the motorist-information system at the site by installing improved advance-warning signs and markings that conform to the Manual on Uniform Traffic Control Devices. (The crossing is on a minor county road, not on the state system.) Then, application of the positive-guidance procedure resulted in the addition of rumble strips on both approaches and LOOK FOR TRAIN and HIDDEN XING signs on the more restricted approach. The as-is condition and the two levels of improvement were evaluated by observing the extent to which drivers slowed down at a safe rate, stopped at a safe distance from the track, and looked both ways before crossing. It was found that the positive-guidance procedure was workable, and the project yielded field-tested schemes for evaluation that can be recommended to other agencies that desire to use the positive-guidance system at grade crossings. However, overall, the project did not produce an improvement in driver behavior. In fact, the rumble strips induced some swerving into the oncoming lane and may have been responsible for the observed increase in vehicles crossing at reckless speeds. These findings, while essentially negative, are important because they document the difficulty of influencing drivers who are thoroughly familiar with a road. Rumble strips should be reserved for nonresidential areas where unfamiliar drivers are numerous.

Positive guidance is a set of rational steps developed during the 1970s by the Federal Highway Administration (FHWA) (1,2) to provide drivers with sufficient information where they need it and in a form that they can best use to avoid hazards. It combines highway engineering and human factors technologies to produce an information system matched to facility characteristics and driver attributes. Positive guidance often provides high-payoff, short-range solutions to safety and operational problems at relatively low cost. The procedure consists of six major functions, which are as follows:

1. Data collection at problem locations,
2. Specification of problems,
3. Definition of driver-performance factors,
4. Definition of information requirements,
5. Determination of positive-guidance information, and
6. Evaluation.

SITE CONDITIONS

This paper describes a positive-guidance demonstration project funded by FHWA through a contract with the Georgia Department of Transportation (DOT). A railroad-highway grade crossing in rural Georgia was the site of the project. The crossing is used exclusively by local drivers and was controlled by STOP signs throughout the project. The project first upgraded the motorist-information system at the site by installing improved advance-warning signs and markings that conform to the Manual on Uniform Traffic Control Devices (MUTCD) (3). (The crossing is on a minor county road, not on the state system.) Then, the positive-guidance procedure was applied to determine the type and location of additional improvements and modifications in the overall information system. Rumble strips and certain nonstandard signs were identified and installed. The as-is condition and the two levels of improvement were evaluated for improvement in driver performance. This paper briefly summarizes the final report to the Georgia DOT (4).

Figure 1 is a condition diagram for level 1, the as-is condition. Stanley Road, located northwest of Atlanta in Kennesaw, is a rural 18-ft two-lane road that crosses the L&N Railroad with poor sight distance from both roadway approaches (Figure 2). Before any improvement, the crossing had warning and protective devices that consisted of two STOP signs, one stop-ahead sign, and a wood crossbuck that faced in both directions. Figures 3 and 4 give further indication of the sight-distance restrictions due to fences, trees, and hillocks in the four quadrants of the crossing. These figures also show the stations of the hidden observers who collected performance data during the project.

Stanley Road has an average daily traffic (ADT) of 1100 vehicles/day and is used only by local drivers. The speed limit is 35 mph. The crossing averaged only about 8 trains/day during daylight hours when data were collected. County records over a number of years showed no accidents at this site. Federal records listed a recent accident when a train struck an unoccupied car that had stalled on the track on a rainy night. The Peabody-Dimmick hazard-index formula, which considers traffic volume, train volume, and level of crossing protection, predicts over eight accidents over a five-year period. Train arrivals were entirely unpredictable; drivers had no expectancy as to when a train might arrive. Train speed varied widely from 5 to 30 mph, depending on block signals.

Pilot observations showed that a significant fraction of the motorists ignored the STOP sign and slowed down no more than necessary to negotiate the crossing, i.e., between 20-25 mph. With sight distance limited as it is, they relied entirely on the locomotive engineer's duty to sound the horn for the crossing. Those who stopped did so too close to the tracks. The site typified the classic problem of the inattentive local motorist who lacks respect for the danger of a crossing.

Figure 1. Condition diagram for level 1 (as-is) condition.

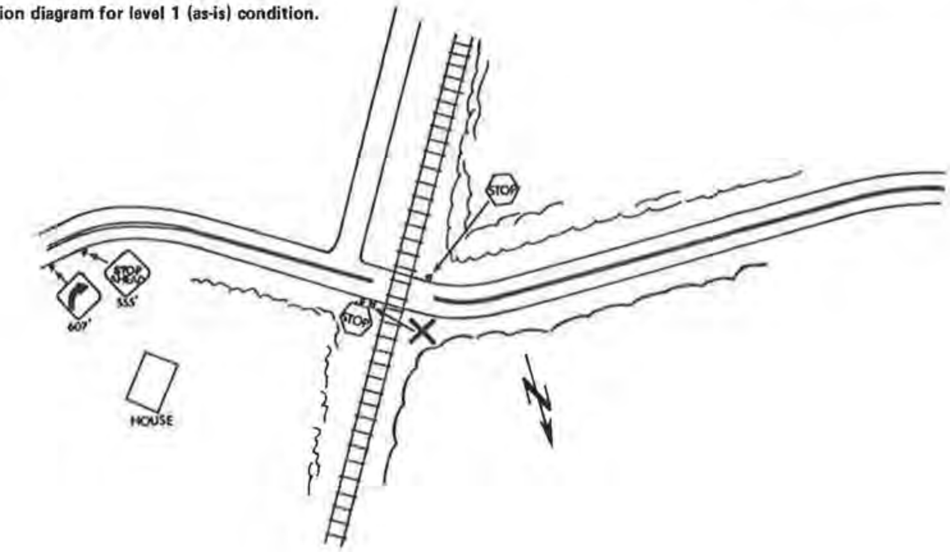


Figure 2. Sight distance graph.

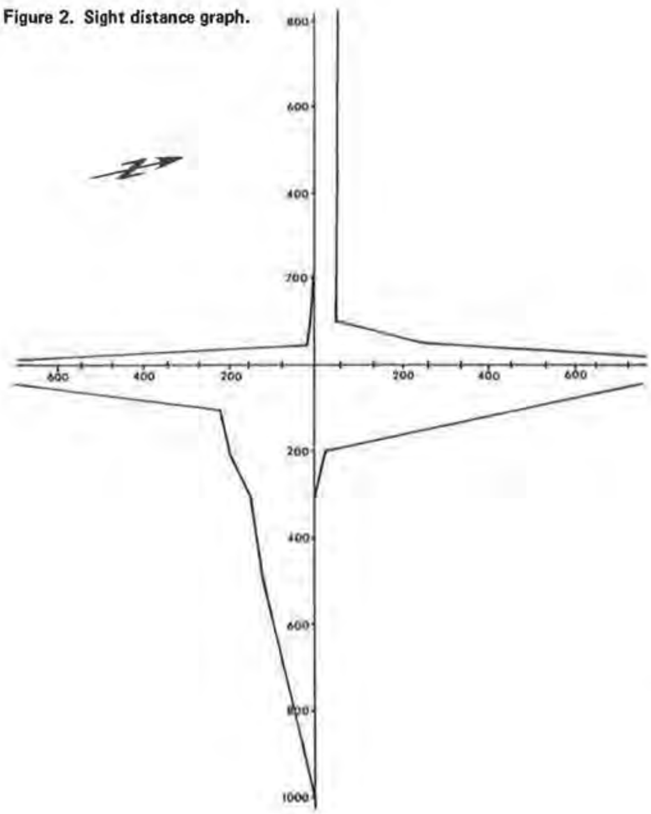


Figure 3. Sketch of west (eastbound) approach.

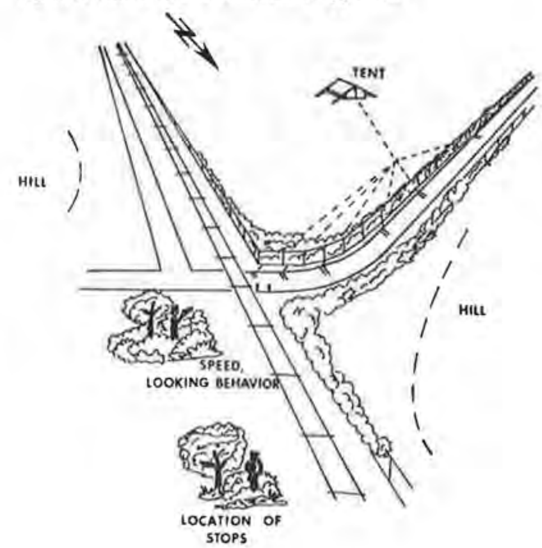
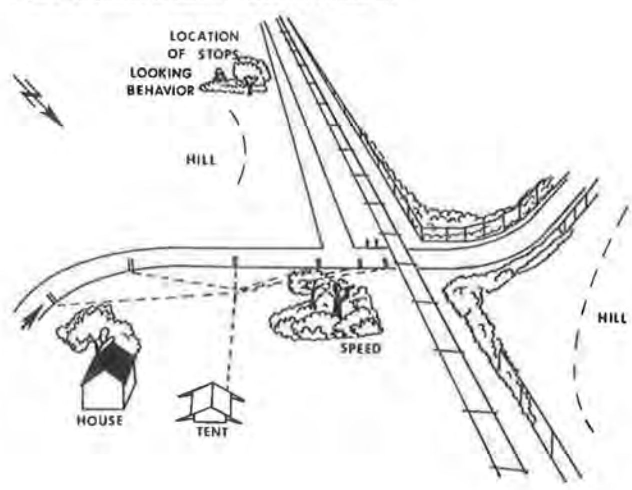


Figure 4. Sketch of east (westbound) approach.



EVALUATION DESIGN

Driver performance was evaluated for level 1 (the as-is condition) by obtaining the following data for each approach for two weekdays, a Saturday, and a Sunday, during daylight hours.

1. Driver looking behavior. Hidden observers with binoculars noted whether drivers turned their heads to the left and/or the right. It was not attempted to judge whether the head motion was for the purpose of seeing a train.

2. Location of stop, for those vehicles that do stop. Three zones (0-10 ft, 10-20 ft, and more than 20 ft) were identified on the assumption that at least 10 ft of clearance from the nearer rail to the front bumper of the vehicle are required for safety. The stop lines that would be added later in level 2 should be placed 15 ft from the track, according to MUTCD, so the zone of 10-20 ft represents normal and safe compliance.

3. Speed profiles. Speed profiles were obtained by using pairs of tapeswitches located 10, 50, 100, 200, 300, and 500 ft from the crossing. Figure 5 (5) illustrates the concept of speed profiles for grade crossings protected by a crossbuck or a STOP sign. The Georgia Institute of Technology used a RATEM II microprocessor, designed by Ken G. Courage of the University of Florida, to record the tapeswitch closures and print out statistical summaries on paper tape in the field. Figures 3 and 4 show the tapeswitches in place on each approach, with wires leading off to a small tent out of sight of the motorists, where the microprocessor and printer were located. Tapeswitches are all but invisible to motorists at speed and are quite silent and unobtrusive. Ignored by motorists during level 1 and 2 evaluations, the tapeswitches became a target for vandals after the positive-guidance solution was installed.

4. Crossing speeds. Crossing speeds of all lead vehicles were obtained by a hidden observer with a radar gun. The minimum speed as the vehicle approaches and crosses the tracks is recorded. The gun may be designed to blank out its display at speeds below 3 mph, in which case a zero is recorded.

The results of the level 1 evaluation are reported later, along with the level 2 and level 3 results.

The site was then upgraded to level 2 to conform with the MUTCD by adding stop lines and advance-warning signs and markings as shown in Figure 6. An acclimation period of 30 days was allowed to pass before driver-performance data were taken again. It was obvious to the project staff that driver performance under level 2 conditions was still inadequate. A positive-guidance solution (level 3) was clearly still needed to improve driver behavior.

POSITIVE-GUIDANCE SOLUTION

The eastbound approach offers an especially poor view of the track from a distance. It was decided to install a LOOK FOR TRAIN sign 150 ft from the crossing and a HIDDEN XING plate below the railroad (RR) advance-warning sign 435 ft from the track (Figure 7; note, shaded areas are proposed rumble strips). The word hidden was specifically considered

Figure 5. Concept of speed profiles for crossbuck and STOP sign grade crossings.

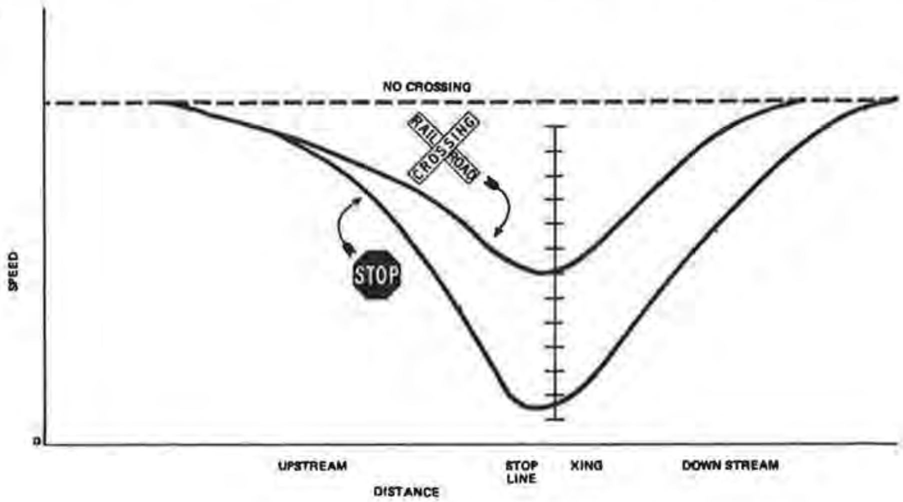
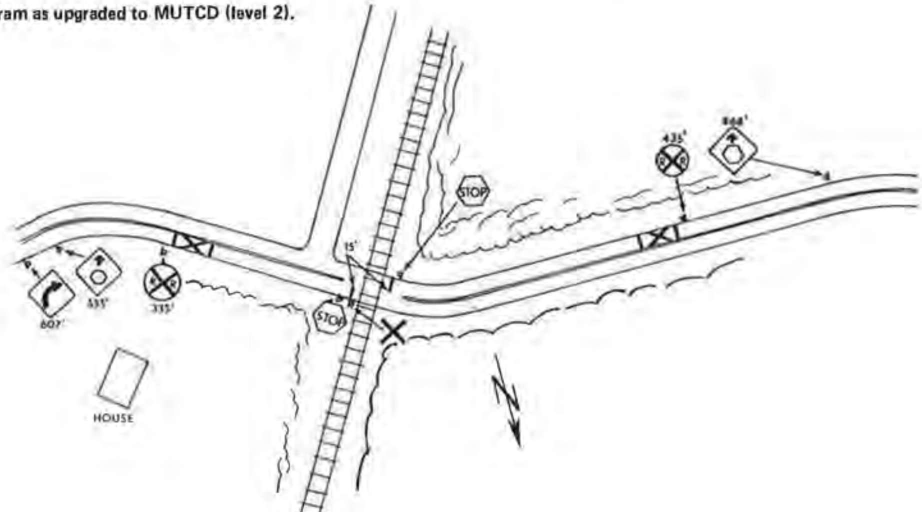


Figure 6. Condition diagram as upgraded to MUTCD (level 2).



preferable to blind. No new signs or markings were recommended for the westbound approach.

It was decided to install three rumble strips on each approach to the crossing in order to call attention to the warning signs. Rumble strips offer a cross-modality stimulation that is both tactile and auditory. They would appear to offer an attractive reinforcement to the visual stimulation of the signs (provided they are not used everywhere). They are formed of corrugations 0.75-in deep. They should not be used indiscriminately in residential areas, such as the project's westbound approach, as their noise can annoy and disturb neighbors. Furthermore, a local driver who uses the route frequently may avoid the noise and vibration by crossing the centerline into the lane used by oncoming traffic. Such a maneuver could pose a greater hazard than the trains.

The warning signs and rumble strips were installed at locations determined through the positive-guidance procedures. Figure 8 shows, for each approach, the three zones that correspond to the nature of the tasks the driver must perform when approaching the crossing. The approach zone corresponds to the decision sight distance (6) minus the desirable stopping sight distance (7). The nonrecovery zone begins at the point beyond which there is insufficient stopping sight distance. It was prepared for a design speed of 35 mph. An analysis of information needs and zone assignments led to the conclusion that, on the eastbound approach, a rumble strip was needed at the beginning of the nonrecovery zone (250 ft from the crossing) to call attention to the LOOK FOR TRAIN sign 100 ft ahead. Similarly, another rumble strip was installed 100 ft in advance of the RR advance-warning sign, with its HIDDEN XING plate. The third rumble strip was installed 100-ft upstream of the symbol stop-ahead sign. The same procedure was followed in locating the three rumble strips on the westbound approach.

Figure 7 shows a diagrammatic left-turn railroad-crossing sign recommended for the road that runs parallel to the track.

RESULTS

Table 1 reports the looking (head-turning) behavior for levels 1, 2, and 3, which were the as-is, MUTCD, and positive-guidance conditions, respectively. The table shows that looking behavior became progres-

Figure 7. Diagram of proposed positive-guidance solution.

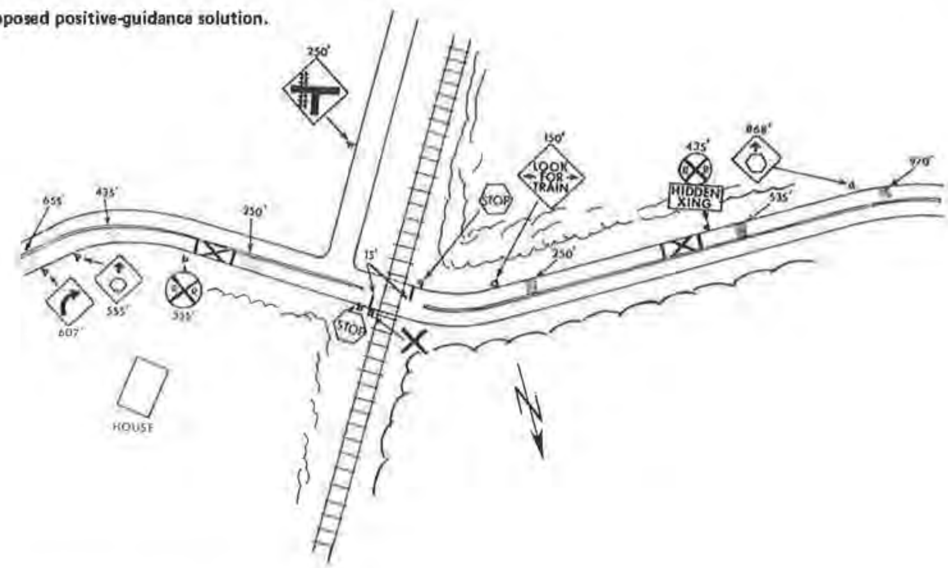
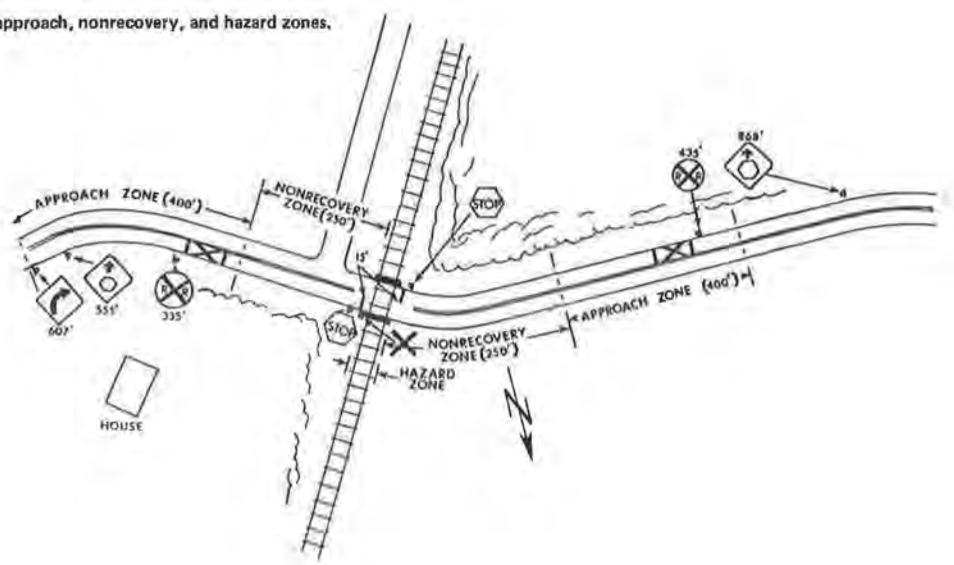


Figure 8. Plot of approach, nonrecovery, and hazard zones.



sively worse from level 1 to 2 to 3. A chi-square test showed that these results were highly significant statistically.

Table 2 shows the changes in stopping location and the percentage of vehicles not stopping at all for the three levels of control. For both eastbound and westbound vehicles, the percentage of vehicles not stopping decreased dramatically after the installation of the positive-guidance solution. The location of stop improved appreciably for the westbound flow but stayed about the same for the eastbound movement.

Speed profiles were determined by tapeswitch from 7:00 a.m. to 6:00 p.m. on two weekdays, a Saturday, and a Sunday, just the same as the other types of data. Each approach averaged about 300 vehicles during an 11-h period. No significant difference from day to day was found. The 85th percentile speeds for levels 1, 2, and 3 at each of the six distances from the track are summarized in Table 3. (The 85th percentile speed was preferred to the mean as an indicator of the performance of the relatively reckless drivers.) It is immediately apparent that there are no differences to speak of among the three levels. The speed at 200 ft from the crossing is considered to be especially important, as the safe driver will have reacted to the advance-warning signs before reaching that location (8). Table 3 shows that the speeds at 200 ft, on both approaches, were unaffected by the two levels of improvement and were approximately as high as the posted speed limit.

A concealed observer with a hand-held radar speed meter determined the lowest speed of each vehicle as it approached and crossed the track. The means of these speeds are not of much interest, as the average driver typically operates his or her vehicle in a safe manner. Tables 4 and 5 examine the speeds of the faster vehicles, which are those more likely to be involved in an accident. The tables show that the fast group of eastbound drivers (≥11 mph) held steady at only about 7 percent of the stream. However, the truly reckless drivers, crossing at more than 25 mph, increased eightfold to almost 1 percent of the total. The fast group of westbound drivers increased their proportion of the stream from 14 to 22 percent, and reckless drivers tripled to about 0.5 percent of the total.

This rural area is very conservative politically. Perhaps some of these reckless drivers were rebelling against noisy, annoying rumble strips by doing the opposite of what they know the authorities are trying to get them to do. About six drivers/day in each direction were observed to avoid the rumble strips by crossing the centerline into the opposing lane.

Table 1. Looking behavior for levels 1, 2, and 3.

Behavior	Percentage of Drivers					
	Level 1		Level 2		Level 3	
	Yes	No	Yes	No	Yes	No
Eastbound						
Looked left	85.9	14.1	82.7	17.3	82.1	17.9
Looked right	85.9	14.1	81.1	18.9	77.9	22.1
Looked one/both directions	89.9	10.1	86.2	13.8	85.9	14.1
Westbound						
Looked left	88.1	11.9	76.2	23.8	68.5	31.5
Looked right	86.7	13.3	75.2	24.8	63.8	36.2
Looked one/both directions	91.2	8.8	81.3	18.3	75.2	24.8

CONCLUSIONS AND RECOMMENDATIONS

The primary objective of this demonstration project was to test the positive-guidance procedures for applicability to the problem at a highway-railroad grade crossing with restricted sight distance. A secondary goal was to achieve an improvement in traffic operation at the site.

The project staff had no difficulty in applying the positive-guidance procedures. The procedures may seem unnecessarily comprehensive for this simple site; however, agencies concerned with mounting numbers of lawsuits should find that time spent documenting positive-guidance procedures will pay for itself many times over in reduced liability.

The evaluation procedures purposely were more ex-

Table 2. Chi-square analysis of stopping zone.

Zone (ft)	Percentage of Vehicles in Zone			Zone (ft)	Percentage of Vehicles in Zone		
	Level 1	Level 2	Level 3		Level 1	Level 2	Level 3
Eastbound[a]				Westbound[b]			
0-10	18.0	9.5	24.3	0-10	7.7	3.6	10.4
11-20	39.6	28.9	60.4	11-20	14.4	12.2	51.3
More than 20	3.7	5.6	9.8	More than 20	6.8	6.7	25.7
No stop	38.7	56.1	5.4	No stop	71.2	77.5	12.6

[a]Chi-square = 313.3, significant at 90 percent, and probability of error (type I error) less than 0.
[b]Chi-square = 368.6, significant at 90 percent, and probability of error (type I error) less than 0.

Table 3. Speeds from tapeswitch data.

Item	85th Percentile Speed[a] (mph)			Item	85th Percentile Speed[a] (mph)		
	Level 1	Level 2	Level 3		Level 1	Level 2	Level 3
Eastbound				Westbound			
Distance from track (ft)				Distance from track (ft)			
10	11	12	11.5	10	13.5	14	14.5
50	20	19	20.5	20	19.5	18	20
100	28	17.5	28	100	26.5	27	27.5
200	37	36	36	200	34	33	34
300	40	40	40	300	35	35	35
500	43.5[b]	43[b]	41[b]	500	38	37	37
Sample size	1999	1216	1222	Sample size	1333	1210	1147

[a]Avg of four days.
[b]Speeds above about 40 mph are not precise because of the speed range programmed for the microprocessor

Table 4. Percentage stratification of lowest approach speeds into speed groups.

Item	Speed Group (mph) 0-5	6-10	11-15	16-20	21-25	>25
Eastbound[a]						
Level 1	66.0	27.0	5.3	0.8	0.8	0.1
Level 2	64.3	29.2	4.8	1.4	0.4	0.1
Level 3	66.7	26.0	5.0	1.1	0.4	0.8
Westbound[b]						
Level 1	39.2	47.0	11.8	1.5	0.3	0.2
Level 2	48.5	37.4	11.3	2.4	0.5	0
Level 3	41.9	36.5	13.9	5.4	1.7	0.6

[a]Chi-square = 16.8 with 10 df; significance = 0.0784.
[b]Chi-square = 55.9 with 10 df; significance = 0.000.

Table 5. Stratification of lowest approach speeds into groups of fast and slow.

Item	Percentage of Vehicles: Slow (<11 mph)	Fast (>11 mph)	Sample Size[a]	Item	Percentage of Vehicles: Slow (<11 mph)	Fast (>11 mph)	Sample Size[a]
Eastbound[b]				Both approaches combined[d]			
Level 1	93.0	7.0	769	Level 1	90.0	10.0	1417
Level 2	93.4	6.6	1368	Level 2	90.0	9.6	2271
Level 3	92.7	7.3	857	Level 3	86.5	13.5	1525
Westbound[c]							
Level 1	86.2	13.8	648				
Level 2	85.9	14.1	903				
Level 3	78.4	21.6	668				

[a]These sample sizes pertain to Tables 1, 2, and 4, also. They are smaller than the sample sizes in Table 3 because only the lead vehicle in a platoon was recorded.
[b]Chi-square = 0.4264 with 2 df; significance = 0.808.
[c]Chi-square = 19.83 with 2 df; significance = 0.000.
[d]Chi-square = 15.92 with 2 df; significance = 0.0003.

tensive than any operating agency would use, as it was desired to determine which of the procedures is most cost effective. It is recommended that tape-switches not be used for routine evaluation because of the complexity of the equipment and the susceptibility to vandalism. It is recommended that observers not be deployed to determine the percentage of motorists stopping and the zone of stop. These judgments are too subjective and raise serious questions of inter-observer repeatability.

It is recommended that evaluations of this type be performed by two observers located as close to the road as possible (that is, not at a side location down the tracks). One observer holds a radar speed meter and records the minimum speed of all oncoming vehicles and as many vehicles moving away from him or her as convenient. The second observer holds 8-power binoculars (or possibly a 20-power telescope for unusual distances) and observes head movements of oncoming vehicles only. This observer should be instructed to look for a "Fuzzbuster" on the dash.

Stanley Road is used entirely by local motorists. It may be impossible to change their behavior at the crossing short of installing gates, lights, and bells. Overall, driver performance did not improve as a result of the two levels of upgrading. In fact, the rumble strips induced some swerving into the oncoming lane and may have been responsible for the observed increase in vehicles crossing at reckless speeds. Recommendations in the literature (9) for rumble strips at grade crossings should be amended to apply only to nonresidential locations where unfamiliar drivers are numerous enough to form the target population.

ACKNOWLEDGMENT

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This paper reflects our views, and we are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Georgia DOT or FHWA. This paper does not constitute a standard, specification, or regulation.

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