MIDWEST SMART WORK ZONE DEPLOYMENT INITIATIVE

MwSWZDI

FHWA POOLED FUND STUDY

Report Title

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LightGuard System

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Supplemental Notes

Abstract

This project designed and evaluated a system of lighted RPMs used to delineate a crossover in advance of an Interstate work zone. Vehicle speeds were collected at the crossover and approximately half a mile upstream of the crossover. Lane keeping data was also collected by utilizing several automatic traffic recorders, a complex array of pneumatic hoses, and some custom software. The system was found to result in statistically significant reductions in speed and in the number of vehicles nearing the edgeline (i.e., within 1-ft for cars, 2-ft for trucks). The system demonstrated the capability to improve delineation in a rural rossover, but the need for power to operate the lights could be problematic in some locations. Because the system was experimental, no cost figures are available.

LIGHTGUARD SYSTEM

LightGuard Systems, Inc.

Evaluation Team

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Description

The LightGuard System, a ground-mounted lighted delineation device with steady burn, flashing, or "racing" lights used to provide additional guidance through a work zone, was installed near the east end of the project to provide additional guidance through the westbound mainline crossover to the eastbound lanes.

The Lightguard lighted RPMs were tested in an experimental configuration used to delineate a crossover in a rural construction zone. Amber lights were used to delineate the inside edge, placed just beyond the edge line, and white lights were used to delineate the outside edge, also placed just beyond the edge line. The lights operated in a steady burn mode.

Study site

I-135, from the Harvey/Sedgwick County line north to 0.3 miles south of the South K-15 interchange, Harvey County

South end of project near the 125th Street interchange and the northbound mainline crossover to the southbound lanes

The evaluation occurred at the westbound entrance to a rural Interstate work zone on I-70 approximately 16 km (10 mi) east of Salina, Kansas. In the work zone, the westbound lanes were closed and two-way traffic was carried in the eastbound lanes. The Safety Warning System (SWS) was deployed at the lane taper on the westbound lanes, preceding the crossover where the RPMs were installed. The pavement in the crossover is 5.5 m (18 ft) wide, with edge lines inset by 0.3 m (1 ft).

I-70, Saline County

ADT = 8,100 vpd — Is this ADT directional? YES
T = 18.0%
D = 60%
$V_{current}$ = 70 mph
$V_{construction}$ = 70 mph
$V_{advisory}$ = NA

Performance Measures

The objectives of this application and the associated performance measures are shown in Table 3-3.

TABLE 3-3. LightGuard RPMs: objectives and performance measures.

Objectives	Performance Measures
Provide additional guidance	1. Lane distribution upstream of the taper 2. Speed upstream of the taper 3. Speed in the cross-over 4. Vehicle position in the cross-over

Experimental Design

Study type: Before and after

Data Collected

Lane distribution at locations 500 ft, 1000 ft, and 1500 ft upstream of taper

Collection method: pneumatic tubes and automatic traffic recorders.
Sample size: one 24 hr day before and one 24 hr day after installation.
Analysis technique: comparison of lane distributions before and after installation.

Speed of vehicles upstream of taper

Collection method: pneumatic tubes and automatic traffic recorders.
Sample size: one 24 hr day before and one 24 hr day after installation.
Analysis technique: comparison of 85th percentile speeds, average speeds, and percent of vehicles exceeding the posted speed limit before and after installation.

Speed of vehicles in the cross-over

Collection method: pneumatic tubes and automatic traffic recorders.
Sample size: one 24 hr day before and one 24 hr day after installation.
Analysis technique: comparison of 85th percentile speeds, average speeds, and percent of vehicles exceeding the posted speed limit before and after installation.

Position of vehicles in the cross-over (relative to the edge lines)

Collection method: pneumatic tubes and automatic traffic recorders.
Sample size: one 24 hr day before and one 24 hr day after installation.
Analysis technique: comparison of distributions of vehicle positions relative to the edge lines.

One day of lane distribution data was collected upstream of the taper, then the SWS was activated approximately 0.8 km (0.5 mi) upstream of the crossover. After data was collected for one day, the RPMs were activated and another day of data was collected. Two evaluation measures were used to evaluate the RPMs. The data was collected on the same schedule described for the lane distributions. The first measure focused on speeds (mean and 85th percentile), and the second focused on lane keeping. To measure lane keeping (and speeds, in the process), a configuration of hoses was set out as shown in Figure 3-2. Each of the short hoses detected a vehicle's encroachment into a given area near the edge line, the width of the area being determined by the distance the hose extended inside the edge line. The hoses were configured to count vehicles that tracked within 0.9 m (3 ft), 0.6 m (2 ft), and 0.3 m (1 ft) of the edge line, as well as those that crossed the edge line. Both edge lines were observed, requiring a total of 16 hoses and 4 counters for the full array. The A and B inputs for each counter were used to measure speeds, while the C and D inputs were used to track vehicle positions. Software was developed to use the speeds and times to match individual vehicles in the data sets produced by the four counters.

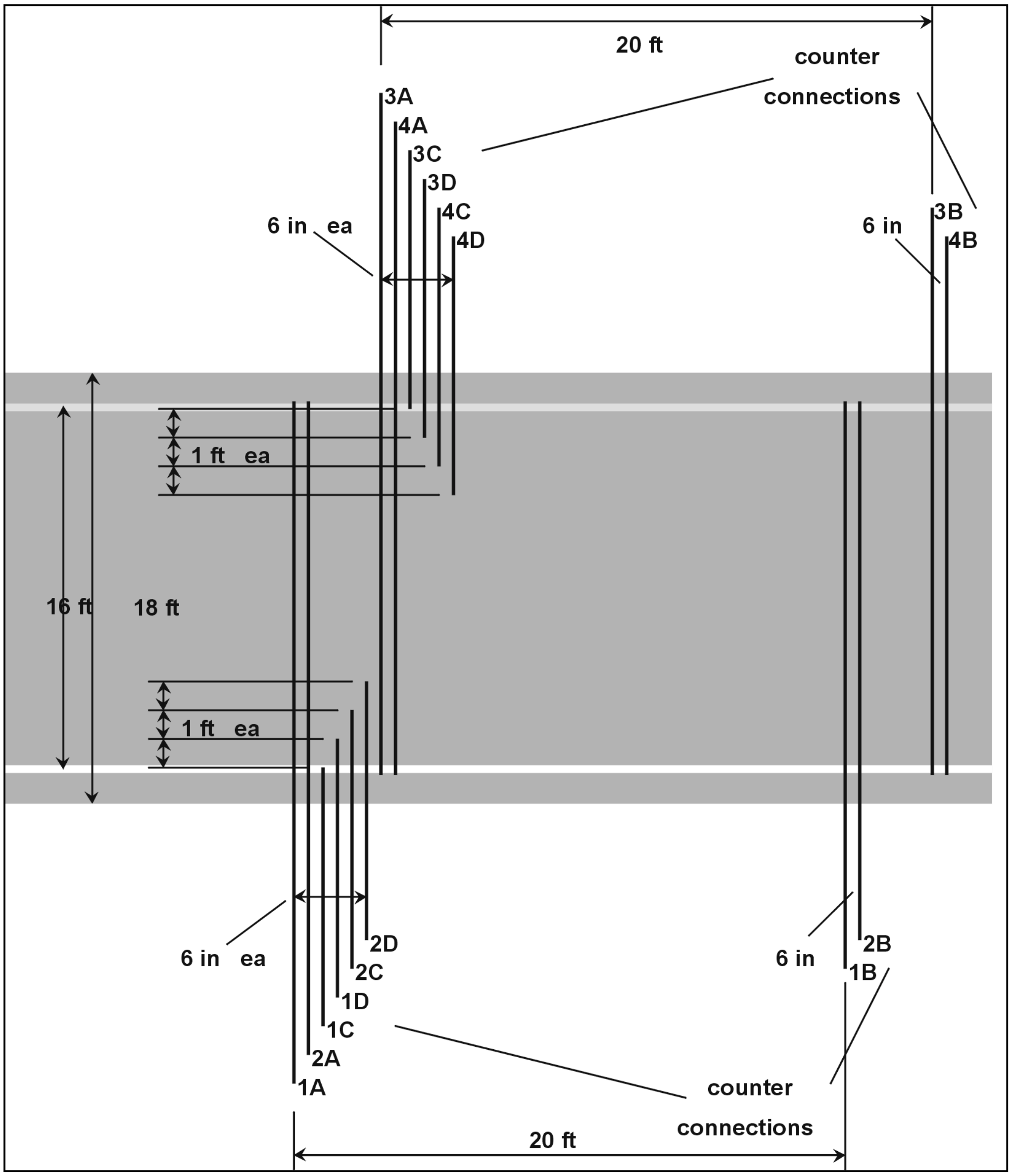

FIGURE 3-2. Hose configuration for measuring lane position.

Evaluation Results

During the three days of the evaluation (including both the Safety Warning System—discussed elsewhere—and the LightGuard RPMs), 6212 passenger cars were observed during the daytime (12:00 PM to 8:30 PM) and 1918 passenger cars were observed during the nighttime (9:00 PM to 6:00 AM). 1733 and 823 trucks, respectively, were observed during the same time periods. Daytime observations prior to noon were not considered in the analysis, because the precise times at which the systems were turned on were not reported by the contractor.

Lane Distributions

No significant changes in lane distributions were observed. The statistical results of the lane distribution analysis for data collected 500 ft upstream of the taper is shown in Table 3-4. In the table, the *Before* data represents the baseline, while the *After* data was collected with both the LightGuard RPMs and the Safety Warning System active.

TABLE 3-4. LightGuard RPMs: percent of vehicles in lane 2.

								level of significance	
	Lane 1	Lane 2	Total Vehs	% Lane 2	Avg %	sigma	z	0.05	0.01
DAYLIGHT,PASSENGER CARS									
Before	788	2845	3633	0.7831	0.7831	0.0097	0.0010	1.96	2.576
After	785	2834	3619	0.7831				**no change**	**no change**
NIGHTTIME,PASSENGER CARS									
Before	165	508	673	0.7548	0.7573	0.0237	-0.2102	1.96	2.576
After	153	484	637	0.7598				**no change**	**no change**
DAYLIGHT,TRUCKS									
Before	237	1143	1380	0.8283	0.8284	0.0140	-0.0168	1.96	2.576
After	260	1256	1516	0.8285				**no change**	**no change**
NIGHTTIME,TRUCKS									
Before	127	382	509	0.7505	0.7486	0.0266	0.1360	1.96	2.576
After	142	419	561	0.7469				**no change**	**no change**

Lane Position Distributions

Vehicle lane positions were collected in approximately the middle of the leading curve of the crossover. The lane keeping data showed that only 11 vehicles actually crossed the edge line on the inside (i.e., left) and none crossed the outside (i.e., right) edge line. Only 7 vehicles tracked within 0.9 m (3 ft) of the outside edge line. Distances used were measured from the vehicle to the nearest edge line, although nearly all (> 99%) of vehicles were positioned closer to the inside edge line.

The nighttime distributions for positions among passenger cars and among trucks are shown in Figure 3-3 and Figure 3-4, respectively. For both vehicle classifications, the percentages of vehicles passing within 1 ft of the edge line decreased slightly with the deployment of the SWS and by a larger amount with the deployment of the lighted RPMs. However, these changes were not statistically significant at a 95% confidence level. At a 90% confidence level, however, the LightGuard system resulted in a significant decrease in the percentage of passenger cars tracking within 1 ft of the edge line, as shown in Table 3-5.

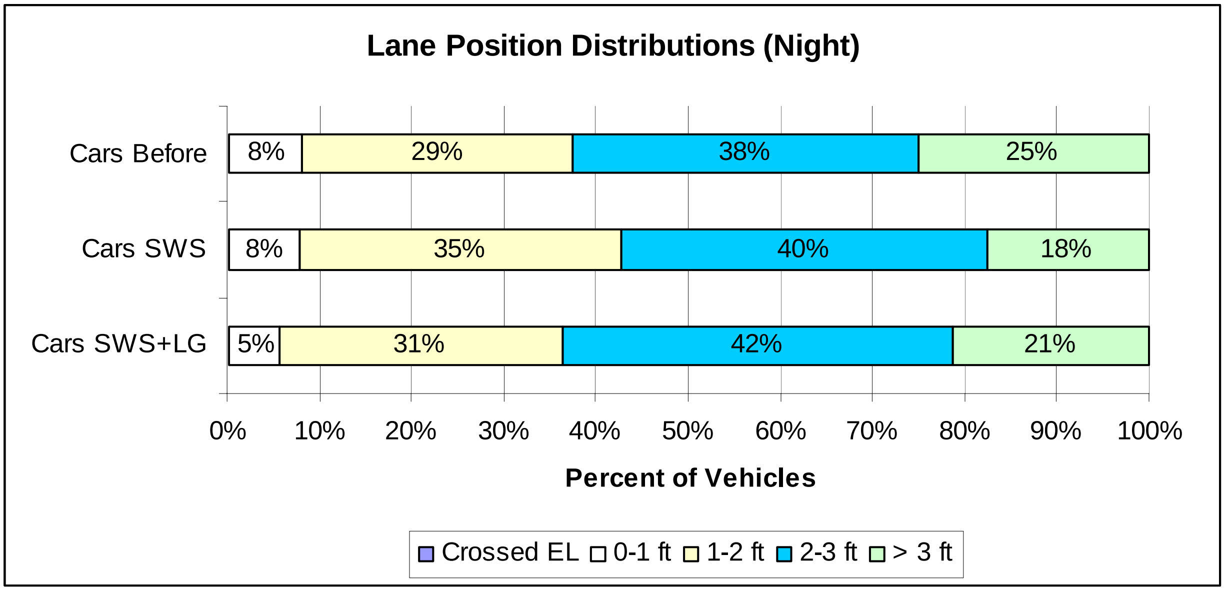

FIGURE 3-3. Lane position distributions for passenger cars at night.

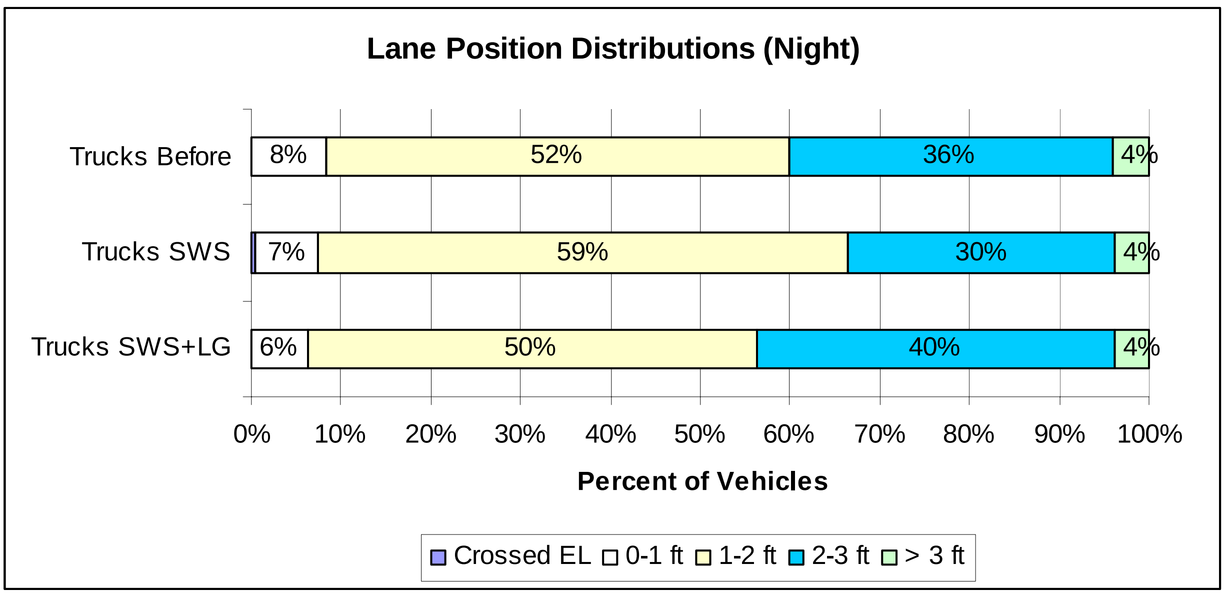

FIGURE 3-4. Lane position distributions for trucks at night.

TABLE 3-5 Statistical analysis for cars at night, percent within 1ft of edge line.

Cars	Vehicles detected within 1 ft of edge line	Total Vehicles	p	avg p	sigma 1-2	z	0.10	0.05
Before	43	537	0.08007	0.07983	0.01579	0.03	1.645	1.960
SWS	52	653	0.07963				no change	no change
SWS	52	653	0.07963	0.06734	0.01351	1.73	1.645	1.960
SWS+LG	41	728	0.05632				DIFFERENT	no change

At a 95% confidence level, a statistically significant change was observed in the percentage of trucks tracking within 2 ft of the edge line during both the day and night time periods when the LightGuard system was deployed. However, the respective changes were in opposite directions. An increase occurred during daylight conditions, while a comparable decrease occurred at night. As is discussed in the following section, speeds were decreased significantly after the LightGuard system was turned on. This may account for the trucks tracking closer to the edge line during the day. The percentages for daytime are shown in Table 3-6, and the changes for nighttime are shown in Table 3-7.

TABLE 3-6 Statistical analysis for trucks in daylight, percent within 2ft of edge line.

Trucks	Vehicles detected within 2 ft of edge line	Total Vehicles	p	avg p	sigma 1-2	z	0.10	0.05
Before	153	579	0.26425	0.27094	0.02599	-0.51	1.645	1.960
SWS	164	591	0.27750				no change	no change
SWS	164	591	0.27750	0.30936	0.02722	-2.40	1.645	1.960
SWS+LG	193	563	0.34281				DIFFERENT	DIFFERENT

TABLE 3-7 Statistical analysis for trucks at night, percent within 2ft of edge line.

Trucks	Vehicles detected within 2 ft of edge line	Total Vehicles	p	avg p	sigma 1-2	z	0.10	0.05
Before	135	225	0.60000	0.63564	0.04309	-1.49	1.645	1.960
SWS	186	280	0.66429				no change	no change
SWS	186	280	0.66429	0.61037	0.03997	2.54	1.645	1.960
SWS+LG	179	318	0.56289				DIFFERENT	DIFFERENT

Speeds, Speed Distributions, and Percent Speeding

The speed data revealed more dramatic effects than either the lane distribution data or the vehicle position data. Figure 3-5 shows the speed distributions (in the crossover) for the three days of data collection (passenger cars). The distributions for trucks were very similar. For both passenger cars and trucks, the nighttime mean speed dropped by more than 10 kph (6 mph). At night, the percent of drivers exceeding the posted limit decreased from 29% to 22% with the activation of the SWS, compared to 7% with the activation of the RPMs. Percentages, including trucks and daytime, are shown in Figure 3-6.

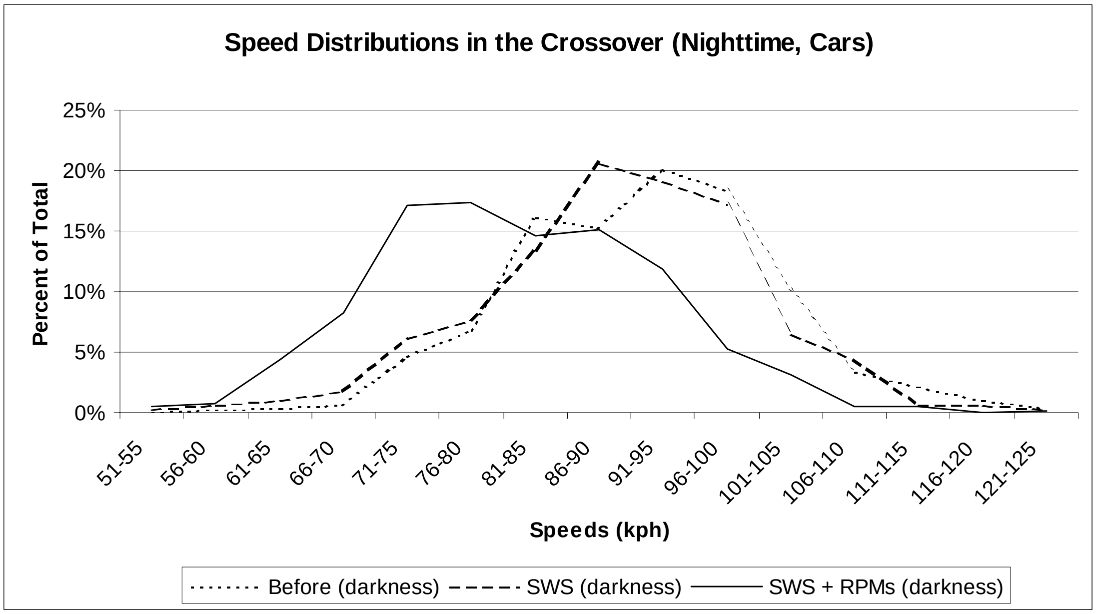

FIGURE 3-5 Speed distributions in the crossover.

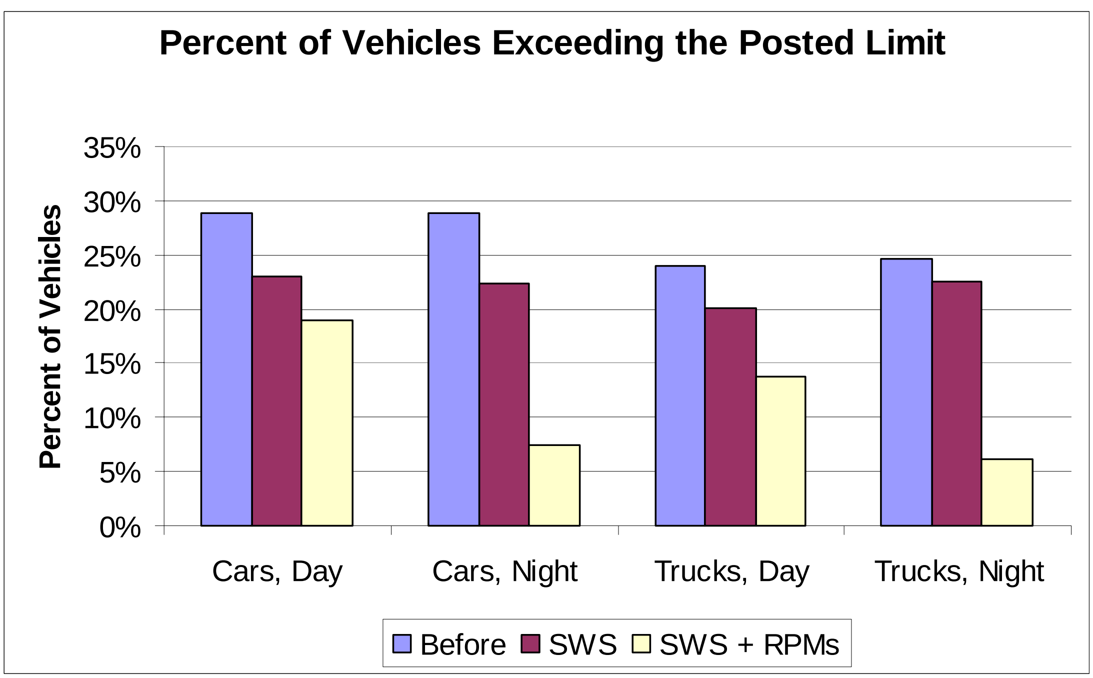

FIGURE 3-6 Percent of vehicles exceeding the posted limit.

Driver’s Perspective

Figure 3-7 is a portion of a frame from the drive-through video taken in the crossover after the LightGuard system had been turned on. The lighted RPMs clearly delineate the geometry of the roadway ahead. Figure 3-8 was excerpted from video footage of another crossover in the same construction project. Standard traffic control was used in this crossover, including only reflectorized drums and edge lines for delineation.

Conclusions

The LightGuard Lighted RPMs resulted in a statistically significant improvement in lane keeping among passenger cars at the 1 ft distance and among trucks at the 2 ft distance. The improvements coincide with significant reductions in speeds, particularly at night, and most dramatically with the activation of the lighted RPMs. Because the installation was experimental, no conclusions can be made about either the required effort for installation, maintenance, or removal. The RPM units themselves were easily installed and removed, but the cabling necessary to power the lights could be an obstacle in some locations. Also, because the configuration was experimental, no cost information is available.

FIGURE 3-7 Crossover delineated by Lightguard Lighted RPMs.

FIGURE 3-8 Crossover without lighted delineation.

Recommendations

The Lightguard RPMs resulted in substantial reductions in speeds and improvements in lane placement. Because of the apparent effectiveness of the system, continued development and evaluation should be considered. The following issues should be investigated.

- The relative effectiveness of operating in a random flash mode during daylight hours.
- The relative effectiveness of operating in a sequenced flash (i.e., chasing) mode during nighttime operation.
- Longer term effectiveness in environments with a high percentage of repeat traffic.
- The application of the system to other situations, such as lane tapers.

Based on the results of this evaluation, the LightGuard Lighted RPMs are effective and improve parameters associated with accident reduction in highway work zones. Further development and subsequent deployment is recommended.