Rural Stop-Sign Controlled Intersection Crash Avoidance System Device

Engineering District 10-0
Intelligent Transportation System Review

By

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ABSTRACT

The Crash Avoidance System (CAS) is an Intelligent Transportation System (ITS) traffic control device, consisting of activated warning signs and pavement loop detectors. The CAS system has an eight-hour solar panel backup cell as an added safety measure during possible outages. In addition to a back-up power system, the CAS has a fail-safe mode built into the program. If the system would trip/malfunction, the illuminated signs would activate and flash, such as a worst-case situation to warn motorist that the system is not functioning properly. A CAS application at two rural unsignalized intersections, situated on the crest of over-verticals, was projected to enhance driver awareness of cross traffic, thus increasing safety.

An 85th percentile speed sample was taken before, immediately after, and two months after the CAS installation. The speeds of the vehicles observed were taken while the CAS was in non-activation mode and during an activated mode.

Evaluations of Effectiveness (EOEs) were derived from the CAS operational objectives. Functional EOEs were: (1) vehicle CAS speed responses in the presence of cross traffic; (2) intersection approach speed reductions; and (3) crash reduction.

The following findings support a conclusion that the installation of the CAS system has reduced the crash potential.

- Reduction of speed during the presence of cross-traffic.
- Lower intersection-approach speeds were observed following the installation and after two-month operation of the CAS.
- 85th and 90th percentile speeds were reduced at the two-month operation when compared to data collected prior to installation.

INTRODUCTIONS

Design and Construction of the CAS

The district completed the project design through an open-end contract with Trans Associates. The project was competitively bid and a construction contract was awarded to Post Construction Inc., in July of 2001 for the construction of the system. The software vendor for this project was awarded to McCain Traffic from California. The final cost of the design of these devices at both locations was $52,300; and the cost to construct them was $370,000. A major portion of the cost can be attributed to the uniqueness of the project. However, the cost is considerably lower than that to reconstruct the vertical geometry at the intersections.

Intersections

The Crash Avoidance Systems are located at two, two-lane rural intersections in Butler County. The first intersection, **intersection a**, is located in North Washington Township at S.R. 38 and S.R. 138/S.R. 1004.

- S.R. 38 has 10' lanes with 3' paved shoulders
- Northbound approach has a positive 5% grade
- Southbound approach is a positive 5.1% grade
- Overall vertical curve length of over 2000 feet
- Posted legal speed limit of 35 M.P.H.
- 3,395 Annual Average Daily Traffic

The northbound approach to **intersection a** has an standard intersection sign with an advisory speed of 35 M.P.H. located at 750' followed by an ITS controlled illuminated sign at 450' and a final ITS controlled illuminated sign 200' prior to the intersection. The southbound approach has a standard intersection sign with an advisory speed of 35 M.P.H. located at 750' followed by an ITS controlled illuminated sign at 500' and a final ITS controlled illuminated sign 300' prior to the intersection. Figure 1 demonstrates the general placement of signing as you approach both of the intersections.

The second intersection, **intersection b**, is located in Concord Township, near the Village of Hooker, at State Route 38 and State Route 1010.

- S.R. 38 has 10' lanes with 4' paved shoulders
- Northbound approach has a positive 4.3% grade
- Southbound approach is a positive 3% grade
- Overall vertical curve length of over 3000 feet
- Posted legal speed limit of 35 M.P.H.
- 3,675 Annual Average Daily Traffic

The northbound approach to **intersection b** has a standard intersection sign with an advisory speed of 25 M.P.H. located at 700' followed by an ITS controlled illuminated sign at 450' and a final ITS controlled illuminated sign 200' prior to the intersection. The southbound approach has a standard intersection sign with an advisory speed of 25 M.P.H. located at 650' followed by an ITS controlled illuminated sign at 425' and a final ITS controlled illuminated sign 200' prior to the intersection.

Crash Avoidance System

A Crash Avoidance System (CAS) is an ITS traffic control device to advise drivers of conflicting crossroad traffic. The systems are designed for application at two unsignalized, minor side road approach, stop-controlled rural intersections in Butler County, Pennsylvania. Actively illuminated signs, operating on input from vehicle-detection pavement loops, automatically warn drivers of conflicting crossroad traffic approaching the

intersection. Drivers approaching the intersection from all directions are graphically advised of the presence and direction of approaching intersection traffic. Figures 1 and 2 depict signs applied at the major and minor legs, respectively.

Figure 1 – Major Leg CAS Sign
S.R. 38 and S.R. 1010 Southbound

Figure 2 – Minor Leg CAS Sign
S.R. 1004 Southbound approach

The field study consisted of a three-phased ("before", "initial" and "after") CAS evaluation, based on observed vehicle speeds before, immediately after, and two-months following the CAS initial activation. Results reported herein are based on random speed assessments consisting of vehicles navigating the Hooker (**intersection a**) and North Washington (**intersection b**) Township intersections on State Route 38 in Butler County, Pennsylvania.

BACKGROUND

A number of studies have addressed crash occurrence at rural intersections. Hanna, et al. (1976) in a study of over 300 Virginia locations determined that rural intersections with poor sight distance on one or more approaches exhibit higher-than-normal crash rates. A 1981 study (Christian, et al.) evaluated a standard intersection warning signs at sight-restricted locations. Speed data collected at critical crash-potential locations indicated that the warning sign, although supplemented with advisory speed plates, had no effect at slowing vehicles. An ITS approach was considered necessary for applications at these two rural stop-sign-controlled intersections with limited sight distances.

For traffic control devices to produce a safe response at an intersection, they must provide the driver with adequate time to detect, recognize, decide, and initiate an appropriate response. The CAS demonstrates

when traffic is approaching the intersection from all four legs. The major leg approach depicts when vehicles are entering the intersection. The minor leg shows vehicles approaching the intersection, which warns motorists not to traverse through the intersection.

SPEED DATA

Speed data was collected to determine the effectiveness and driver response to the CAS. The speed of the approaching vehicles was compared two different ways to determine the effectiveness. (1) Comparison of vehicles over 50 M.P.H., over 45 M.P.H., and over 35 M.P.H. (2) Comparison of the 85^{th}%, 90^{th}%, and 95^{th}% speeds of vehicles with respect to data collected prior to installation of the CAS.

The table shown below gives an overall picture of the speed data collected at the two intersections:

- **Intersection a**, S.R. 38 and S.R. 1004
  - The overall vehicle speed decreased. The vehicles traveling over 50 M.P.H. on mainline S.R. 38 through the intersection, after two months of implementation, decreased by 7.88% while the CAS system was activated for cross traffic. Vehicle speeds over 35 M.P.H. also decreased at a rate of 13.35% while the system was activated.
- **Intersection b**, S.R. 38 and S.R. 1010
  - While the overall vehicle speed (speed over 35 M.P.H.) decreased by 8.8%, the vehicles traveling over 50 M.P.H. as well as 45 M.P.H. increased after two months of activation on mainline S.R. 38. It is also noted that this intersection is located in a legal posted speed zone of 35 M.P.H.

Table 1

Overall Vehicle Speed Criteria

Location		Speed Criteria	Prior %	Two-week %	Two-month %
Intersection a, 35 M.P.H.	SR 38 & SR 1004	Over 50 MPH	9.18	0	1.3
	SR 38 & SR 1004	Over 45 MPH	17.35	9	4
	SR 38 & SR 1004	Over 35 MPH	66.32	50	34
Intersection b, 35 M.P.H.	SR 38 & SR 1010	Over 50 MPH	4.3	2	5.26
	SR 38 & SR 1010	Over 45 MPH	6.45	6	17.54
	SR 38 & SR 1010	Over 35 MPH	66.7	62	57.9

The following chart and graphs represent the overall percentile speeds for vehicles traveling through the intersection. The speeds are compared to

pre- and post-installation and while the CAS system is activated and not activated. The majority of the speed through the intersection while the CAS system is activated and non-activated decreased.

Table 2

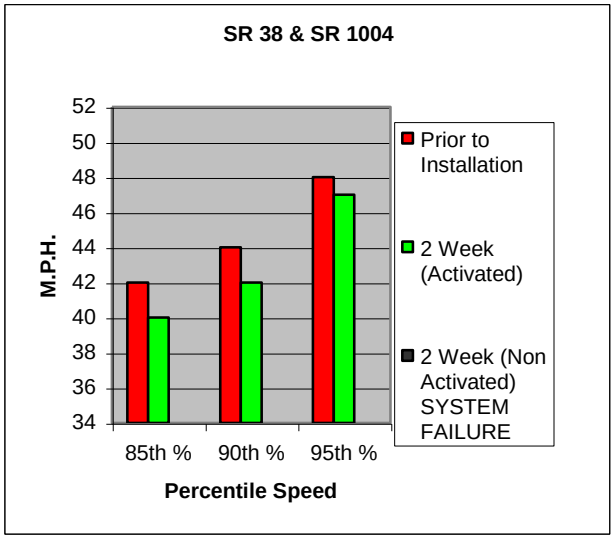
Vehicle Percentile Speeds (M.P.H.)

	SR 38 & SR 1004	**SR 38 & SR 1004**		**SR 38 & SR 1004**	
	Prior to Installation	*2 week Activated*	*2 week Non-Activated*	*2 month Activated*	*2 month Non-Activated*
85th %	42	40	System Failure	37	46
90th %	44	42		39	47
95th %	48	47		44	49

	SR 38 & SR 1004	**SR 38 & SR 1010**		**SR 38 & SR 1010**	
	Prior to Installation	*2 week Activated*	*2 week Non-Activated*	*2 month Activated*	*2 month Non-Activated*
85th %	47	45	48	41	42
90th %	49	47	49	43	44
95th %	51	52	50	48	46

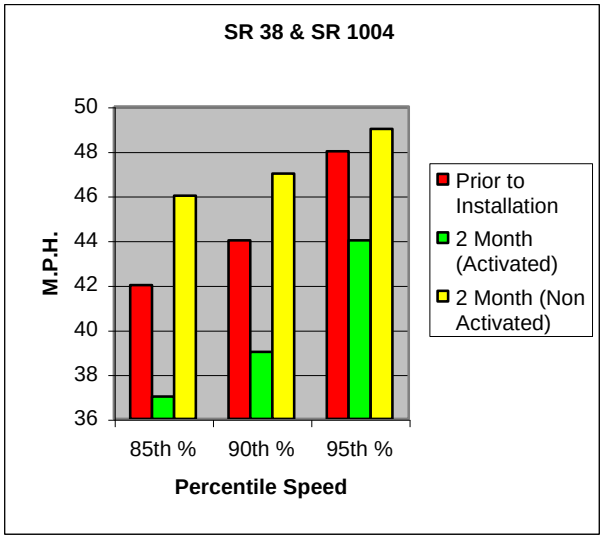
The following charts represent the above table in graphical format:

Mainline S.R. 38



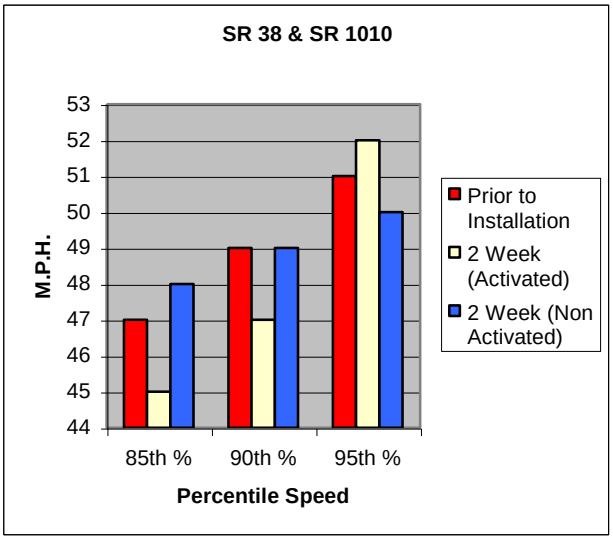
Graph 1
Percentile Speed Comparison
Two-week

Mainline S.R. 38



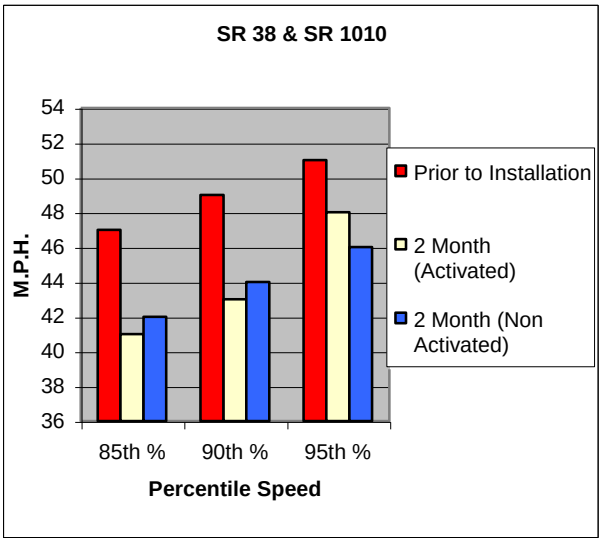
Graph 2
Percentile Speed Comparison
Two-month

Mainline S.R. 38



Graph 3
Percentile Speed Comparison
Two-week

Mainline S.R. 38



Graph 4
Percentile Speed Comparison
Two-month

SUMMARY AND CONCLUSIONS

The field study analyzed behaviors of drivers passing through the intersection before, two-weeks following, and two-months following the CAS installation. During this analysis, the vehicles analyzed were those approaching the intersection during two phases: 1) while the CAS system was activated; and 2) and when the CAS system was not activated.

The assessment procedure developed and analyzed Measures of Effectiveness (MOEs) based on CAS operation objectives. The MOEs consisted of CAS vehicle speed responses in the presence of cross traffic, intersection approach speed reductions, and crash reduction. The MOEs analysis was conducted on the sample of all potentially conflicting traffic, i.e., activating the signs at the sight distance-restricted intersections. Results demonstrated favorable CAS effects, e.g., reduction of the top 15 percentile speeds approaching on the mainline of the intersections.

The data analysis demonstrated that the CAS has a greater impact on driver behavior while the signs of approaching vehicles are illuminated. Specific findings were as follows:

- Lower vehicle speeds approaching on the main leg of intersection while the signs were illuminated.
- A reduction of speed for vehicles traveling over 35 M.P.H. through the intersections while illuminated.
- A reduction of the 95-percentile speed at intersections while illuminated.

One negative behavior was also noted. At the two-month study, vehicle speeds through the intersection while the signs were not activated were higher than when studied prior to the installation of the CAS system. However, the fact that this behavior is occurring may show motorists are more comfortable with the intersection and no longer have the threat of vehicles approaching the intersection surprisingly.

The data and analysis reported herein support conclusions that safer traffic operations, i.e., lower intersection speeds, resulted from installation and continued operation of the CAS.

LIST OF REFERENCES

Christian, T.R., Barnak, J.J. and A.E. Karoly. *Evaluation of Limited Sight Distance Warning Signs*, New York State Department of Transportation, Albany, NY 1981

Hanna, J.T., Flynn, T.E. and W.T. Tyler. "Characteristics of Intersection Accidents in Rural Municipalities." *Transportation Research Record 601.* Transportation Research Board, National Research Council, Washington, DC 1976, pp.79-82.