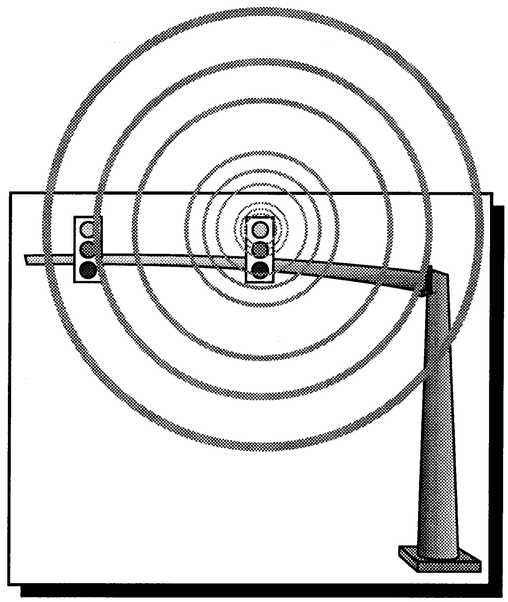
TECHNICAL
ASSISTANCE REPORT

EVALUATION OF THE USE OF STROBE LIGHTS IN THE RED LENS OF TRAFFIC SIGNALS



B. H. COTTRELL, JR.
Senior Research Scientist

V · I · R · G · I · N · I · A
VTRC
TRANSPORTATION RESEARCH COUNCIL

VIRGINIA TRANSPORTATION RESEARCH COUNCIL

TECHNICAL ASSISTANCE REPORT

EVALUATION OF THE USE OF STROBE LIGHTS IN THE RED LENS OF TRAFFIC SIGNALS

B. H. Cottrell, Jr.
Senior Research Scientist

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

November 1994
VTRC 95-TAR-5

TRAFFIC RESEARCH ADVISORY COMMITTEE

ABSTRACT

The objective of this study was to evaluate the effectiveness of using strobe lights in the red lens of traffic signals and, if appropriate, to recommend guidelines for their use. Strobe lights are used as a supplement to the red lens to draw the attention of drivers to a traffic signal. VDOT has 22 intersections with strobe lights in six of its nine districts; this is up from 3 intersections in 1987. Nineteen of these are in the western part of the state, and most have the strobe light in the red signal over the left through lane. The Barlo strobe light, a horizontal bar positioned across the middle of the red lens with about 60 flashes of white light per minute, is used at all 22 intersections. The cost of a red signal head with a Barlo strobe light is about $765.

Strobe lights are used by VDOT primarily for (1) areas with a high truck volume and high speed; (2) areas with a high accident rate; (3) areas with road geometrics, especially grades (downgrade), horizontal curves, and other features, that result in limited sight distance; and (4) isolated intersections where a signal is unexpected.

Based on the analyses, there was no evidence indicating that strobe lights are consistently effective in reducing accidents. The limitations of the analyses are identified in the study. There is no basis for recommending the use of strobe lights unless there are other bona fide measures of effectiveness that can be used to justify installing them.

EVALUATION OF THE USE OF STROBE LIGHTS IN THE RED LENS OF TRAFFIC SIGNALS

B. H. Cottrell, Jr.
Senior Research Scientist

INTRODUCTION

Strobe lights have been used as a supplement to the red lens to draw the attention of drivers to a traffic signal. They have been used in situations where a signal is unexpected, a signal may be difficult to see, or there is a high accident rate or a potentially hazardous intersection. Specific applications of strobe lights include the following:

1. isolated, high-speed, rural intersections

2. the first signalized intersection into an urbanized area after an extended road section without a signal

3. the first signalized intersection after a transition from a grade-separated or limited access highway to an at-grade highway with intersections

4. locations where background lighting and signs (visual noise) are a problem.

Since the applications of strobe lights in the red indication are limited in the United States, few studies have evaluated their effectiveness. The study results that are available are inconsistent and inconclusive.[1] In many cases, especially in North Carolina, strobe lights are included among multiple safety improvements at intersections, making it impossible to determine their effectiveness. A similar situation exists at new signal installations.

In June 1987, 3 intersections in two Virginia Department of Transportation (VDOT) districts had strobe lights. In April 1994, 22 intersections in six VDOT districts had them. Apparently, the interest and popularity of strobe lights have increased in Virginia. The Barlo strobe light, a horizontal bar positioned across the middle of the red lens with about 60 flashes of white light per minute, is used at all of the intersections. A red signal head with a Barlo strobe light costs about $765.

According to the Federal Highway Administration (FHWA),[2] there is insufficient evidence to support the inclusion of strobe lights in the *Manual of Uniform Traffic Control Devices (MUTCD)*.[3] Other concerns regarding strobe light usage expressed by traffic engineers include whether they distract the driver's attention from other traffic control devices and other vehicles and whether their attention-getting value diminishes with time. Thus, VDOT's Traffic

Engineering Division requested a scientific evaluation of the use of strobe lights in the red lens of traffic signals.

OBJECTIVES AND SCOPE

The objectives of this study were to evaluate the effectiveness of the use of strobe lights in the red lens of traffic signals and, if appropriate, to recommend guidelines for their application. Only applications of the Barlo strobe light were studied.

METHODS

Two activities were conducted to accomplish the study objectives:

1. *Data collection.* A questionnaire survey was sent to the nine VDOT district traffic engineers (DTEs) to obtain information on strobe light use. The questionnaire sought an inventory of strobe light installations, maintenance experiences, and reasons for installing the strobe. Accident data were collected for selected sites.

2. *Data analysis and evaluation.* The questionnaire information was summarized and analyzed to assess the use and performance of strobe lights, and accident analyses were conducted. Of the 22 intersections that had strobe lights, 6 of them had 3 years of associated accident data before and after the strobe lights were installed. The accident analysis was performed in three parts: a review of accident trends at the six sites; a before-and-after analysis; and a before-and-after analysis with a comparison group and a check for comparability for three of the six sites for which a comparison site was identified. Rear-end, angle, and total accidents that involved at least one vehicle on the strobe light approaches were examined.

RESULTS

Results from the Survey of VDOT District Traffic Engineers

The results of the survey are shown in Table 1. Nineteen of the 22 strobe lights are in the western part of the state, with 8 in Salem, 7 in Bristol, and 4 in Staunton.

TABLE 1
STROBE LIGHT SURVEY RESULTS

DISTRICT	INTERSECTION	COUNTY	STROBE LOCATION (Q1)	STROBE INSTALLED (Q2A)	SIGNAL INSTALLED (Q2B)	REASON FOR INSTALLATION (Q3)
SALEM	221 & 1415	BEDFORD	LEFT THRU LANE/NB	91/08	90/11	ENHANCE VISIBILITY; ACC.; DOWNGRADE
SALEM	220 & 58 BP	HENRY	LEFT THRU LANE/NB	91/01	90/11	ENHANCE VIS./REDUCE ACC.
SALEM	220 & CROSSBOW RD	ROANOKE	LEFT THRU LANE/BOTH DIR	89/08	89/06	ENHANCE VIS./HIGH VOL. LARGE TRUCK TRAFFIC
SALEM	460 & 220 ALT	ROANOKE	LEFT THRU LANE/BOTH DIR	89/08	74/07	HIGH SPEED; HIGH VOL TRUCKS LIMITED SIGHT DIST; ACC.
SALEM	460 & TOMS CK RD	MONTGOMERY	LEFT THRU LANE/BOTH DIR	89/09	89/09	HIGH SPEED, TRUCK VOL, SLIGHT CURV
SALEM	460 & 314	MONTGOMERY	LEFT THRU LANE/BOTH DIR	89/09	89/09	HIGH VOL TRUCKS; HIGH SPEED
SALEM	460 & ARBOR DR	MONTGOMERY	LEFT THRU LANE/BOTH DIR	89/09	89/09	LIMITED SIGHT DIST
SALEM	100 & 683	PULASKI	LEFT THRU LANE/BOTH DIR	90/03	90/01	RES. ENGR. REQUEST (DOWNGRADE, TRUCKS)
STAUNTON	33 & 276/620	ROCKINGHAM	BOTH THRU LANES/BOTH DIR	86/04	85/07	ACCIDENTS
STAUNTON	17/50 & 340	CLARKE	BOTH THRU LANES/BOTH DIR	89/11	81/01	REQUESTED; ACCIDENTS
STAUNTON	522 & 739 S	FREDERICK	BOTH LANES/SB ONLY	89/11	79/06	REQUEST BY RESIDENCY; ISOLATED; HIGH SPEED; LARGE TRUCK SKIDS
STAUNTON	7 & 7 BUS	CLARKE	BOTH THRU LANES/BOTH DIR	92/04	89/08	RES. ENGR. REQUEST; ACC; NEAR ACC
BRISTOL	460 & 719 (MALL)	TAZEWELL	LEFT THRU LANE/BOTH DIR	89/03	83/12	MALL TRAFFIC; TRUCK TRAFFIC; DOWNGRADE
BRISTOL	23 & 23 BUS	WISE	LEFT THRU LANE/BOTH DIR	84/02	84/02	DOWNGRADE
BRISTOL	421/23/58 & 871	SCOTT	LEFT THRU LANE/BOTH DIR	87/06	87/06	HIGH VOL; HIGH SPEEDS; TRUCKS; ACCIDENTS
BRISTOL	23/23 BUS & 823	WISE	LEFT THRU LANE/BOTH DIR	87/06	87/06	SIGHT DIST.; HIGH SPEEDS; HISTORY OF ACCIDENTS; GEOMETRICS
BRISTOL	23/23BUS & 757	WISE	LEFT THRU LANE/BOTH DIR	87/12	87/12	HIGH SPEED; HIGH VOL; DOWNGRADES
BRISTOL	460 & ANCHORAGE	BUCHANAN	LEFT THRU LANE/BOTH DIR	91/08	91/08	ROADWAY GEOMETRICS
BRISTOL	19/460 BP & 640	TAZEWELL	LEFT THRU LANE/BOTH DIR ON RT 19 AND ON 460 BP	91/01	91/01	ACCIDENTS; HIGH VOL; HIGH SPEEDS ISOLATED
RICHMOND	33 & 249	NEW KENT	LEFT THRU LANE/BOTH DIR	88/10	88/05	STATE TRAFFIC ENGR REQUEST

TABLE 1 (CON"T)
STROBE LIGHT SURVEY RESULTS

DISTRICT	INTERSECTION	COUNTY	STROBE LOCATION (Q1)	STROBE INSTALLED (Q2A)	SIGNAL INSTALLED (Q2B)	REASON FOR INSTALLATION (Q3)
FRED'BURG	301 & 206	KING GEORGE	LEFT THRU LANE/NB	90/10	74/04	HEAVY TRUCK TRAFFIC; STEEP GRADE; ACCIDENTS
SUFFOLK	58 & 35	SOUTHAMPTON	RIGHT THRU LANE/BOTH DIR	93/04	90/08	ISOLATED SIGNAL; ACCIDENTS

*The Culpeper District had a strobe installed at Rte 29 & 29 Business (Culpeper County) for a 16-month period. The signal was removed in 1992 upon completion of an interchange to eliminate the intersection.

*The Lynchburg District's response indicated no strobe locations.

TABLE 1 (CON'T)
STROBE LIGHT SURVEY RESULTS

DISTRICT	MAINTENANCE (Q4)	WHEN TO USE STROBE (Q6)	NO. OF REQUESTS (Q7)
SALEM	INITIALLY HAD TROUBLE WITH CONTROL CIRCUITS--PROBLEMS HAVE DECREASED NOW ANNUAL PREVENTIVE MAINTENANCE PROGRAM	HIGH SPEED; LIMITED SIGHT	REASONABLE
STAUNTON	REGULAR PREVENTIVE MAINTENANCE PROGRAM	ISOLATED INT.; HIGH SPEED; POOR ALIGNMENT	2
BRISTOL	COMPLETE PREVENTIVE MAINTENANCE ANNUALLY ANY MALFUNCTION USUALLY POWER PACK ($$$)	ISOLATED INT; HIGH VOL; CURVES OR DOWNGRADE	NONE
RICHMOND	STROBES FAILED INITIALLY; NO PROBLEM 1 YR	LIMITED SIGHT; FOGGY OR LOW VISIBILITY AREAS	1/YR
FRED'BURG	NO PROBLEMS EXPERIENCED	HIGH SPEED W/ TRUCKS	NONE
SUFFOLK	NO MAINTENANCE THUS FAR	ISOLATED LOCATIONS; HIGH ACC	ONE REQUEST

Location of Strobe Light

At 17 intersections, the strobe light is in the red signal indicator over the left through lane. This location was selected based on the notion that the strobe light would be detected at a greater distance in the left through lane signal because horizontal curves and possibly overhanging foliage on the right shoulder might block the view of the right through lane signal.

At the 4 intersections in the Staunton District, strobe lights are in the red signal indicator over both through lanes. It is suspected that two strobe lights were used to enhance the visibility of these devices.

In Suffolk, the strobe light is in a separate red signal head next to the traffic signal over the right lane, a configuration that Suffolk District staff had observed in North Carolina and the City of Virginia Beach.

At 17 intersections, strobe lights were installed on both directions of the major roadway; at 4 intersections, the devices were needed in only one direction. Strobe lights were installed on all approaches at only 1 intersection.

At 9 intersections, strobe lights were installed with a new traffic signal; at 7, they were installed less than 12 months after a signal installation. Of the remaining 6 intersections, 5 had a traffic signal in place at least 3 years before the strobe light was installed.

Reasons for Installation

Reasons for installing the strobe lights included one or more of the following: (1) high truck volumes and high speed; (2) a high accident rate; (3) road geometrics, especially grades (downgrade), horizontal curves, and other features, that resulted in limited sight distance; and (4) an isolated intersection where a signal was unexpected.

Maintenance

Although maintenance of the strobe lights has generally not been a problem, certain districts reported that they had problems initially. In one district, the strobe light exploded because it failed to release stored energy; this was solved by using a strobe from a different manufacturer. In another district, there were a number of failures with the control circuits, which decreased after several discussions with the supplier and manufacturer. In a third district, a transformer exploded when the side-street strobe lights were flashing; these strobes were removed. One district noted that any malfunction was usually due to the power pack, which is relatively expensive (about $110).

The annual preventive maintenance routine typically includes cleaning the explosion guards, lenses, and reflector; replacing the incandescent lamp; and inspecting the seals for leaks that could result in water damage. Extreme care must be exercised because of the very high voltage in and around the strobe apparatus.

Indications for Use of Strobe Lights

When asked where strobe lights should be used, the DTE's responses were (1) at isolated intersections, (2) at locations with limited sight distance, (3) at high-speed locations, and (4) at locations with poor alignment, curves, and/or grades. A potential concern was that many requests would be made for strobe lights. However, the district offices have received very few. During the last 3 years, there have been only three requests statewide.

Respondents noted that potential uses of strobe lights include (1) with a hazardous indication beacon for a warning sign, (2) in school flashing lights, and (3) with emergency vehicles. In the Salem District, a strobe light in an amber lens was installed above a sign warning of "trucks crossing highway 800 ft" near a truck stop on Route 220 in Franklin County. There is limited sight distance (600 ft) southbound because of an upgrade.

Other Expressed Concerns

The Bristol District requested guidelines on when to remove strobe lights. There was some concern about liability in the event of an accident following removal.

Based on comments from some DTE staff, in some areas, motorists and VDOT personnel perceive strobe lights as effective in improving safety at an intersection. For example, DTE staff from one district commented that the strobe lights were especially useful at dawn and dusk and whenever visibility is poor.

Accident Analysis and Evaluation

Review of Accident Trends

Traffic and geometric data are shown in Table 2. All of the sites have a four-lane divided highway as the main approach.

Before-and-after accident data are shown in Table 3. For rear-end accidents, there was no change at four sites and an increase of 100 percent or more at two sites. At three sites, angle accidents decreased between 38 and 75 percent; at two sites, they increased 25 and 400 percent, respectively; and there was no change at one site. For total accidents, two sites each had no

TABLE 2

STUDY SITE TRAFFIC AND GEOMETRIC DATA

Site	No. Strobe Lights Per Approach	+ or T	Major Route Speed Limit kph	Major Route Speed Limit (mph)	Major Route Estimated ADT	Minor Route Speed Limit kph	Minor Route Speed Limit (mph)	Minor Route Estimated ADT
301/206	1	+	66	45	11,000	66	45	6,300
460/220 ALT	1	+	80	55	21,000	80	55	11,000
50/340	2	+	59	40	9,000	59	40	4,400
522/739 S	2	T	66	45	14,200	66	45	1,100
7/7 BUS	2	+	80	55	9,400	66	45	2,500
460/719	1	+	66	45	11,000	66	45	2,400

Note-- Sites 301/206, 460/220, and 460/719 are each in a different district. The remaining sites in the same district.

TABLE 3

SUMMARY OF ACCIDENT DATA

		REAR END ACCIDENTS				ANGLE ACCIDENTS				TOTAL			
				DIFFERENCE				DIFFERENCE				DIFFERENCE	
RTE #	COUNTY	BEFORE	AFTER	#	%	BEFORE	AFTER	#	%	BEFORE	AFTER	#	%
301/206	KING GEORGE	4	4	0	0	13	8	-5	-38	19	20	1	5
460/220 ALT	ROANOKE	2	7	5	250	1	5	4	400	3	15	12	400
50/340	CLARKE	4	4	0	0	8	3	-5	-63	13	7	-6	-46
522/739 S	FREDERICK	6	6	0	0	4	1	-3	-75	12	9	-3	-25
7/7 BUS	CLARKE	0	0	0	0	1	1	0	0	2	2	0	0
460/719	TAZEWELL	3	6	3	100	12	15	3	25	15	28	13	87

change, an increase of at least 80 percent, and a decrease of at least 25 percent, respectively. The accident experience at the Route 7 site was identical for both periods, and the number of accidents was the lowest of all the sites. Based on a review of the data trends for all six sites, there was no evidence to indicate that the strobe light had an impact on the incidence of accidents.

Three sites have one strobe light per approach, and three have two. Both sites where rear-end and angle accidents increased had one strobe light per approach. For total accidents, accidents increased more than 80 percent at two sites with one strobe light and decreased at least 25 percent at two sites with two lights per approach.

Although the sample size was too small to allow definitive conclusions, the use of two strobe lights per approach appears to be more effective than the use of one per approach. It seems logical that if two strobe lights reduced accidents then one would also reduce accidents, but possibly to a lesser degree. Because accidents tended to increase at sites with one strobe light, factors other than the strobe lights may have contributed to the increase. Thus, the study sites were further examined to determine what factors other than the strobe lights might have contributed to the accident experience. The following factors were considered:

- The intersection of Routes 460/220 ALT is in an industrial area with a high volume of trucks. The side street, which is a primary arterial, is being widened from two to four lanes. Subsequently, the intersection will be rebuilt to include dual left-turn lanes from the mainline in one direction and a sweeping right-turn lane in the opposing direction. The additional capacity should help reduce the number of accidents.

- The intersection of Routes 522/739 S was once the location of the first signal inbound near a town. Around the time the strobe light was installed, a new signal was installed about 670 m (2,200 ft) in advance of Site 4; therefore, it is no longer the first signal encountered. A right-turn lane was also added to the mainline.

- The intersection of Routes 660/719 has one leg of the side street for access to a shopping mall with heavy traffic, and the opposing side street approach has light traffic. In May 1994, two traffic signal changes were made to improve operations and safety at the intersection: the exclusive permissive left-turn signal phasing on the mainline was replaced with an exclusive left-turn phase, and a shared phase was replaced by split phases for the two side street approaches.

- The remaining sites are in rural areas with no distinguishing features.

It thus remains unclear whether there is a benefit for installing two strobe lights per approach compared to one.

TABLE 4

BEFORE VS AFTER Z TESTS

RTE #s	REAR END ACCIDENTS BEFORE	REAR END ACCIDENTS AFTER	Z	ANGLE ACCIDENTS BEFORE	ANGLE ACCIDENTS AFTER	Z	TOTAL ACCIDENTS BEFORE	TOTAL ACCIDENTS AFTER	Z	
301/206	4	4	0.00	13	8	-1.09	19	20	0.16	
460/220 ALT	2	7	1.67	1	5	1.63	3	15	2.83	*
50/340	4	4	0.00	8	3	-1.51	13	7	-1.34	
522/739 S	6	6	0.00	4	1	-1.34	12	9	-0.65	
7/7 BUS	0	0	0.00	1	1	0.00	2	2	0.00	
460/719	3	6	1.00	12	15	0.58	15	28	1.98	*

* Z > 1.96; THEREFORE THE TREATMENT IS HARMFUL

IF Z IS BETWEEN -1.96 AND +1.96, THE TREATMENT HAS NO EFFECT

A futile attempt was made to determine if there were any similar characteristics for sites with similar before and after accident trends.

Before-and-After Accident Analysis Using the *Z* Test

Comparison sites were identified for three of the six study sites, and a before-and-after accident analysis using the *Z* test was performed. The formula used for the *Z* test was[4]:

$$Z = A - B/(A + B)^{1/2}$$

where *A* is the after accident frequency and *B* is the before accident frequency. For a level of significance of 0.05, $Z_{0.05} = \pm\text{-}1.96$.

The results for rear-end, angle, and total accidents are shown in Table 4. For rear-end and angle accidents, there was no statistical evidence to indicate that the strobe light had an effect. In fact, for total accidents at two of the six sites, there was statistical evidence that the strobe light had a harmful effect. It was unclear why accidents increased significantly, but it is suspected that factors other than the strobe light were responsible. This demonstrates one of the shortcomings of a before-and-after accident analysis; it is assumed that the treatment was the cause of any change in accidents.

Before-and-After Analysis with a Comparison Group and a Check for Comparability

This evaluation design was used because it is more rigorous than a before-and-after design with a comparison group. The use of multiple before-and-after readings allows some relief from the regression toward the mean fallacy. The analysis procedure is described in detail in a report by Griffin[4] and in an evaluation of wide edgelines by the author.[5] It is described briefly here.

Step 1. Check for comparability. If the rate of change in the frequency of accidents (expressed as natural logarithms) does not deviate by more than chance expectation during the before and after periods, then the comparison group is appropriate. If the treatment and comparison groups are not comparable, then further analysis is terminated.

Step 2. Collapse the treatment and comparison groups across the before and after periods. If the rate of change in the frequency of accidents for the treatment and comparison groups does not deviate by more than chance expectation, then there is no evidence that the treatment affected the incidence of accidents. If the rate of change in the comparison group is more negative (or more positive), then the treatment was beneficial (or harmful).

These two steps are performed using the likelihood ratio chi-square test. A 2 x *n (n* is the total number of years of data) is partitioned into two parts: chi-square comparability and chi-square treatment.

The three treatment and comparison sites were as follows:

	Treatment	Comparison
1.	Routes 301/206	Routes 301/218
2.	Routes 522/739 N	Routes 522/739 S
3.	Routes 17, 50/340	Routes 522/340

Each treatment and comparison site share a common route and therefore experience similar traffic on at least one of the intersecting routes.

In the analysis of rear-end accidents, the after periods of the treatment and comparison sites were not comparable for site 1 and the before periods were not comparable for site 2. For site 3, the sites were comparable, and there was no statistical evidence that the strobe light was effective in reducing rear-end accidents.

For angle accidents, sites 2 and 3 and their respective comparison site were both comparable. Neither the before nor after period was comparable at site 1. For sites 2 and 3, there was no statistical evidence that the treatment was effective in reducing angle accidents.

The results of the total accident analysis were similar to those of the angle accident analysis; sites 2 and 3 and their respective comparison site were comparable, but there was no statistical evidence that the strobe light was effective in reducing accidents. For site 1, the after periods were not comparable.

Limitations of the Analysis

Strobe lights flash only when the red signals in which they are housed are on. Ideally, there should have been ways to ensure that the accidents under review occurred when the strobe light was flashing. Unfortunately, there is no reliable item on the standard police accident report form that provides such information. The item "driver action," which includes "disregard for the stop-go signal/ran the red light," is potentially useful. However, the majority of accidents under review had driver inattention, a catch-all description with little value, as the driver action. Although copies of the actual accident reports completed by the police would have been helpful in determining driver action, the reports for most of the accidents were more than 5 years old and not readily available.

Strobe lights were installed at locations with potential safety problems. These sites may have a propensity for higher than normal accident rates. The fact that the strobe light sites were selected for an atypical condition or their accident experience, rather than randomly, may explain in part why the treatment and comparison sites were not comparable in several instances.

Although the statistical analyses were presented, the power of the test is low because of the relatively small number of accidents at the test sites. Consequently, the results of the trend analysis were the basis for the conclusions.

Summary of Findings

Based on these analyses, it is concluded that there is no statistical evidence to suggest that the strobe lights were effective in reducing accidents. Based on the annual accident trends at the three treatment sites, there is no evidence that the effectiveness of the strobe lights diminished over time. Given the lack of evidence that strobe lights were effective, the absence of a trend of diminishing effectiveness is not surprising.

DISCUSSION

Driver Noncompliance and Strobe Lights

At the October 1993 meeting of the Traffic Research Advisory Committee, the top research priority identified by attendees was noncompliance with traffic control devices. It was noted that driver noncompliance, such as the running of red traffic signals, is increasingly common. Perhaps this type of behavior may be one factor that contributes to the lack of effectiveness of strobe lights.

Alternatives to Strobe Lights

Of the four reasons cited in the Introduction for installing strobe lights, three involve conditions where a traffic signal may not be expected. Such instances include an isolated rural intersection and the first signal after an extended road section without traffic signals. A method cited in the *MUTCD* to alert motorists to a traffic signal ahead is the use of a signal ahead warning sign (W3-3). Hazard identification beacons (flashing yellow lights) should supplement the sign to increase its attention-getting value. An alternative to the fourth application of strobe lights, conditions where visual noise is a problem, is the use of a back-plate to increase the signal target value.

One of the four reasons for installing strobe lights cited by the DTEs was road geometrics that limit sight distance. One alternative, the use of "prepare to stop when flashing" warning signs, is being tested in the Salem District.

CONCLUSIONS AND RECOMMENDATIONS

1. The results do not provide a basis for recommending the use of strobe lights. However, if other bona fide measures of effectiveness can be used to justify installing strobe lights, then they should be considered for use.

2. With regard to driver noncompliance, it is probable that willful, defiant behavior is not likely to be affected by the presence of a strobe light.

3. The conclusion that there is no evidence that strobe lights are consistently effective in reducing accidents can be used as justification for their removal.

4. VDOT's current focus on providing customer service and being responsive to the citizens of the Commonwealth may provide some impetus to continue to install strobe lights. One approach is to install devices requested by the citizenry if the devices do no harm. Engineering judgment is another factor that may cause the installation of additional strobe lights despite the findings of this study.

REFERENCES

1. West Virginia University, Department of Civil Engineering. *Accident Countermeasures at High-Speed Signalized Intersections: Phase I—Synthesis of Practice.* Morgantown, 1984.

2. Federal Highway Administration. *Manual on Uniform Traffic Control Devices.* Washington, D.C., 1988.

3. Virginia Department of Highways and Transportation, Traffic Engineering Division. *Correspondence to district engineers on strobe lights on traffic signals.* Richmond, June 30, 1985.

4. Griffin, L.I. III. *Three Procedures for Evaluating Highway Safety Improvement Programs.* Texas Transportation Institute, College Station, 1982.

5. Cottrell, B.H., Jr. *Evaluation of Wide Edgelines on Two-Lane Rural Roads.* Virginia Transportation Research Council, Charlottesville, 1987.

ACKNOWLEDGMENTS

The author thanks the following for their contributions toward this study: Jan Kennedy for data analysis; the DTE staff that responded to the survey or otherwise provided information; Mike Perfater for reviewing the draft report; and Linda Evans for report editing.

This technical assistance effort was funded with state planning research funds through the Federal Highway Administration.