TECHBRIEF

Pedestrian and Bicycle Safety

Comparison of Driver Yielding for Three Rapid-Flashing Patterns Used With Pedestrian Crossing Signs

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FHWA Contact: Ann Do, HRDS-30, (202) 493-3319, ann.do@dot.gov

Introduction

Flashing traffic control devices can help draw drivers' attention to the traffic control device and to the area around the device. An example of a device that has resulted in significant improvements in increasing driver yielding to crossing pedestrians is the rectangular rapid-flashing beacon (RRFB). Studies have been conducted in several locations, including Florida, Texas, Oregon, Michigan, Arizona, Wisconsin, and Calgary, AB. (See references 1 through 10.) These studies show a large range in the number of driver yielding responses for the RRFBs, extending from a low of 22 percent to a high of 98 percent. This wide range in yielding indicates that device, site, or roadway characteristics are potentially affecting the driver's decision to yield. Even with this wide range, the use of RRFBs has resulted in more drivers yielding to crossing pedestrians.

Although the RRFB is allowed under interim approval from the Federal Highway Administration (FHWA), there is growing interest in adding it to the *Manual on Uniform Traffic Control Devices* (MUTCD).[11,12] The Signals Technical Committee (STC) of the National Committee on Uniform Traffic Control Devices (NCUTCD), which assists in developing language for chapter 4 of the MUTCD, is interested in research and/or assistance in developing materials on the design, application, and effectiveness of the RRFB. The initial research studies did not address certain issues that the STC believes are important in crafting language suitable for the MUTCD. For example,

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

www.fhwa.dot.gov/research

will other flash patterns be just as effective as the initial flash pattern that was evaluated and approved by FHWA?

This TechBrief describes the methodology and results from an open-road study sponsored by FHWA that examined driver yielding behavior at crosswalks with three different flash patterns used with yellow, rapid-flashing beacons.

FHWA Interim Approval of RRFB

On July 16, 2008, FHWA issued Interim Approval 11 (IA-11) for the optional use of the RRFB at uncontrolled pedestrian and school crosswalks.[11] As defined in IA-11, the RRFB should consist of two rapidly and alternately flashing rectangular yellow indicators with light-emitting diode array-based pulsing light sources.[11] When IA-11 was issued, the only flash pattern that had been tested was a pattern commonly called the 2-5 pattern as part of the initial evaluations conducted in Florida.[1] The name of the 2-5 pattern was developed based on the flash cycle of the beacon, which pulses two times on one side followed by five faster pulses on the other side. Because the 2-5 pattern appears to the human eye to be a 2-3 flash pattern, the IA-11 contained language describing a 2-3 pattern. Therefore, several devices were installed with the 2-3 pattern rather than the 2-5 pattern. Only after looking at the flash pattern using an oscilloscope were university researchers able to determine that the original devices had a 2-5 pattern, which led to FHWA changing the flash pattern from a 2-3 pattern to a 2-5 pattern in Official Interpretation 4(09)-21.[13]

Study Objective

An inability to accurately determine the number of pulses within the 2-5 RRFB pattern was later confirmed in a closed-course study.[14] The same study found that certain flash patterns—those that could be characterized as having limited or no dark periods within the flash pattern—negatively influenced the amount of time participants needed to identify a pedestrian's direction of travel at night. Participants needed more time to identify the pedestrian walking direction when a pattern had limited or no dark periods. Before developing the proposed provisions for incorporating a rapid-flashing beacon traffic control device into the MUTCD, it is important to determine which flash patterns are acceptable from the perspectives of driver yielding and flash pattern simplicity.[12] This study sought to determine whether less complicated flash patterns and flash patterns with different proportions of dark and light periods can be equally or more effective than the 2-5 pattern during daytime conditions. A reason for investigating patterns with increased dark periods is to study the effect that increased dark periods would have on driver yielding compliance.

Study Development

Study Sites

Based on a statistical analysis of past driver yielding data at RRFB locations in Texas, the research team estimated that it would take between 7 and 13 sites to obtain a sufficient sample of data to permit detection of at least a 5-percent difference in driver yielding.[5] Given available resources for the study, a total of eight sites were selected for testing.

The Texas cities of College Station and Garland, along with Texas A&M University, agreed to participate in the study by providing locations where the research team could install temporary equipment. Table 1 lists the sites included in this study. A goal was to try to match the distribution of site characteristics used in the original FHWA study on RRFBs.[1] For example, the research team preferred locations on multilane roads so that yielding behavior associated with the "multiple threats" issue could be observed. Because of limited ability to mount temporary beacons on overhead mast arms, the research team did not consider locations where the existing RRFBs are located on mast arms over the roadway.

Temporary Light Bar

To conduct an in-field evaluation of multiple flash patterns, the research team needed to be able to set the flash pattern and brightness of the beacons at the study sites in a quick, reliable, and consistent manner. Because of the difficulties with working with different equipment in different cities and unknown characteristics of the beacons at these locations (such as brightness), the research team designed temporary controllers for use with temporary light bars. In the field, the temporary light bars were mounted in front of existing RRFB light bars.

The temporary light bar setup was designed so that it was not obvious that the beacons being observed during the staged pedestrian crossings were any different from the permanent RRFB equipment. Figure 1 shows an example of the installed light bar being used by a staged pedestrian. Findings from a closed-course study indicate that brightness of the beacons can influence how quickly a participant can detect a pedestrian within a crosswalk.[14] Findings from another open-road study revealed that brightness affects driver yielding decisions.[7] Therefore, the same brightness level was used for all three flash patterns tested.

Flash Patterns

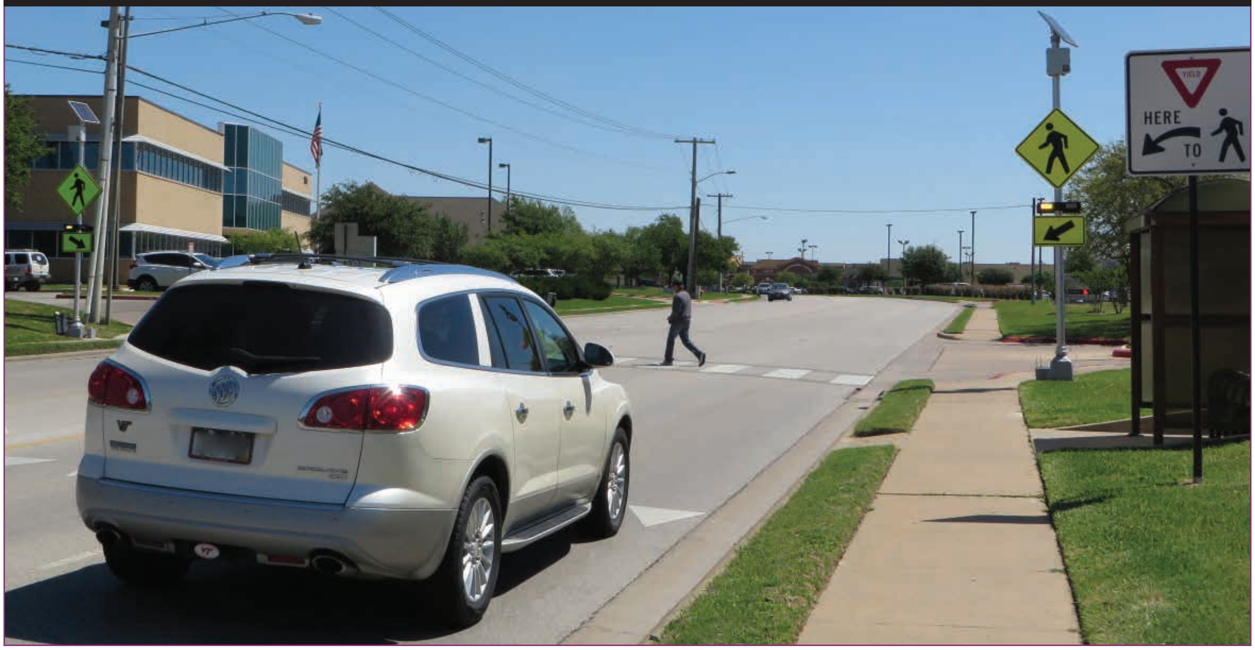
The study budget and parameters made it possible to test three different flash patterns

Table 1. List of sites for rapid-flash pattern study.

Site ID	Posted Speed Limit (mi/h)	Number of Lanes	Median	Crossing Distance (ft)
CS-02	40	4	TWLTL	56
CS-03	30	2	TWLTL	37
GA-02	40	4	LTL	58
GA-06	40	4	Raised	80
GA-07	45	4	Raised	82
GA-10	40	4	Raised	62
GA-11	40	4	Raised	62
GA-13	40	4	Raised	55

LTL = Left-turn lane.
TWLTL =Two-way, left-turn lane.

Figure 1. CS-02 study site with installed temporary light bars and staged pedestrian crossing.[15]



Source: Fitzpatrick.

at each study site with one of the patterns reserved for the baseline 2-5 flash pattern. To determine flash patterns for the other two conditions, a flash pattern workshop was held consisting of a selection of licensed transportation engineering professionals, representatives of FHWA, and Texas A&M Transportation Institute research staff. Several predeveloped patterns were shown to the participants. Based on participant comments, new patterns were developed. For example, some flash patterns were changed to have longer dark periods within the cycle, and some were changed to have periods where both beacons were on. Based on the meeting participants' comments, two potential patterns in addition to the 2-5 pattern were selected. These two patterns were demonstrated to FHWA representatives, and final approval was given.

Figure 2 shows the three patterns selected for testing in the field using the temporary light bars. The three conditions considered in this study include the following:

- Pattern using a combination of long and short flashes (called Blocks).
- Pattern using a combination of wig-wag and simultaneous flashes (called WW+S).
- The 2-5 pattern (called 2-5).

The order in which treatments are presented could have an effect on results; therefore, flash pattern order for the sites was randomized.

Figure 2. Flash patterns studied.[15]

Pattern	Blocks		WW+S		2-5	
Cumulative Time in Milliseconds (ms)	Left [a] (ms)	Right [b] (ms)	Left [a] (ms)	Right [b] (ms)	Left [a] (ms)	Right [b] (ms)
25	25		25		25	
50	25		25		25	
75	25				25	
100	25	25			25	
125	25	25		25	25	
150	25	25		25		
175	25					
200	25					
225	25		25		25	
250			25		25	
275					25	
300					25	
325		25		25	25	
350		25		25		
375		25				
400	25	25				
425	25	25	25	25		25
450	25	25	25	25		
475		25				25
500		25				
525		25	25	25		25
550			25	25		
575						25
600						
625						25
650						25
675						25
700						25
725						25
750						25
775						25
800						25
On time (ms)	300	300	200	200	250	300
Percent of cycle for a given beacon with the beacon on	38%	38%	25%	25%	31%	38%
On ratio = percent of cycle where at least one of the beacons is on	56%		37%		69%	
Off ratio = percent of cycle where both beacons are dark	44%		63%		31%	

Yellow cell = beacon is on for 25 ms

Gray cell = beacon is off

[a] **Left—time left beacon is on (ms),** [b] **Right—time right beacon is on (ms)**

Source: Adapted from Fitzpatrick.

Data Collection

The data were collected during daytime conditions in February and March 2014. The research team used a staged pedestrian protocol to collect driver-yielding data to present oncoming drivers with a consistent presentation of approaching pedestrians. Under this protocol, a member of the research team acted as a pedestrian using the crosswalk. Each staged pedestrian wore similar clothing (gray T-shirt, blue jeans, and gray tennis shoes) and followed specific instructions in crossing the roadway. A second researcher accompanied the staged pedestrian and was responsible for observing and recording the yielding data on datasheets. Additional details regarding the protocol are available elsewhere.(6)

The protocol specified the completion of a minimum of 20 staged crossing maneuvers in each direction of travel for each condition, which is a minimum of 40 total crossings for each condition and 120 total crossings at each study site. Observation periods were chosen so that vehicle traffic was heavy enough to create frequent yielding situations but not heavy enough for congestion to affect vehicle speeds. Researchers only collected data during daylight and in good weather, with a focus on avoiding rain, wet pavement following rain, dusk or dawn, or other conditions that affect a driver's ability to see and react to a waiting, staged pedestrian. In situations where a nonstaged pedestrian approached the crosswalk, data collection would stop momentarily, and the researcher would activate the temporary beacons for the pedestrian crossing.

Results

After completing the data collection, researchers returned to the office and entered the crossing data and the site characteristics data from the field worksheets into an electronic database. The average yielding rate for each flash pattern was calculated; however, data for individual crossings were used in the statistical evaluation. The average driver yielding rates for each flash pattern were as follows:

- Blocks: 80 percent.
- WW+S: 80 percent.
- 2-5: 78 percent.

When a driver approaches a crossing, the driver either yields and stops the vehicle or does not yield to the waiting staged pedestrian. This binary behavior (yield or no yield) can be modeled using logistic regression. A significant advantage of using logistic regression is that it permits consideration of individual crossing data rather than reducing all the data at a site to only one value.

From the preliminary review of the results above, it appears that there are only minor, if any, differences between the tested flash patterns. Because a previous study on RRFBs found that posted speed limit, crossing distance, and city influenced driver yielding, this analysis also considered those variables.(5)

The statistical analyses conducted using individual crossing data found that there are no significant differences between the tested flash patterns.

Conclusions

This study investigated whether different flash patterns used with an RRFB are associated with different driver yielding. For the three patterns tested (see figure 2), no statistically significant differences were found. A closed-course study found that drivers are better at judging pedestrian direction when there are more or longer dark periods within a flash pattern, suggesting an advantage in using a flash pattern with more or longer dark period(s).[14] The findings of this study indicated that the advantages of longer or more dark periods are not offset by a reduction in driver yielding (at least during the daytime conditions because data were only collected during daytime for this study). These findings suggest that the profession should consider using a flash pattern with increased dark periods when specifiying the pattern for RRFBs.

The findings from these research efforts were presented to the NCUTCD STC during its June 2014 meeting. STC recommended that the WW+S pattern be used with future rapid-flashing pedestrian treatments. Based on the findings from this research, FHWA issued an official interpretation on July 25, 2014, to permit agencies to use either the previously approved 2-5 flash pattern or the optional WW+S flash pattern.[16]

Although both flash patterns are available for use, the official interpretation mentions that FHWA favors the WW+S flash pattern because it has a greater percentage of dark time when both beacons of the RRFB are off and because the beacons are on for less total time. The greater percentage of dark time is important because drivers will be able to read the sign and to see the waiting pedestrian more easily, especially under nighttime conditions. The lesser total on time will make the RRFB more energy efficient, which is important because they are usually powered by solar energy.

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Researchers—This study was performed by Principal Investigator Kay Fitzpatrick along with Raul Avelar, James Robertson, and Jeff Miles. For more information about this research, contact Dr. Kay Fitzpatrick, Texas A&M Transportation Institute, 2935 Research Parkway, College Station, TX 77845-3135, k-fitzpatrick@tamu.edu.

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