

VERMONT AGENCY OF TRANSPORTATION

**Research & Development Section
Research Report**



**PEDESTRIAN HYBRID BEACON CROSSWALK SYSTEM (PHB)
OR HIGH-INTENSITY ACTIVATED CROSSWALK (HAWK)**

Report 2014 – 10

November 2014

**Pedestrian Hybrid Beacon Crosswalk System (PHB) or
High-Intensity Activated Crosswalk (HAWK)
Evaluation**

Initial Report

Report 2014 – 10

November, 2014

Reporting on Work Plan 2011-R-03

STATE OF VERMONT
AGENCY OF TRANSPORTATION

RESEARCH & DEVELOPMENT SECTION

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ABSTRACT

The Pedestrian Hybrid Beacon Crosswalk (PHB) is a type of traffic control system, used to aid pedestrians safely crossing the street and to regulate traffic flow. This study examines the success of the first PHB installed in the state of Vermont. Erected in Colchester, VT, the area is noted for its high traffic flow, as it connects the Fanny Allen Hospital to several travel destination points across VT Route 15. By measuring yielding compliance, approach speed and advance speed, this study seeks to monitor the safety and success of the Pedestrian Hybrid Beacon Crosswalk over a 3-year period.

After analyzing the results from the speed study, the Pedestrian Hybrid Beacon Crosswalk has proven more effective, and therefore safer, than having no system in place. Following installation of the PHB, yielding compliance increased by 18% on average, and an 83% increase was found in the number of vehicles slowing down as they approach within 300 feet of the crosswalk. Another pedestrian study will be performed in the future to determine if the system provides long-term benefits once drivers become used to the system.

INTRODUCTION

According to the National Highway Traffic Safety Administration (NHTSA), pedestrians represent a significant portion of traffic-related injuries and fatalities in the United States. In 2012, there were 4,743 pedestrian fatalities and 76,000 pedestrian injuries in traffic crashes. Relatively, a pedestrian was killed every 111 minutes and injured every 7 minutes on average (1). In an effort to reduce these alarming totals, numerous design guidelines and electronic traffic control devices have been developed.

In accordance with the 2009 Manual on Uniform Traffic Control (MUTCD), Section 4F.01, Pedestrian Hybrid Beacons (PHB), “A pedestrian hybrid beacon is a special type of hybrid beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk” (2). In an effort to increase pedestrian safety and driver awareness, the Vermont Agency of Transportation installed two PHB signals at a newly constructed crosswalk along Vermont Route 15 in the town of Colchester, VT.

The new crosswalk is located at the Fanny Allen Hospital entrance, which will allow for easy pedestrian access to destination points on the opposite side of VT Route 15 without risking safety by uncontrolled crossings. There may be a learning curve for drivers because this is the first installation of a PHB in Vermont. This particular model, a High intensity Activated crossWalk (HAWK) will allow both vehicular and pedestrian traffic to flow smoothly through the area with limited stopping by allowing pedestrians to cross the street and then permit drivers to proceed as soon as the pedestrians have passed. As can be expected with any new traffic light or disruption in traffic flow, associated confusion is a concern. As noted in a Federal Highway Administration (FHWA) report, “Safety Effectiveness of the HAWK Pedestrian Crossing Treatment” (FHWA-HRT-10-042), “Concerns have been expressed regarding confusion that may result from the dark beacon display, as some drivers may interpret it as a power outage. However, anecdotal experiences in Tucson, AZ have indicated that the dark display does not create such a problem.” (3)

The purpose of this study is to examine and evaluate the overall effectiveness of this pedestrian hybrid beacon crosswalk system.

PROJECT LOCATION AND SUMMARY

The HAWK was installed as part of the Colchester TCSP TSCE (8) improvement project at mile marker 0.8 along Vermont Route 15, a principle arterial route in the town of Colchester, VT. There are four travel lanes, two in each direction at this location separated by a median.

According to the contract plans, this project included installing the HAWK pedestrian hybrid beacon system, traffic signs, pavement markings, and other related items. The average annual daily traffic (AADT) is 26,900. Figure 1 below shows the plan view of the proposed improvement. The Hybrid Beacon Crosswalk System was installed on December 7, 2012.

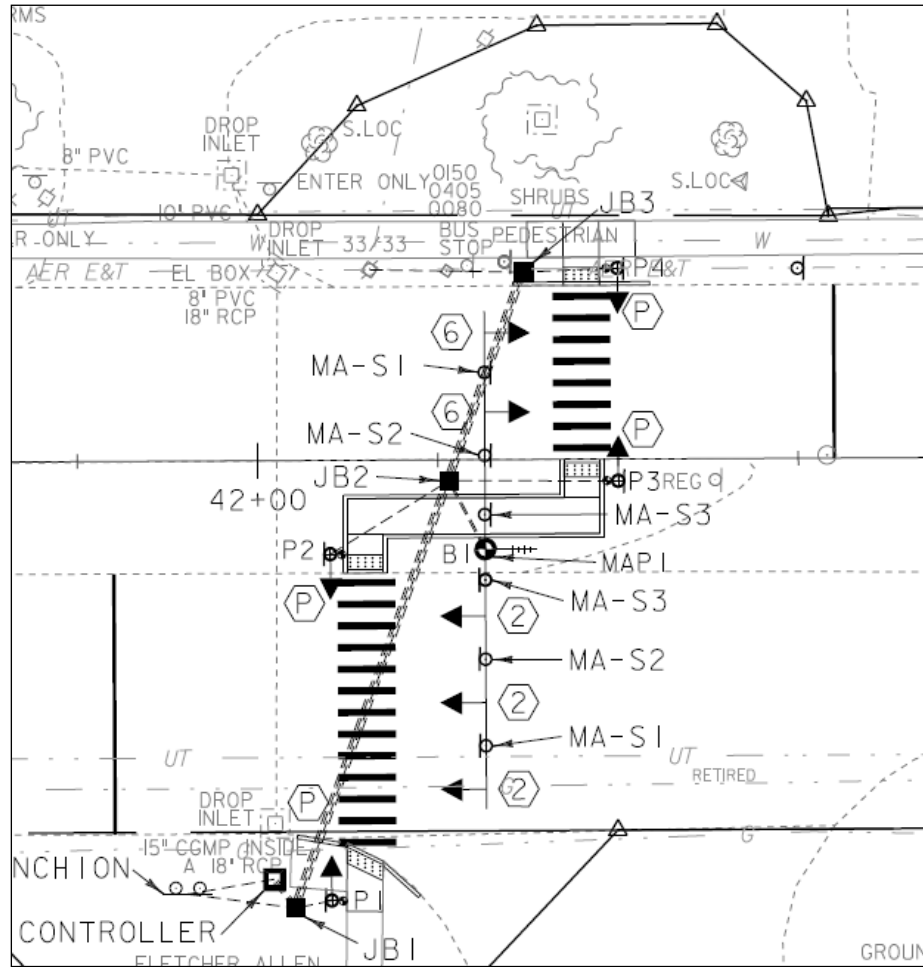


Figure 1. Plan view of the proposed improvement.

PRODUCT DESCRIPTION

According to a FHWA report, FHWA-HRT-10-042, the HAWK was developed by the city of Tucson, AZ in the late 1990s with the intention of decreasing pedestrian-vehicular traffic delay time (3). MUTCD section, 4F.02, Design of Pedestrian Hybrid Beacons (PHB), requires that, “A pedestrian hybrid beacon face shall consist of three signal sections, with a circular

yellow signal indication centered below two horizontally aligned circular red signal indications” (4). The standard further states that when a PHB is warranted “At least two pedestrian hybrid beacon faces shall be installed for each approach of the major street, a stop line shall be installed for each approach to the crosswalk, a pedestrian signal head conforming to the provisions set forth in Chapter 4E shall be installed at each end of the marked crosswalk, and the pedestrian hybrid beacon shall be pedestrian actuated” (5). The sequence of the PHB as shown in the MUTCD is shown below in Figure 2:

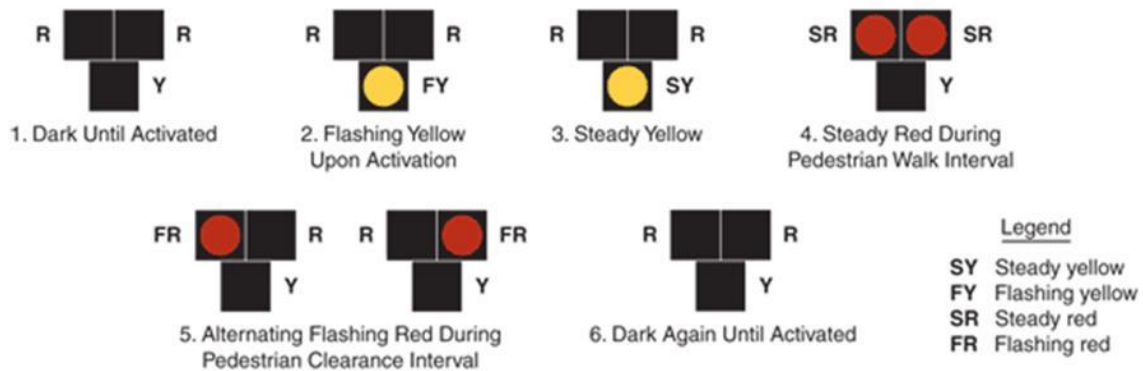


Figure 2. HAWK signal sequence (6).

The system will remain inactive and stay dark until a pedestrian pushes the button to cross. Once the system is activated, the sequence will begin. First, the vehicles will see flashing yellow, then steady yellow, and then steady double red. At this phase in the sequence the vehicles should stop. The signal will then flash in an alternating red flashing pattern during the pedestrian clearance interval. At this point, vehicles should proceed once pedestrians have cleared the roadway. The signal will then revert to dark until the button is pushed again (7).

PERFORMANCE AND OBSERVATIONS

Pedestrian Study Overview

This pedestrian crossing study was modeled after an evaluation completed by the City of San Rafael, CA. The study assessed changes in driver behavior attributed to a crosswalk enhancement system. “Before” and “after” studies evaluated differences in vehicle behavior pre-

and post-installation of the Pedestrian Hybrid Beacon Crosswalk System. Each study incorporated a Vermont Agency of Transportation member dressed in typical pedestrian clothing with two crossing scenarios. In scenario 1, the decoy pedestrian provided the impression that they were about to step in the crosswalk by looking in both directions. In scenario 2, the decoy pedestrian looked in both directions and placed one foot into the crosswalk, as shown in Figure 3. Oncoming traffic was visually monitored during these events in order to assess driver behavior. Each scenario was completed 200 times (100 times per lane direction).



Figure 3. Looking and stepping crossing scenario, pre HAWK installation.

The first study took place on May 30, 2012, six months prior to the HAWK installation. The “after” study was conducted on May 29, 2013, six months after installation. During both studies, weather conditions were sunny and clear, and the same individual was used as the decoy pedestrian.

Methodology was parallel in both studies. The first task was to delineate observation stations. This was done with painted stakes, marked out within a 500-foot stretch from the crosswalk in both the east and westbound directions. Observation stations are shown in Figure 4

below, which details the test area. After stations were set, the decoy pedestrian carried out the two crossing scenarios for both traffic directions. During this time, agency workers were taking observations 500 and 300 feet back from the crosswalk. All non-crossing Agency personnel were stationed to be as inconspicuous as possible while remaining safe.

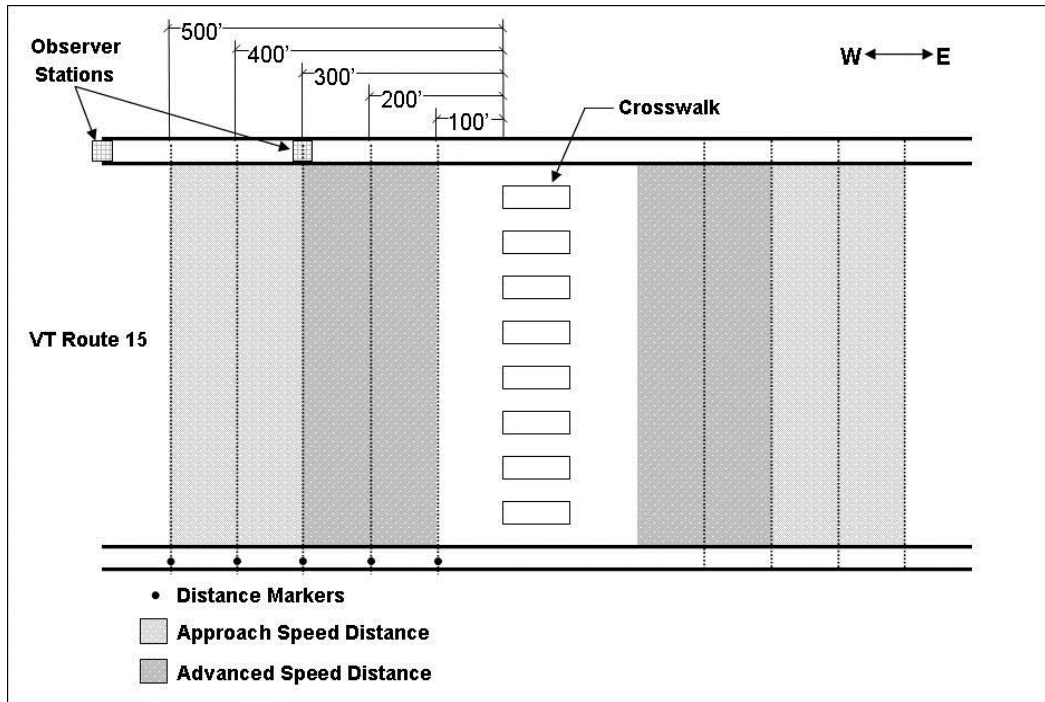


Figure 4. PHB study test area, for both pre- and post-installation experiments.

Numerical data was collected using a stopwatch. The time in seconds for the leading car to travel from the 500' - 300' from the crosswalk was recorded. This data was used to calculate the leading car's approach speed, in mph. The deceleration speed was calculated similarly, using the time to travel from the stakes marked off at 300 and 100 feet. Additional observations included the vehicle's first braking distance, its compliance to the crosswalk system, and state of licensure.

Data Analysis

All data was entered into a spreadsheet to be analyzed. Average speeds (miles per hour) were calculated by dividing the travel distance (feet) by travel time (seconds). All values were subsequently converted into miles per hour. Pre- and post-installation data was pooled together to develop a final summary, composed of roughly 800 data points. Results compared the test site before and after installation of the High-Intensity Activated Crosswalk. Data analysis yielded the

system's performance success through percent increase/decrease of vehicles yielding, and percent increase/decrease of approach and deceleration speeds. All definitions and data analysis are summarized below. Please note that all raw data is available upon request.

Approach Speed

The approach speed is the speed of the vehicle while approaching the crosswalk within a range of 300 to 500 feet. This value represents the travel speed of the vehicle prior to and/or as the driver is first able to see the pedestrian. At this point, the driver should recognize the need to start slowing down in preparation to stop at the crosswalk. It is calculated by dividing the distance travelled, (300 to 500 feet = 200 feet) by the time in seconds, it took the vehicle to travel the distance.

A graphical representation for the system exhibiting the average approach speeds for both east and westbound travel directions are showing below in Figure 5. It should be noted that this figure includes speeds of all vehicles whether they yielded to the decoy pedestrian or not. A breakdown of each scenario for the two directions is provided following Table 1. Trends within the data show that vehicles are approaching the crosswalk faster by about 7 mph from the eastbound direction than the westbound direction. A traffic signal located 530 feet away from the crosswalk in the westbound approach is causing traffic that was stopped by the signal to be approaching much slower. Approach speeds during the looking only scenario were near identical for both pre and post-HAWK, while speeds were higher (about 5 mph) with the system in both directions for the look and step scenario.

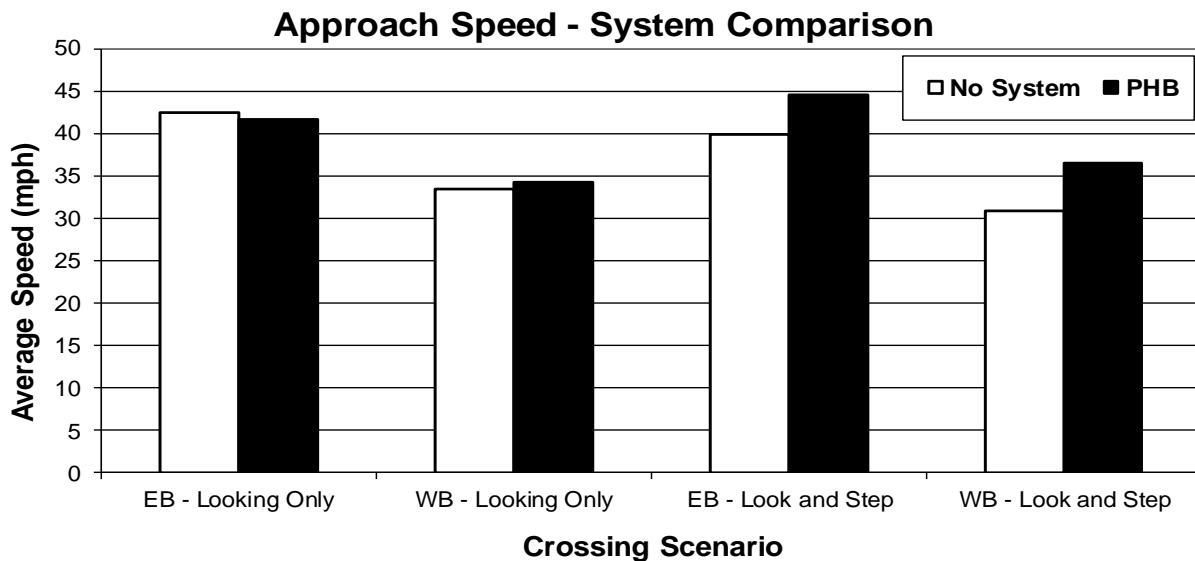


Figure 5. Average approach speeds.

Table 1. Average approach speeds (mph) and associated standard deviations.

System	EB Look only		WB Look Only		EB Look Step		WB Look Step	
	Average	Std Dev	Average	Std Dev	Average	Std Dev	Average	Std Dev
None	42.4	6.1	33.5	5.7	39.9	4.0	30.9	6.5
PHB	41.6	5.4	34.3	7.3	44.5	5.4	36.5	8.3

The standard deviation for all systems in both directions and crossing scenarios are comparable and reasonable as to suggest a small amount of variability within the data sets or in this case driver response. While the average speeds are below (westbound) or slightly above (eastbound) the posted speed limit, the standard deviations imply that some portion of the study population is traveling well above the speed limit of 35 mph assuming normal distribution. This evidence supports the need for an advanced warning system.

Deceleration Speed

The deceleration speed is the speed of the vehicle within the distance of 100 to 300 feet in the advance of the crosswalk. This value represents the average speed that vehicles travel over the 200-foot distance. It is calculated by dividing the distance traveled, (100 to 300 feet = 200 feet) by the time, in seconds, it took the vehicle to travel that distance. This speed should reflect, when compared to the vehicle’s approach speed, whether or not it has begun to slow down once recognizing the pedestrian or signal being activated.

A graphical representation exhibiting the average deceleration speeds for both east and westbound travel directions are shown in Figure 6. It should be noted that the figure includes speeds of all vehicles whether they yielded to the decoy pedestrian or not. Averages and associated standard deviation results are shown in Table 2.

The standard deviation for all systems in both directions and crossing scenarios are comparable based on the average speed results. Once again, standard deviations are relatively small indicating consistent driver behavior.

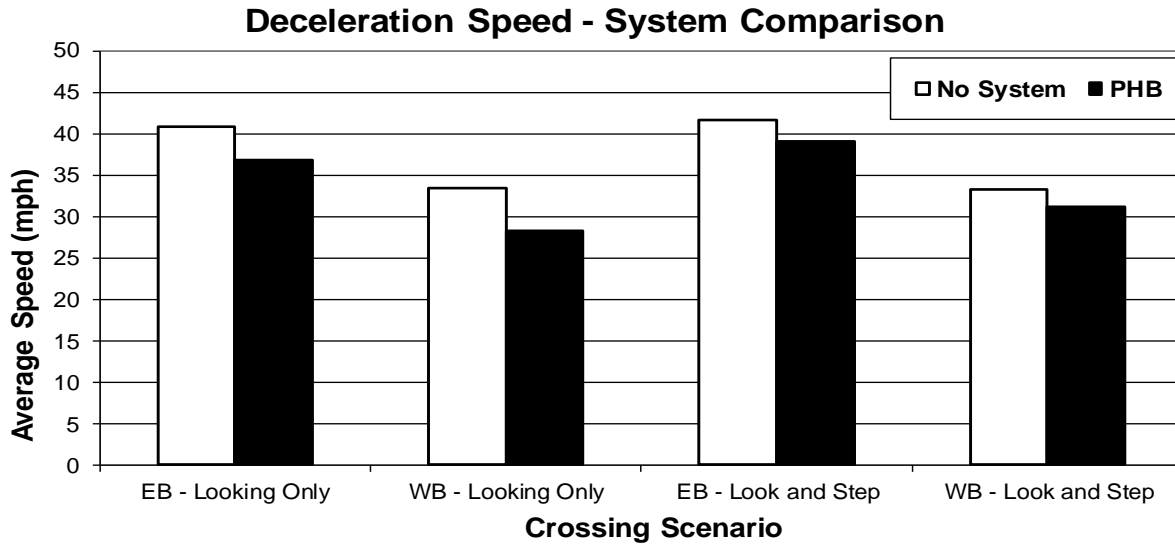


Figure 6. Average deceleration speeds.

Table 2. Average deceleration speeds (mph) and associated standard deviations.

System	EB Look only		WB Look Only		EB Look Step		WB Look Step	
	Average	Std Dev	Average	Std Dev	Average	Std Dev	Average	Std Dev
None	40.8	6.6	33.5	5.3	41.6	6.1	33.3	5.6
PHB	36.8	6.6	28.3	5.6	39.0	5.9	31.1	7.6

Approach and Deceleration Speed Comparison

Approach and deceleration speeds hold an interesting comparison. In theory, it could be expected that average approach speeds would be greater than average deceleration speeds, as at least some portion of the population would slow down for a pedestrian in a crossing scenario. However, with no system installed, the average deceleration speeds were actually greater (0.6 mph) than the approach speed average. (See Table 3.) This means that some portion of the driver population actually accelerated within a range of 100 to 300 feet in advance of the crosswalk.

Once the HAWK system was installed these trends changed considerably. With the HAWK installed the deceleration speed averaged 5.4 mph lower than the approach speed, a significant decrease, which proves the beacon had a significant effect on driver behavior.

Table 3. Average speeds through both directions and crossing scenarios.

	With No System	With HAWK Installed
Approach Speed	36.7	39.2
Deceleration Speed	37.3	33.8

A graphical comparison of the difference between approach and deceleration speeds is shown in Figure 7 and Figure 8. Figure 7 plots approach speed (x-axis) and deceleration speeds (y-axis) couplets on a scatter plot for the no-system pedestrian study, while Figure 8 shows them for the HAWK study. The diagonal lines in each figure represent approach speeds equaling deceleration speeds. The more data points that are present below the line, the more vehicles slowed down during the studies. It is evident from the plots that the data shifts below the line in general with HAWK, indicating many more drivers slowed down when the system was activated than previously had with the pedestrian only as the visual key. The data shows that only 85 vehicles out of 200 (43%) slowed down with no system while that number increased to 156 (78%) with the system.

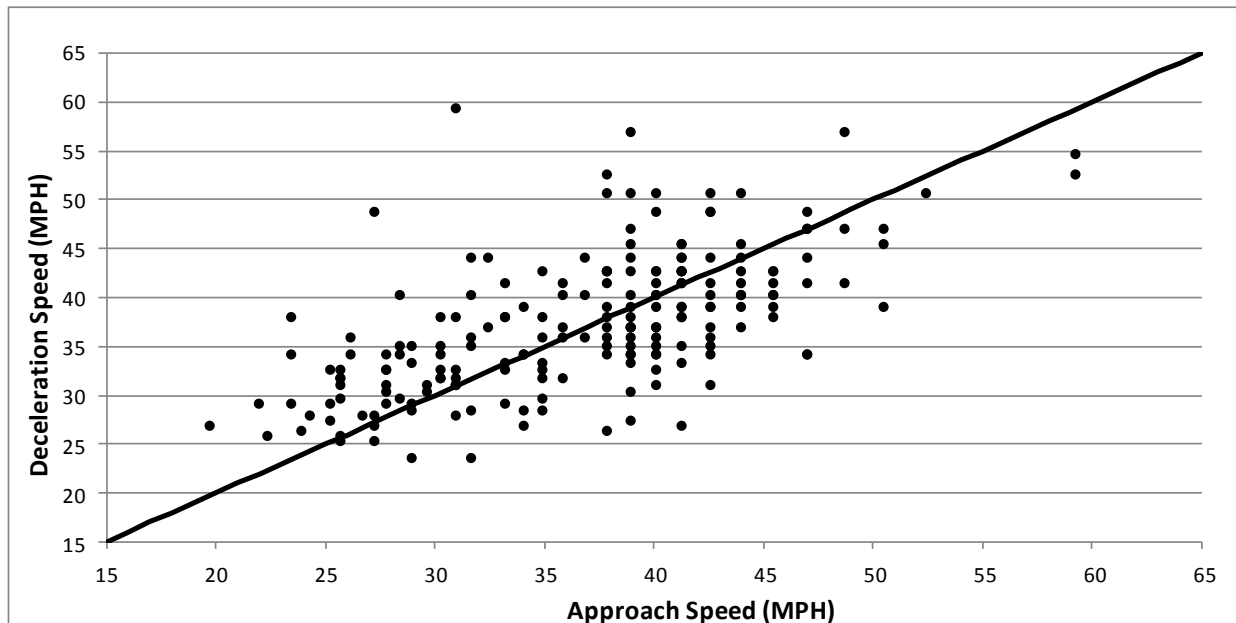


Figure 7. Deceleration vs. approach speed with no system.

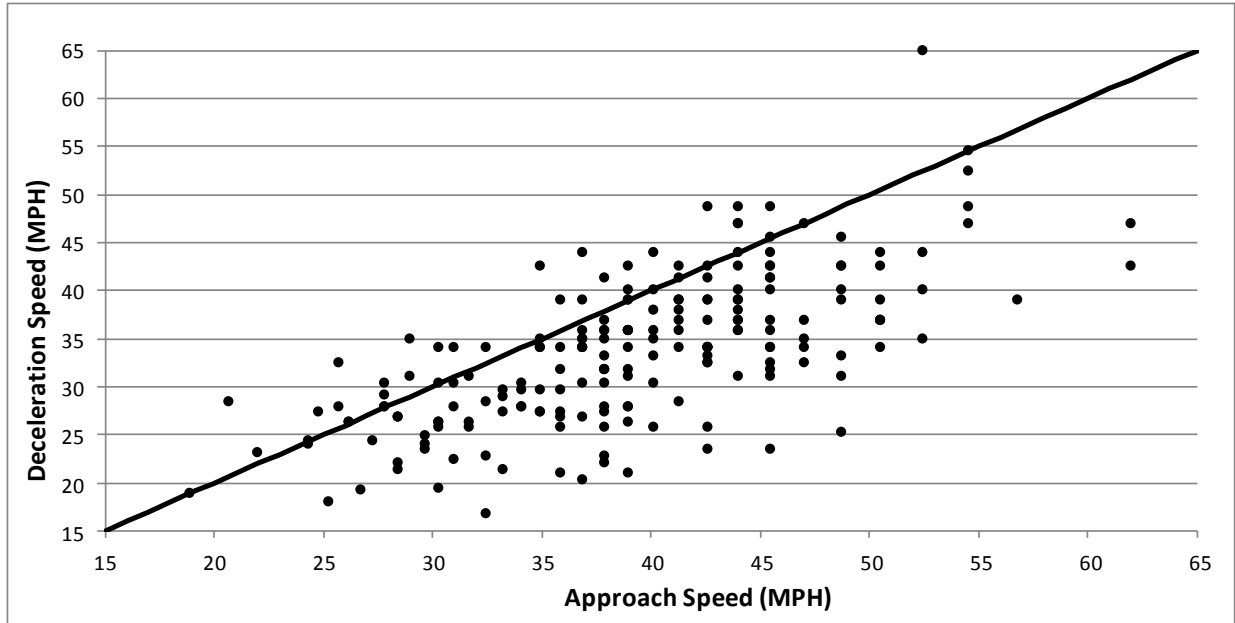


Figure 8. Deceleration vs. approach speed with HAWK installed.

Yielding Compliance

Yielding compliance is the percentage of vehicles approaching the crosswalk during the staged experiment that yielded/stopped for the pedestrian. Table 4 shows the percentage of vehicles that yielded for the staged pedestrian during each crossing scenario for both lane directions. The percent increase/decrease column represents the percent change in yielding behavior between no system in place and the HAWK.

For example, there was a 0% yielding compliance rate before the PHB was installed, in the looking only scenario for the eastbound direction. After the installation of the PHB, 12% of the eastbound vehicles yielded the lowest compliance rate with the beacon activated. Overall, the percentage of traffic that yielded to pedestrians increased following the installation of the pedestrian hybrid beacon crosswalk system. When no system was in place 4.5% of the overall traffic yielded, compared to 22.5% compliance with the activated PHB. The overall percentages are comprised of both directions and crossing scenarios. Of the two scenarios, it is interesting to note the considerable increase in driver compliance when the decoy pedestrian acts as if they are crossing the road by beginning to step out into the crosswalk; double the number of drivers yielded with stepping out than without with the system installed. This indicates that a subset of the population only complies with the flashing beacons when they feel compelled to avoid hitting a pedestrian.

Table 4. Vehicle yielding compliance.

Direction	No System	HAWK	Comparison
	% Vehicles Yielding	% Vehicles Yielding	% Increase / Decrease*
Looking Only			
EB	0%	12%	12%
WB	10%	18%	8%
Looking and Stepping			
EB	0%	28%	28%
WB	8%	32%	24%
Overall Average			
Overall	4.5%	22.5%	18%

System Comparison

After analyzing the results from the speed study, the Pedestrian Hybrid Beacon Crosswalk has proven more effective, and therefore safer, than having no system in place. Following installation of the PHB, yielding compliance increased by 18% on average. However, the data does not accurately portray the complete success of the advanced warning system. During the post-installation study, the majority of observed cars that did not yield were crossing through the intersection on a yellow light. Although approximately 87.5% of the time the drivers did not stop, 75% of the immediate following cars yielded to the pedestrian on red. Deceleration speeds were also affected by this, as vehicles accelerated closer to the crosswalk to pass through the intersection on yellow.

The results from the before and after PHB installation are promising. Although average approach speeds increased in some crossing scenario categories, the yielding percentages increased having a system in place. It is recommended that another round of observations be conducted two years after the previous round to examine the effectiveness of the signs over time. The follow-up will be used to determine if drivers get complacent and start ignoring the signals.

COSTS

The product material and installation costs were paid for through the construction project. The bid cost of the Pedestrian Hybrid Beacon Crosswalk unit was \$85,000. Bid cost of the entire construction project including mobilization, traffic control, the HAWK installation, related traffic signs, markings, and miscellaneous work totaled \$273,855.30. There have been no reported service calls or issues with the system since installation, which depicts a high reliability for the signal system.

SUMMARY AND RECOMMENDATIONS

The pedestrian study results are promising, showing increased yielding compliance and lower speeds from vehicles as they near the crosswalk. There have been no documented complaints from vehicular or pedestrian traffic. The system will continue to be examined for any visible damage, complaints and vehicular or pedestrian accidents, along with another pedestrian study conducted in the future. Further deployment should be considered at high pedestrian count unsignalized intersections or crosswalks.

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EXPERIMENTAL FEATURE WORKPLAN

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH SECTION

WORK PLAN FOR
RESEARCH INVESTIGATION
Pedestrian Hybrid Beacon Crosswalk System (PHB) or
High-Intensity Activated Crosswalk (HAWK)
Work Plan No. WP 2011-3

OBJECTIVE OF STUDY:

According to the National Highway Traffic Safety Administration (NHTSA), pedestrians represent a significant portion of traffic-related injuries and fatalities in the United States. In 2008 there were 4,378 pedestrian fatalities and 69,000 pedestrian injuries. Relatively, a pedestrian was killed every 120 minutes and injured every 8 minutes on average (1). In an effort to reduce these alarming totals, numerous design guidelines and electronic traffic control devices have been developed.

In accordance with the 2009 Manual on Uniform Traffic Control (MUTCD), Section 4F.01, Pedestrian Hybrid Beacons, “A pedestrian hybrid beacon is a special type of hybrid beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk” (2). In an effort to increase pedestrian safety and driver awareness the Vermont Agency of Transportation will install two PHB signals at a newly constructed crosswalk along Vermont Route 15 in the town of Colchester, VT.

The new crosswalk will be located at the Fanny Allen Hospital entrance which will allow for pedestrian traffic from the hospital to easily reach destination points across VT Route 15 without risking their safety by illegally crossing.. Although there will be a learning curve for drivers because this is the first installation of a Pedestrian Hybrid Beacon (PHB) in Vermont, the HAWK will allow both vehicular and pedestrian traffic to flow smoothly through the area with limited stopping by allowing pedestrians to cross the street and then permit drivers to proceed as soon as the pedestrians have passed. Confusion is a concern as can be expected with any new traffic light or disruption in traffic flow but as noted in a Federal Highway Administration (FHWA) report, “Safety Effectiveness of the HAWK Pedestrian Crossing Treatment” (FHWA-HRT-10-042), “Concerns have been expressed regarding confusion that may result from the dark beacon display, as some drivers may interpret it as a power outage. However, anecdotal experiences in Tucson, AZ have indicated that the dark display does not create such a problem” (3).

The purpose of this study is to examine and evaluate the overall effectiveness of a pedestrian hybrid beacon crosswalk system.

LOCATION:

The HAWK will be installed as part of the Colchester TCSP TSCE (9) improvement project at mile marker 0.8 along Vermont Route 15, a principle arterial route in the town of Colchester, VT. There are four travel lanes, two in each direction at this location. According to the contract plans, this project includes installing the HAWK pedestrian hybrid beacon system, traffic signs, pavement markings, and other related items. The average annual daily traffic (AADT) is 26,900. Figure 1 below shows the plan view of the proposed improvement.

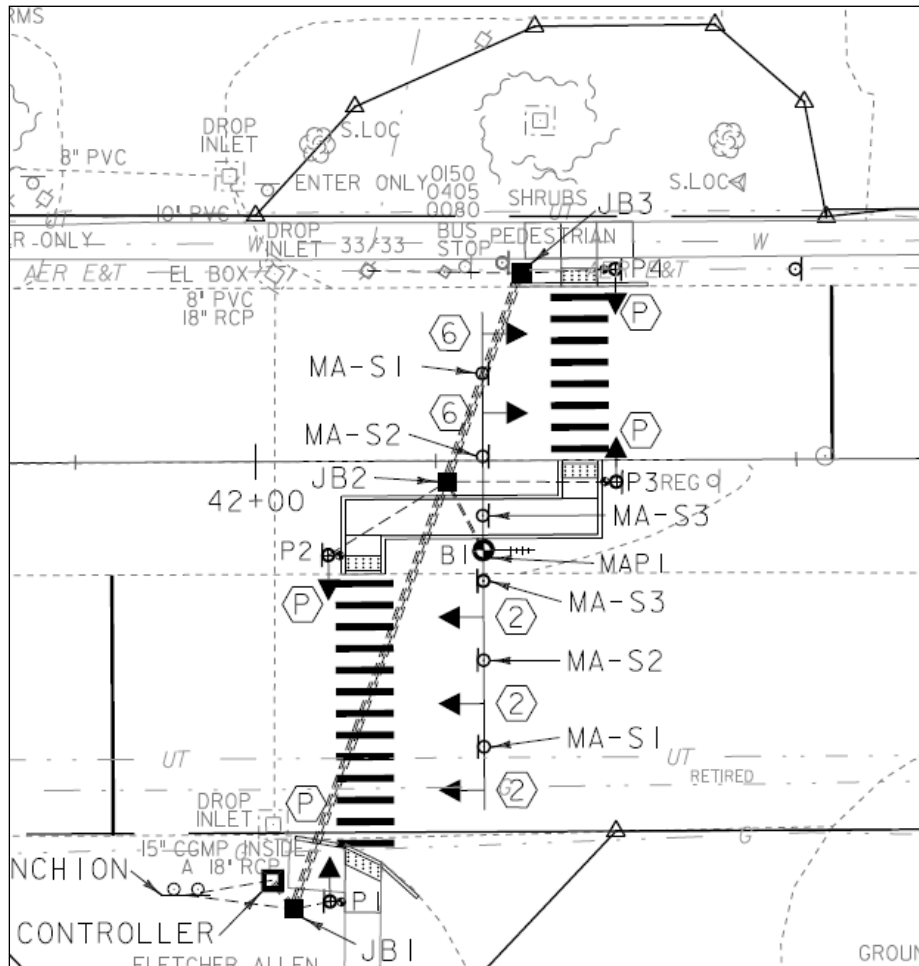


FIGURE 9 Plan view of the proposed improvement.

PRODUCT:

According to the FHWA report FHWA-HRT-10-042, the HAWK was developed by the city of Tucson, AZ in the late 1990s with the intention of decreasing pedestrian-vehicular traffic delay time (3). MUTCD section, 4F.02, Design of Pedestrian Hybrid Beacons (PHB), requires that, “A pedestrian hybrid beacon face shall consist of three signal sections, with a circular yellow signal indication centered below two horizontally aligned circular red signal indications” (4). The

standard further states that when a PHB is warranted then, “At least two pedestrian hybrid beacon faces shall be installed for each approach of the major street, a stop line shall be installed for each approach to the crosswalk, a pedestrian signal head conforming to the provisions set forth in Chapter 4E shall be installed at each end of the marked crosswalk, and the pedestrian hybrid beacon shall be pedestrian actuated” (5). The sequence of the PHB as shown in the MUTCD is shown below in Figure 2:

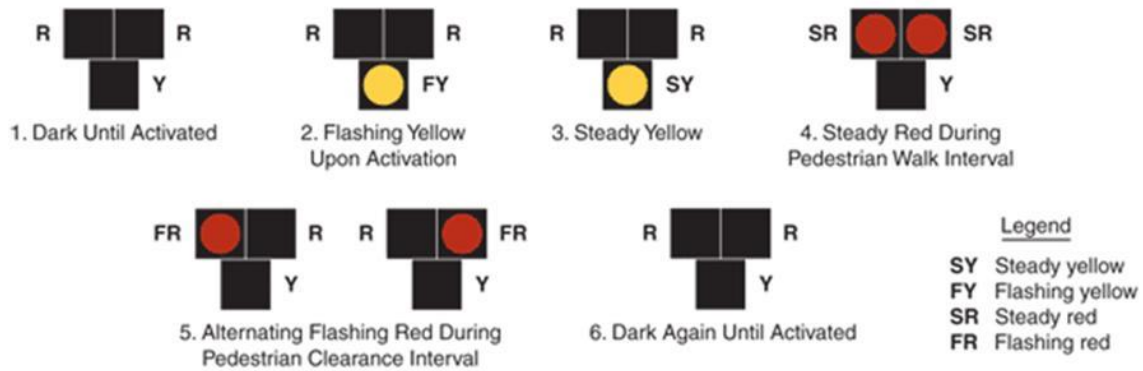


FIGURE 2 HAWK signal sequence (6).

The system will remain inactive and stay dark until a pedestrian pushes the button to cross. Once the system is activated, the sequence will begin. First the vehicles will see flashing yellow, then steady yellow, and then steady double red. At this phase in the sequence the vehicles should stop. The signal will then flash or “wig-wag” in an alternating red flashing pattern during the pedestrian clearance interval. At this point, vehicles should proceed once pedestrians have cleared the roadway. The signal will then revert to dark until the button is pushed again (7).

COST:

The cost product material and installation costs and will be paid for through the construction project.

SURVEILLANCE AND TESTING:

The experimental HAWK system will be monitored during placement in accordance with our Standard Specifications as well as with the manufacturer’s specifications.

Research personnel will periodically monitor the operation of the HAWK system and visually inspect the signals annually for the duration of the study. Research personnel will be present for any significant maintenance activities involving the materials to evaluate the ease and cost of those activities. The surveillance shall include the following:

- 1) Ease of installation of signals and hardware.
- 2) Visibility at installation and delineation performance under various light and weather conditions (daytime and nighttime performance).

- 3) Photographic documentation on the products performance and periodic assessments of operating needs of the system including service calls for the system.
- 4) Field evaluations will entail evaluating the behavior of traffic and pedestrians.
 - a. Vehicle Compliance: A pedestrian crossing study where a staged pedestrian will be placed at the crosswalk and observers will be placed at various distances from the crosswalk in both directions. The observers will record the reaction and compliance of the drivers to the pedestrian in the crosswalk. This will be evaluated prior to installation (No crosswalk or signal is present), post installation (2 months after the crosswalk and signals are in place), and finally three years after the post installation crossing evaluation. As recommended in a TCRP Report 112/NCHRP Report 562, "Improving Pedestrian Safety at Unsignalized Crossings" a minimum of 40 staged crossings in each direction will be observed (8).
 - b. Pedestrian Compliance: A pedestrian crossing evaluation will be completed based on a study conducted by Kansas State University where data will be collected manually at the site at different times in a particular week (9). For this study, the crossing evaluation will be conducted sometime midweek approximately 2 months post installation. The crosswalk will be observed from 8am to 8pm. Each time a pedestrian arrives at the crossing, their compliance as to whether or not they push the button, whether or not they wait for the walking phase (steady red for vehicles) in the HAWK sequence, and their reaction will be noted. Observers will be placed in an obscure place to decrease the potential for interference.
- 5) Crash data prior to and following installation will be analyzed with particular attention to the type and cause of crash and time of day. Analysis of this data will lead to a successful determination of whether or not the HAWK system is a beneficial safety addition to our roadways.

STUDY DURATION:

The duration of this study will be no more than three years or until final conclusions can be drawn from the field observations and crash data analysis.

REPORTS:

An initial report will be prepared once installation and the post-construction pedestrian crossing examination is complete. Interim reports will be prepared and submitted as needed, but not less than biannually. A final report will be published once the evaluation is complete.

Agency of Transportation
Materials and Research Section

Reviewed By:

William Ahearn P.E.
Materials and Research Engineer
Date:

**Approved by Material and Research on February 11, 2011 (WEA)
Approved by Federal Highway Administration on February 18, 2011 (CPJ)**

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