Countermeasure Strategies for Pedestrian Safety

Rectangular Rapid Flashing Beacons

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Lee Engineering

November 5, 2015

Today's Presentation

- **Introduction and housekeeping**
- **Audio issues?**
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Countermeasure Strategies for Pedestrian Safety Webinar Series

Upcoming Webinars

Pedestrian Hybrid Beacons

Thursday, November 12 (2:00 – 3:30 PM Eastern Time)

Leading Pedestrian Interval

Wednesday, December 2 (1:00 – 2:30 PM Eastern Time)

Pedestrian Safety at Interchanges

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RECTANGULAR RAPID FLASHING BEACON (RRFB)

DPS 201

CASE STUDY: RRFB (ST. PETERSBURG, FL)

Problem/Background

- Multi-lane, high-speed roadways
  - Conflicts at uncontrolled crosswalks
- Motorist yielding rates less than 2% at the city's 100 uncontrolled crosswalks
- Pedestrian injury rate higher than the county/state averages

CASE STUDY: RRFB (ST. PETERSBURG, FL)

Solution

- In 2003 city listed enhancements to uncontrolled crosswalks as top priority
- Vendor offered to install RRFB's at two locations
  - City agreed, conducted studies
- Cost was $10,000-15,000 dollars for purchase and installation, which was less expensive than other options

Michael Frederick, City of St. Petersburg, FL

CASE STUDY: RRFB (ST. PETERSBURG, FL)

Details

- Compared RRFB's with dual overhead round yellow flashing beacons and side-mounted round flashing beacons
  - RRFBs provided higher yielding compliance
- Also compared two-beacon and four-beacon RRFB systems
- In all cases, yield markings placed 30 feet before crosswalks

Before

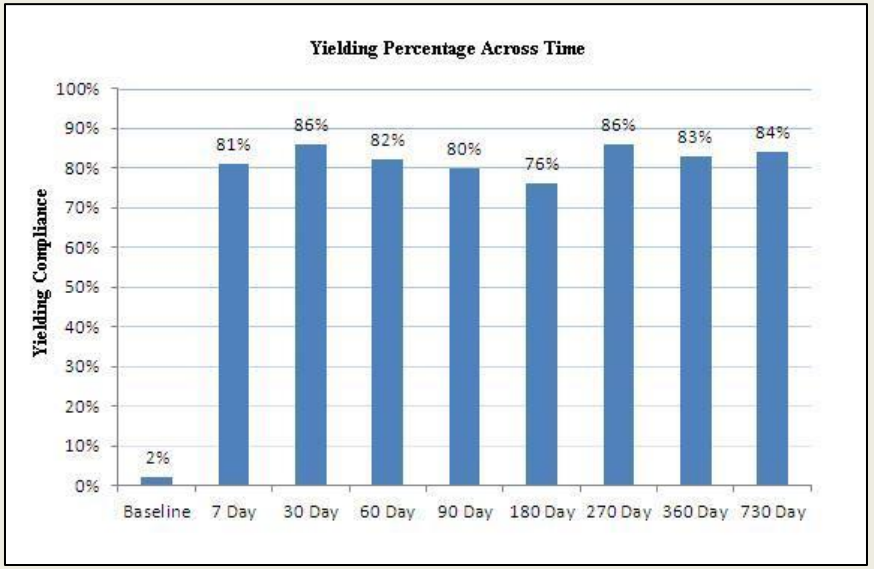
After

CASE STUDY: RRFB (ST. PETERSBURG, FL)

Results

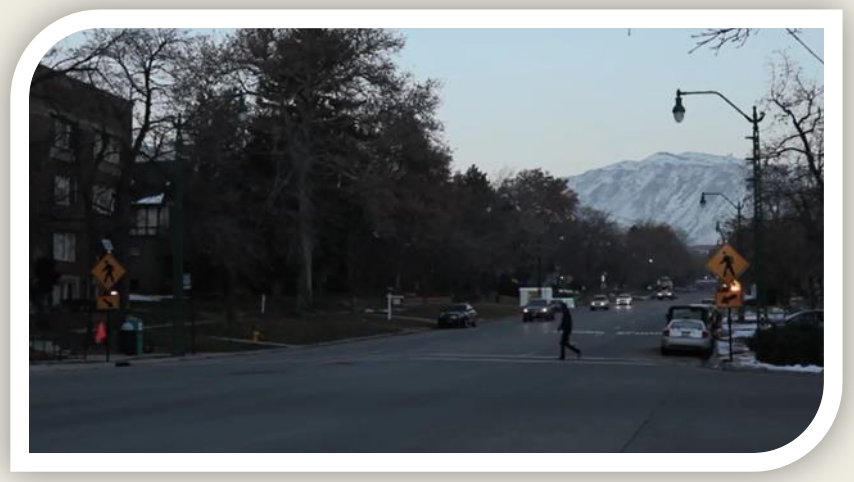
- Initial success led city to install 17 more RRFB's
- Two-year review of the crosswalks
  - RRFB's led to sustained yielding over time
- Performed equally well at night

- Four-beacon system had highest yield rates
- RRFB's also improved yield distance
- In May 2012 City had 42 RRFBs and plans for 20-30 more



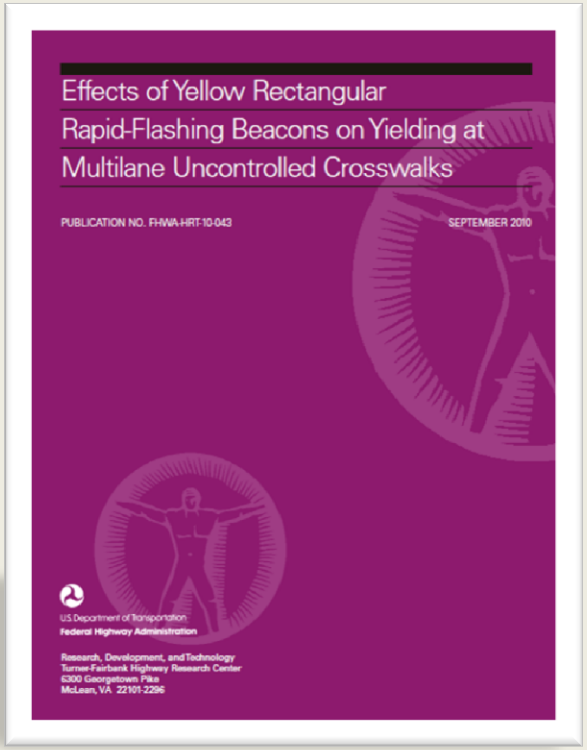
WHERE THEY'VE BEEN USED

- Mid-blocks crossings
- Uncontrolled intersection approaches
  - No language similar to MUTCD Section 4F.02 regarding the PHB installation
  - RRFBs may control both uncontrolled legs at an intersection
- RRFBs may be used at roundabout crosswalks
- Trail crossings



SAFETY CMF & RESEARCH

Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks (Publication No. FHWA-HRT-10-043) 2010



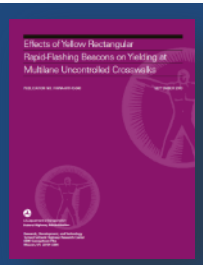

TECHBRIEF

Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks

RESEARCH

Objective

- Examine effects of side-mounted RRFB at uncontrolled marked crosswalks for driver yielding behavior
- 22 Sites in 3 Cities
  - St. Petersburg, FL
  - Washington, DC
  - Mundelein, IL
- 18 Sites studied for 2 years for long-term effects
- Compare RRFB with traditional overhead yellow flashing beacon and a side-mounted traditional yellow flashing beacon
- Identify ways to further increase effectiveness of RRFB

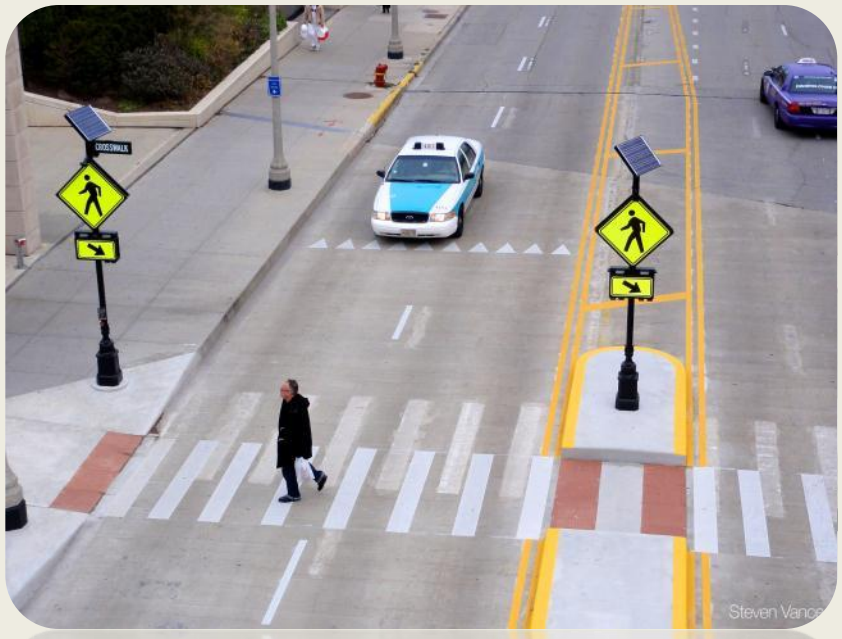


RESEARCH 5 EXPERIMENTS

- 1st compared both sides of the crosswalk (2 sets of beacons) to both sides of the crosswalk plus on the median island (4 sets of beacons).
- 2nd compared traditional overhead flashing beacon & traditional beacons mounted beside pedestrian signs
- 3rd long-term & short term effects - 18 sites in St. Petersburg, FL & 3 sites in two other parts of the country
- 4th efficacy of direct-aim technology allows RRFBs maximum brightness at particular point in roadway
- 5th Effects of additional RRFBs on crosswalk advance warning signs

MUTCD IA MEMO/RESEARCH

- Very high rates of motorist "yield to pedestrians"
  - RRFB - Mostly high 80% & close to 100%
  - 15 to 20% yield rate for standard yellow beacons
- Very high yield rates sustained after 2 years operation
- No identifiable negative effects



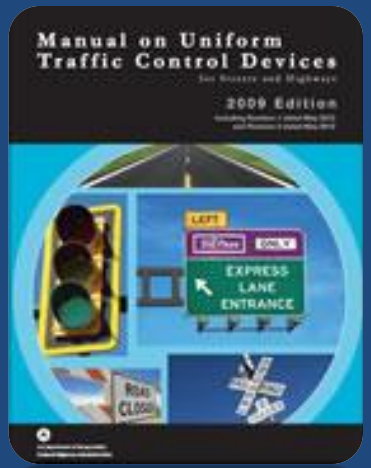
MUTCD IA MEMO/RESEARCH

- RRFB's very high compliance rates are previously unheard of for any device other than a full traffic signal and a pedestrian hybrid beacon (PHB)
- St. Petersburg data shows drivers yield much further in advance of crosswalk with RRFBs than with standard yellow flashing beacons

MUTCD IA MEMO/RESEARCH

- Data from locations other than St. Petersburg is limited but shows similar results
  - Data from DC shows driver yielding compliance rates increased from 26% to 74% after 30 days in operation
  - DC advance yielding distances increased comparable to St. Petersburg results
- Study of 2 RRFB locations in Miami-Dade County, FL (TRB paper) Following were significantly reduced to negligible levels:
  - Evasive conflicts between drivers and pedestrians
  - Percent of pedestrians trapped in the center of an undivided road due to non-yielding drivers in the second half of roadway

MUTCD INTERIM APPROVAL JULY 16, 2008



INTERIM APPROVALS VALID UNDER THE 2009 MUTCD

July 16, 2008 — Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11)

- Interim Approval (IA-11) Memorandum [HTML, PDF 84KB]
- St. Petersburg Experimentation Final Report [HTML, PDF 1.3MB]
- Florida DOT & St. Petersburg Request for Issuance of Interim Approval (excerpt) [HTML, PDF 347KB]
- December 9, 2009, Official Interpretation #4-376 (I) on Overhead Mounting of RRFB [HTML, PDF 85KB]
- August 12, 2010, Official Interpretation #4(09)-5 (I) on RRFB Use with W11-15 Sign [HTML, PDF 49KB]
- January 9, 2012, Official Interpretation #4(09)-17 (I) on RRFB Light Intensity [HTML, PDF 67KB]
- June 13, 2012, Official Interpretation #4(09)-21 (I) on Clarification of RRFB Flashing Pattern [HTML, PDF 3MB]
- August 8, 2012, Official Interpretation #4(09)-22 (I) on Flashing Pattern for Existing RRFBs [HTML, PDF 42KB]
- September 27, 2012, Official Interpretation #4(09)-24 (I) on Dimming of RRFBs during Daytime Hours [HTML, PDF 496KB]
- October 9, 2013, Official Interpretation #4(09)-37 (I) on Definition of Dimming [HTML, PDF 627KB]
- October 22, 2013, Official Interpretation #4(09)-38 (I) on RRFB Flashing Extensions and Delays [HTML, PDF 731KB]
- July 25, 2014, Official Interpretation #4(09)-41 (I) on Additional Flash Pattern for RRFBs [HTML, PDF 738KB]

http://mutcd.fhwa.dot.gov/res-interim_approvals.htm

INTERIM APPROVALS ISSUED BY FHWA

- Letter of request (on agency letterhead) addressed to the Director of the Office of Transportation Operations, FHWA. Send electronically as an e-mail attachment to: MUTCDofficialrequest@dot.gov.
- Remember to copy the FHWA Division office
  - Indicate blanket jurisdiction-wide approval or state the location(s) where the device will be used
  - A State may request Interim Approval for all jurisdictions in their State.

CONDITIONS OF INTERIM APPROVAL

- Must agree to:
  - Restore site(s) of Interim Approval to a condition that complies with the provisions in the MUTCD within 3 months following the issuance of a Final Rule on TCD
  - Terminate use at any time if it is determined a significant safety concern is directly or indirectly attributable to the device or application
- FHWA's Office of Transportation Operations has right to terminate the Interim Approval at any time if there is a safety concern

CONDITIONS OF INTERIM APPROVAL GENERAL CONDITIONS

The following design & operational requirements shall apply & shall take precedence over any conflicting provisions of the MUTCD

- RRFB shall consist of two rapidly & alternately flashed rectangular yellow indications having LED-array based pulsing light sources, and shall be designed, located, and operated in accordance with the detailed requirements specified

CONDITIONS OF INTERIM APPROVAL ALLOWABLE USES

- Shall only be installed as a Warning Beacon
  - see 2009 MUTCD Section 4L.03 Warning Beacon
- Shall only be used to supplement a W11-2 (Pedestrian), W11-15 (Trail) or S1-1 (School) crossing warning sign with a diagonal downward arrow (W16-7P) plaque, located at or immediately adjacent to a marked crosswalk
- Shall not be used for crosswalks controlled by YIELD or STOP signs, or traffic signals.
- May be used at a crosswalk across the approach to or egress from a roundabout controlled by YIELD signs.

CONDITIONS OF INTERIM APPROVAL ALLOWABLE USES

- If sight distance approaching crosswalk is less than deemed necessary by the engineer, an additional RRFB may be installed in advance of the crosswalk to supplement a W11-2 (Pedestrian), W11-15 (Trail), or S1-1 (School) crossing sign with an AHEAD (W16-9P) plaque.
  - Additional RRFB shall be supplemental to and not a replacement for RRFBs at the crosswalk.

CONDITIONS OF INTERIM APPROVAL SIGN/BEACON ASSEMBLY LOCATIONS

- For any approach where RRFBs are used, two W11-2, W11-15 or S1-1 crossing warning signs (each with RRFB and W16-7p plaque) shall be installed at the crosswalk, one on the right side of the roadway and one on the left side of the roadway.
  - On a divided highway, the left side assembly should be installed on the median, if practical, rather than the far left side of the highway.
- RRFB shall not be installed independent of the crossing signs for the approach. The RRFB shall be installed on the same support as the associated W11-2 (Pedestrian), W11-15 (Trail) or S1-1 (School) crossing warning sign and plaque.

CONDITIONS OF INTERIM APPROVAL
DIMENSIONS & PLACEMENT SIGN ASSEMBLY

- Each RRFB shall consist of two rectangular-shaped yellow indications, each with an LED-array based light source. Each RRFB indication shall be a minimum of approximately 5 inches wide by approximately 2 inches high.
- The two RRFB indications shall be aligned horizontally, with the longer dimension horizontal and with a minimum space between the two indications of approximately seven inches (7 in), measured from inside edge of one indication to inside edge of the other indication.

CONDITIONS OF INTERIM APPROVAL
DIMENSIONS & PLACEMENT SIGN ASSEMBLY

- The outside edges of the RRFB indications, including housings, shall not project beyond the outside edges of the W11-2, W11-15 or S1-1 sign.
- The RRFB shall be located between the bottom of the crossing warning sign and the top of the supplemental downward diagonal arrow plaque, rather than 12 inches above or below the sign assembly.

CONDITIONS OF INTERIM APPROVAL BEACON FLASHING REQUIREMENTS

- Flash in a rapidly alternating "wig-wag" sequence
- RRFBs shall use a much faster flash rate.
- Specific exception to 2009 MUTCD Chapter 4L.01 requirements for the flash rate of beacons
- During each of its 70 to 80 flashing periods per minute, one of the yellow indications shall emit two rapid pulses of light and the other yellow indication shall emit five rapid pulses of light.
- A second WW+S flash pattern (Wig Wag + Simultaneous Flash) also allowed (July 2014 Interpretation)

CONDITIONS OF INTERIM APPROVAL BEACON FLASHING REQUIREMENTS

- The flash rate of each individual yellow indication, as applied over the full on-off sequence of a flashing period of the indication, shall not be between 5 and 30 flashes per second, to avoid frequencies that might cause seizures.
- The light intensity of the yellow indications shall meet the minimum specifications of Society of Automotive Engineers (SAE) standard J595 (Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles) dated January 2005.
- January 12, 2012 FHWA Interpretation – RRFBs shall meet the SAE J595 requirements for peak luminous intensity for Class 1

CONDITIONS OF INTERIM APPROVAL BEACON OPERATION

- Shall be normally dark
- Shall initiate operation only upon pedestrian actuation or detection
- Shall cease operation at a predetermined time after the pedestrian actuation or, with passive detection, after the pedestrian clears the crosswalk
- All RRFBs associated with a given crosswalk (including those with an advance crossing sign, if used) shall, when activated, simultaneously commence operation of their alternating rapid flashing indications and shall cease operation simultaneously

CONDITIONS OF INTERIM APPROVAL BEACON OPERATION

- If pedestrian pushbuttons (rather than passive detection) used to actuate the RRFBs, a pedestrian instruction sign with the legend PUSH BUTTON TO TURN ON WARNING LIGHTS should be mounted adjacent to or integral with each pedestrian pushbutton.

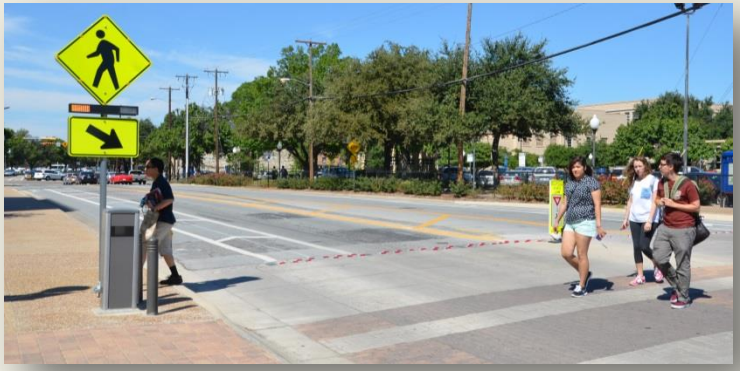
ACTUATION OPTIONS

- Push-button activated or passive detection
- Some, but not all of the accessible pedestrian signal features may be used at RRFB locations:
  - Locator tone
  - Message should only indicate beacon is flashing, not when pedestrians can cross.
- Passive detection options: bollards, video, microwave

ADDITIONAL DESIGN CONSIDERATIONS

NOT A SUBSTITUTE FOR GOOD DESIGN

- RRFBs are NOT a substitute for good crosswalk placement and design.
- The crosswalk is still the primary traffic control element that assigns ROW to the pedestrian.
  - Note that in the event a user does not activate the RRFB (assuming manual actuation) the crosswalk still assigns ROW to the pedestrian.
- RRFBs supplement the crosswalk - call attention to the crosswalk warning signs
- Pre-requisites for RRFB - Use best practices for:
  - Crosswalk placement
  - Pavement markings
  - Lighting



RRFB'S ON HIGHER VOLUME & SPEED STREETS IN ST. PETERSBURG

Roadway				Location	Number of Lanes	Median Y or N	Peak 8-hr Volume	24 Hour Volume	Posted Speed	Average 85th %ile Speed
Park	Street		@	Elbow Lane	5	N	10,719	31,133	40	47.6
38th	Avenue	N	w/of	18th Street	5	Y	15,590	30,750	40	46.9
4th	Street		@	Sunken Gdns	5	Y	16,164	29,333	35	48.0
22nd	Avenue	N	@	56th Street	4	N	14,675	25,370	40	43.0
37th	Street	N	@	Pinellas Trail	4	N	13,156	24,282	35	47.4
22nd	Avenue	S	e/of	40th Street	4	N	13,156	24,282	35	47.4

Since the initial "Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks" (Publication No. FHWA-HRT-10-043) was published in 2010, St. Petersburg has installed RRFBs in some higher-volume, higher-speed locations that test the "envelope" of where they may be applied.

Preliminary results: These have all performed well (75%+ Yield rates, no crash problem).

ALL OTHER RULES APPLY

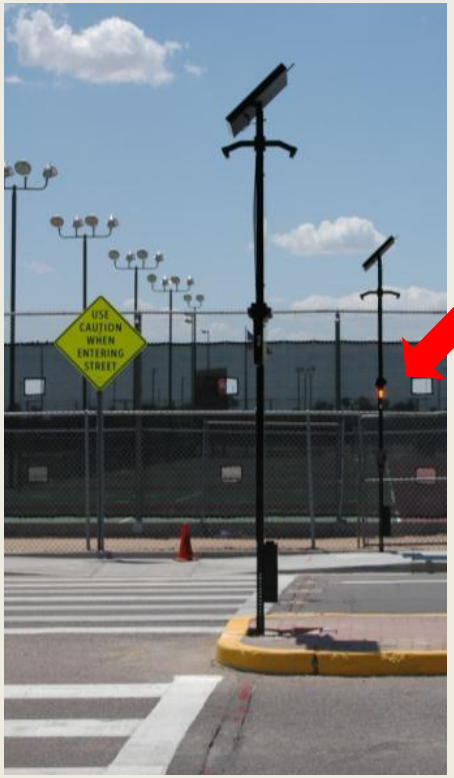
- All other rules for crosswalk placement and pavement marking apply (sight distance, advance stop/yield bar, lighting, clear pedestrian desire lines, etc.)

TIMING DURATION

- Flash duration of RRFBs should be based on the MUTCD procedures for start-up + clearance times at pedestrian signals
- MUTCD: Section 4E.06 Pedestrian Intervals and Signal Phases
- May allow peds to actuate RRFB immediately after a flash interval has ended

INDICATOR LIGHT FOR PEDESTRIAN

A small light directed at and visible to pedestrians in the crosswalk may be integral to the RRFB or push button to confirm the RRFB is in operation.



OVERHEAD PLACEMENT

- Overhead placement is an option
  - Permission originally for sight-obstructed shoulder mounting, but may supplement shoulder and median mounted beacons
- Effectiveness undetermined

DESIGN CRITERIA GUIDANCE

When there is a median (preferred for crossing multi-lane roads) a RRFB should be placed in the median

RESEARCH MEDIAN RRFB

- Standard yellow overhead beacon increased yielding compliance from 11 to 16 percent.
- Side-mounted RRFBs replaced the overhead beacon, yielding compliance increased to 78 percent.
- **Adding the RRFB to the median island increased yielding compliance to 88 percent.**
- Standard yellow side mounted beacons increased yielding compliance from zero to 16 percent.
- Side-mounted RRFBs increased yielding compliance to 72 percent.

ENFORCEMENT FOR NEW INSTALLATIONS

- New installations should be accompanied by education and enforcement
- Yielding compliance should be monitored by police
  - Exception - a new installation along a corridor with multiple beacons or in a community where RRFBs are common throughout
  - No specific threshold or standard but a logical approach is to continue enforcement until yield rates achieve 75%
  - Do added enforcement if yield rates drop precipitously

If there is internet connection click photo to go to YouTube news story of pedestrian enforcement in Orlando FL

COST

From PEDSAFE

Estimated Cost

Infrastructure	Description	Median	Average	Min. Low	Max. High	Cost Unit	# of Sources (Observations)
Flashing Beacon	RRFB	$14,160	$22,250	$4,520	$52,310	Each	3(4)

Easy to install since they communicate wirelessly and may be solar powered

CASE STUDY

CASE STUDY: RRFB PINELLAS TRAIL CROSSING

Problem

- Busy trail crossing for Peds and Bicyclists
- 4-lane urban arterial
- 15,000 ADT
- 1,300 to 2,000 trail users per day
- 80% bicyclists
- Yield Rate < 2%
- 18% of trail users waited in center of street for traffic to clear

CASE STUDY: RRFB PINELLAS TRAIL CROSSING

Solution

- Raised median
- RRFB installed on each side of the road and in median (2008)
- Push Button Activated
- Radio Controlled & solar-powered

CASE STUDY: RRFB
PINELLAS TRAIL CROSSING

Results

	Before	Not Activated	RRFB Activated
Motorist Yielding	2.9%	20%	79.8%

Trail Users

Stranded Before RRFB – 17.8%

Stranded After RRFB - 6.3%

QUESTIONS / RESOURCES

- Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks" (Publication No. FHWA-HRT-10-043) 2010
  - https://www.fhwa.dot.gov/publications/research/safety/pedbike/10043/10043.pdf
- MUTCD Interim Approvals
  - http://mutcd.fhwa.dot.gov/res-interim_approvals.htm
  - RRFB Specific
  - http://mutcd.fhwa.dot.gov/resources/interim_approval/ia11/fhwamemo.htm
- Before-and-after study of the effectiveness of rectangular rapid-flashing beacons used with school sign in Garland, Texas
  - http://www.texite.org/wpcontent/uploads/papers/Tech_Paper_Brewer_Fitzpatrick.pdf
- Driver-Yielding Results for Three Rectangular Rapid-Flash Patterns
  - http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/TTI-2014-5.pdf

Thank You!

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