



Florida Department of
TRANSPORTATION

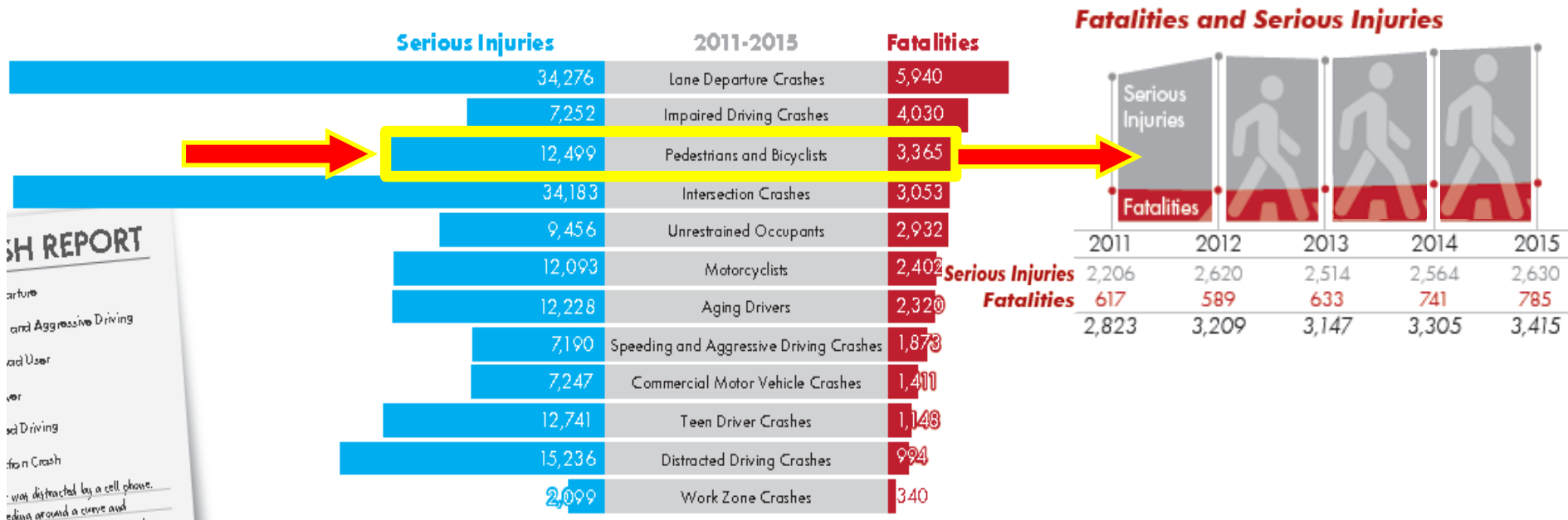
Improving Pedestrian Safety *with Engineering and Technology*

Trey Tillander and Alan El-Urfali
State Traffic Engineering and Operations Office

FSITE Winter Workshop
February 9, 2018

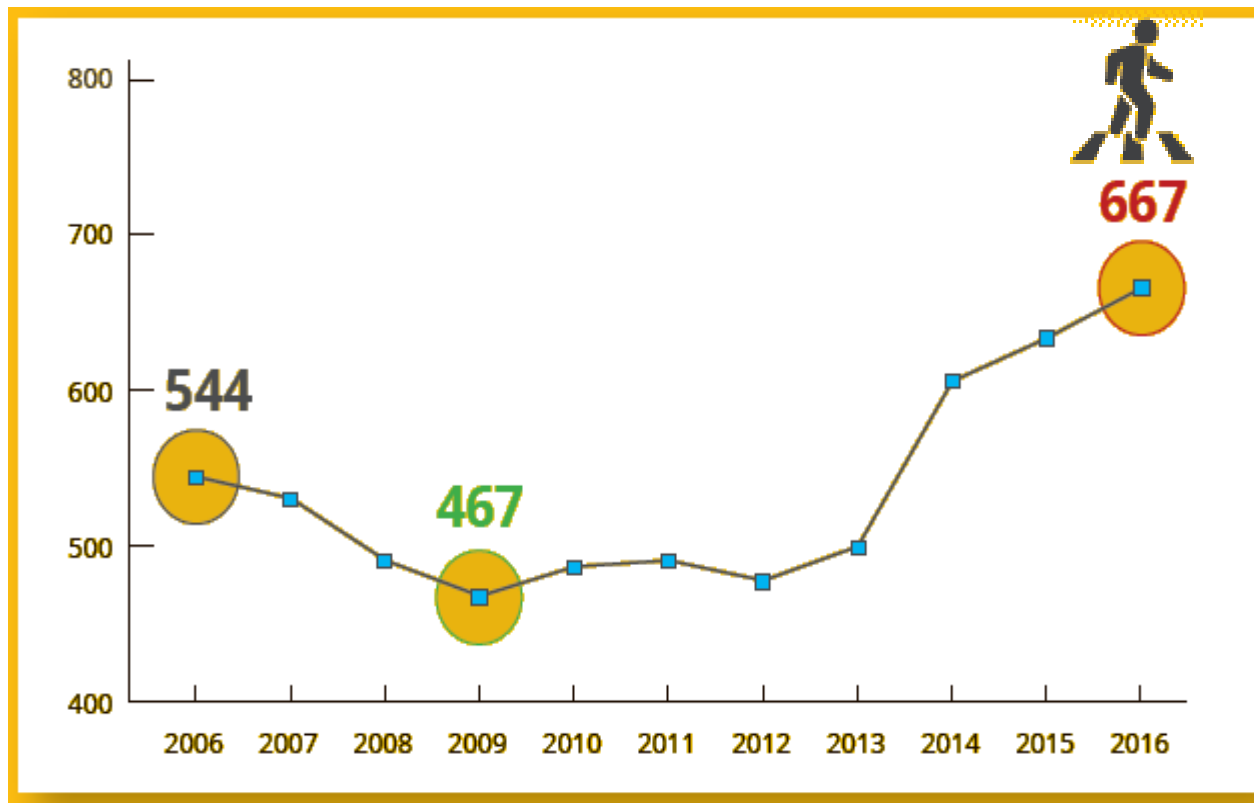
The State of Pedestrian Safety in Florida

- Florida ranks amongst the highest states in pedestrian fatalities and serious injuries
- Pedestrian and Bicycle-related crashes are an emphasis area within the Florida Strategic Highway Safety Plan



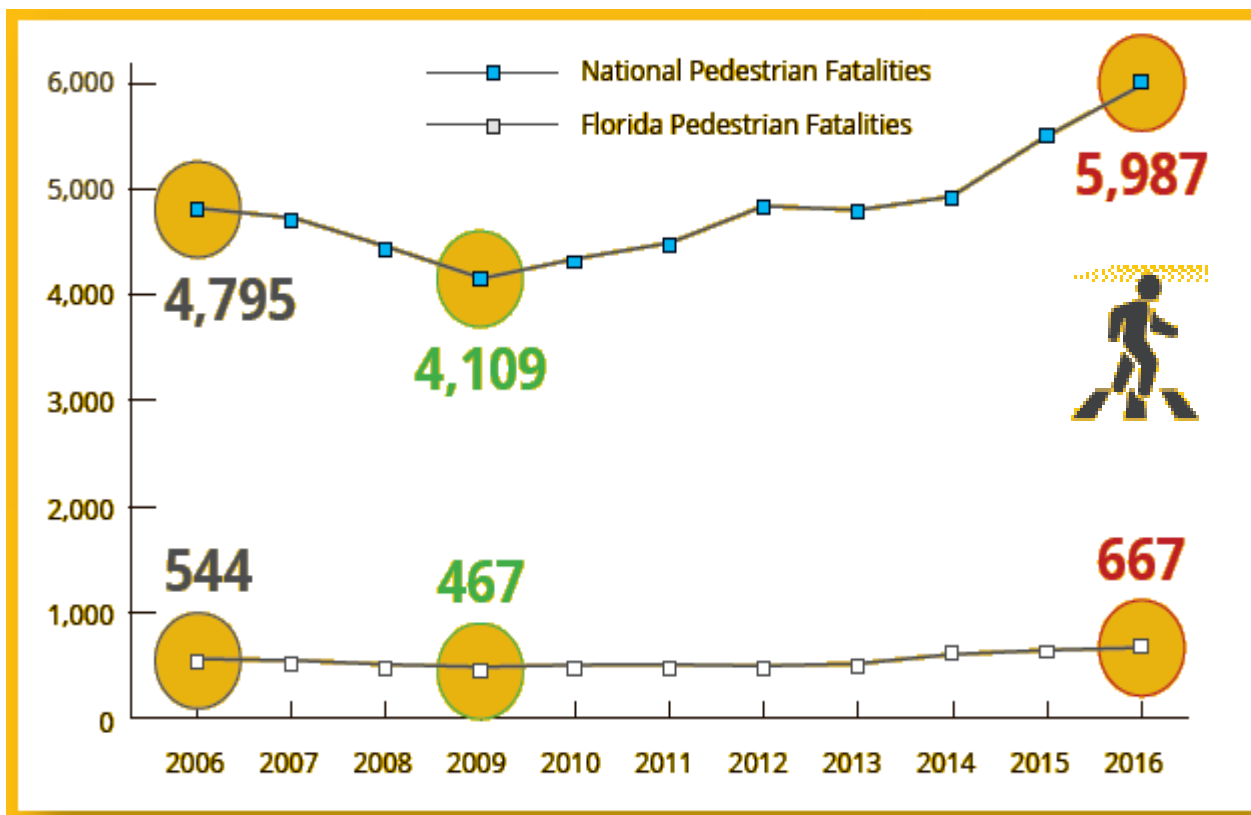
The State of Pedestrian Safety in Florida

Florida's Pedestrian Fatalities (2006 – 2016)



The State of Pedestrian Safety in Florida

Florida's Pedestrian Fatalities: A National Comparison (2006 – 2016)



Florida's Pedestrian and Bicycle Focused Initiative

A comprehensive 4 “E” approach that includes
***ENGINEERING, EDUCATION, ENFORCEMENT, and
EMERGENCY RESPONSE***

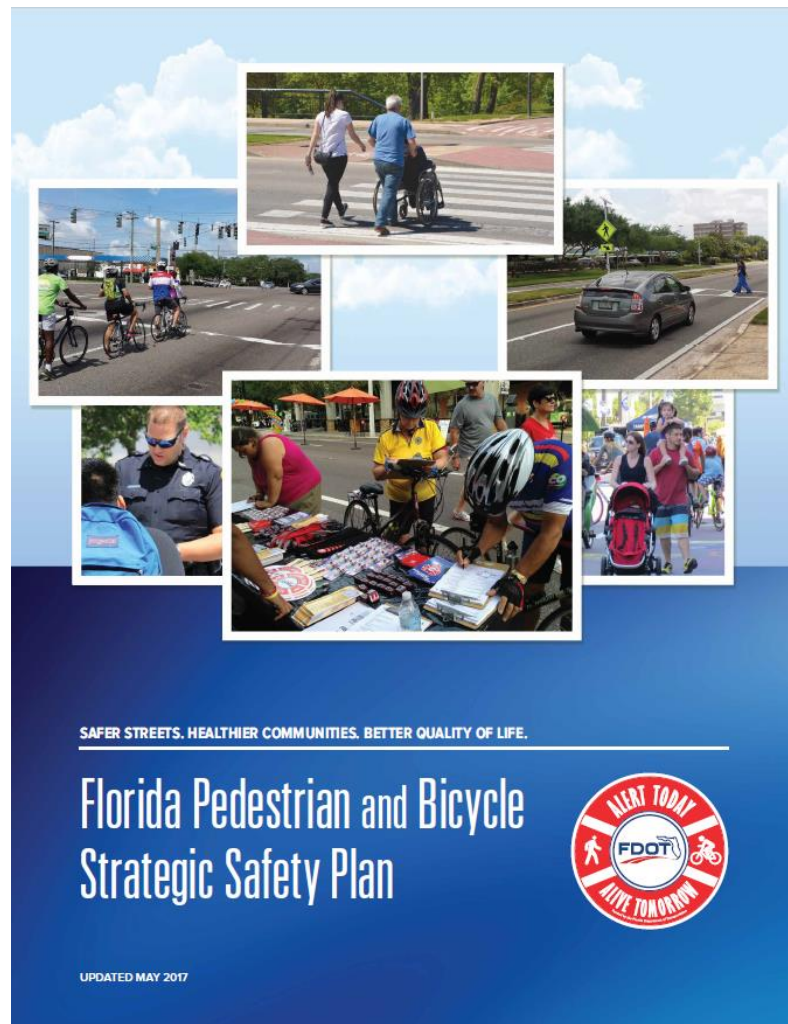
www.alerttodayflorida.com



Florida's Pedestrian and Bicycle Focused Initiative

Florida's Pedestrian and Bicycle Safety Coalition was formed to prioritize and implement the strategies identified in the *Florida Pedestrian and Bicycle Strategic Safety Plan*.

This diverse group represents many agencies and organizations that have a vested interest in pedestrian and bicycle safety in Florida.



Florida's Pedestrian and Bicycle Safety Coalition

FDOT

USDOT / FHWA

Florida Department of Health

Florida DHSMV / FHP

Florida Sheriff's Association

Florida Police Chiefs Association

USF Center for Urban Transportation

UF Transportation Technology Transfer (T2) Center

UNF Institute for Police Technology and Management

Florida State Judicial Outreach Liaison

Florida Bicycle Association

Florida Public Transportation Association

AAA

AARP

Best Foot Forward

Florida Emergency Medical Services for Children Advisory Committee

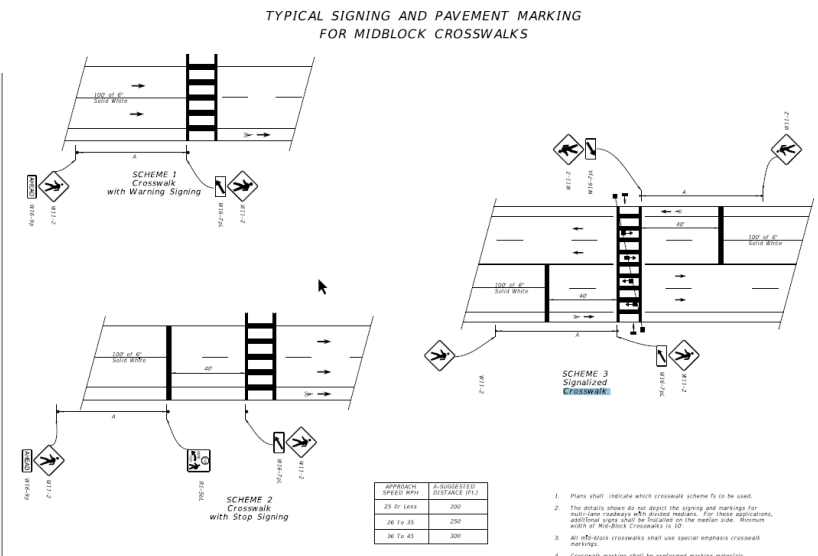
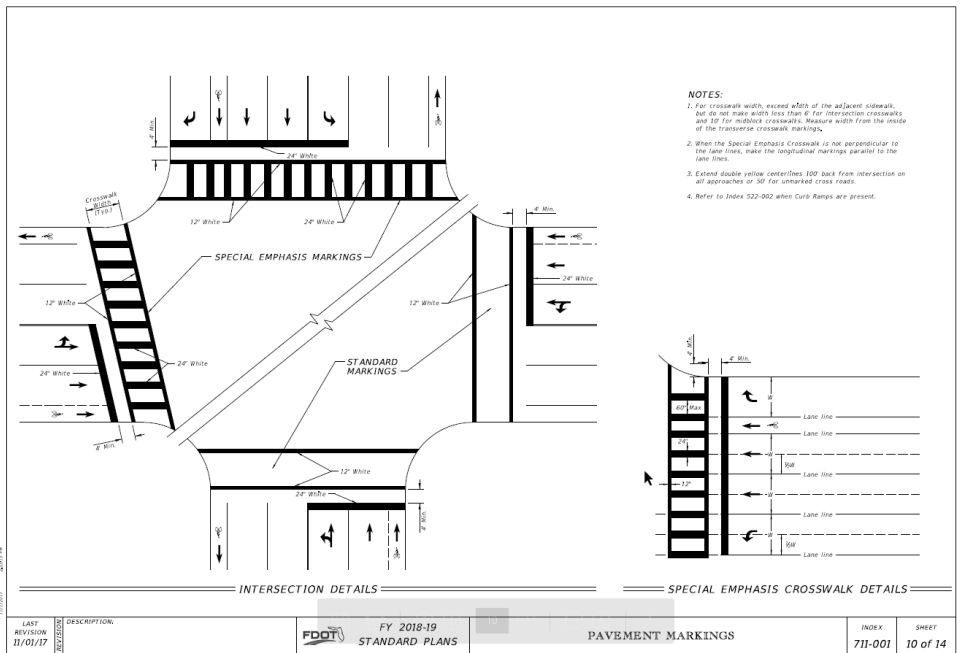
National Coalition for Safer Roads

Several Cities, TPOs, and Transit Agencies

Crosswalk Design Considerations

Pavement Markings for Crosswalks

- Use Special Emphasis crosswalk markings at signalized intersections on all approaches, mid-block crossings, and school crossings. **Standard Plans 711-001, Sheet 10 of 14**
- Use standard crosswalk markings for stop or yield-sign-controlled intersections where pedestrian facilities are present. **FDM Exhibit 230-1**



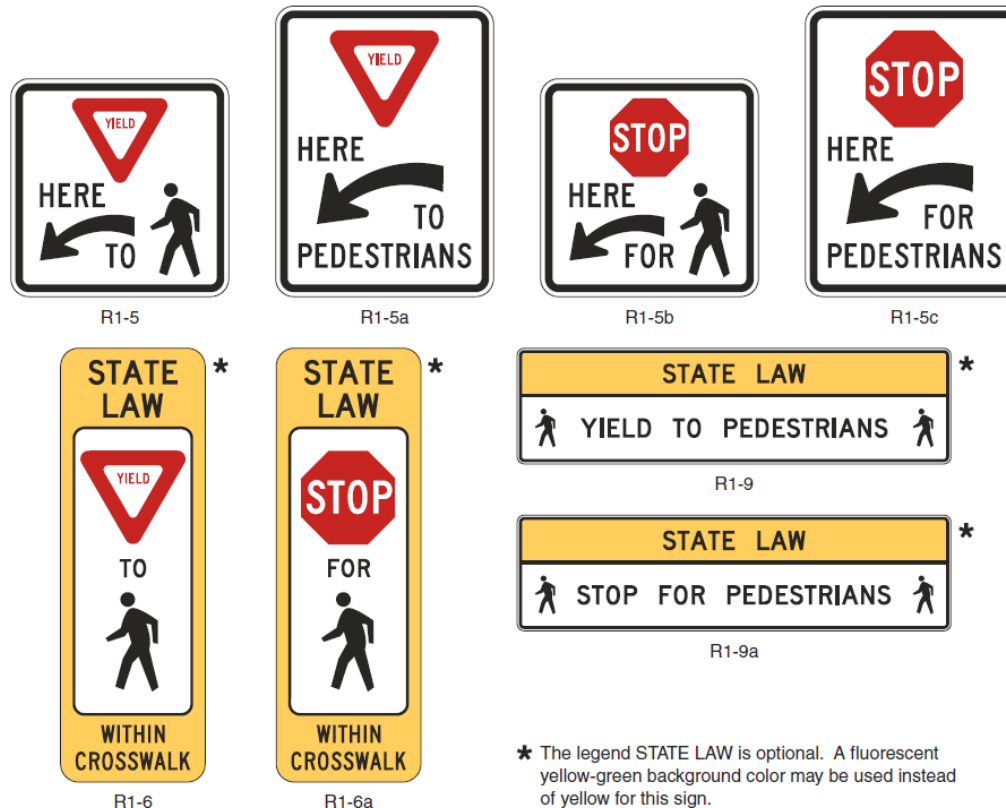
1. Plans shall indicate which crosswalk scheme to be used.
2. The details shown do not depict the signs and markings for mid-block crossings with divided medians. For these applications, additional signs shall be installed on the median side. Minimum width of Mid-Block Crosswalks is 60'.
3. All mid-block crosswalks shall use special emphasis crosswalk markings.
4. Crosswalk marking shall be performed marking materials.

NOT TO SCALE
EXHIBIT 230-1
01/01/2018

Signing for Crosswalks

- 316.130 (7)(b), Florida Statutes mandates the driver of a vehicle to stop at any pedestrian crosswalk where signage so indicates.
- Typically used on un-controlled multi-lane approaches.

Figure 2B-2. Unsignalized Pedestrian Crosswalk Signs



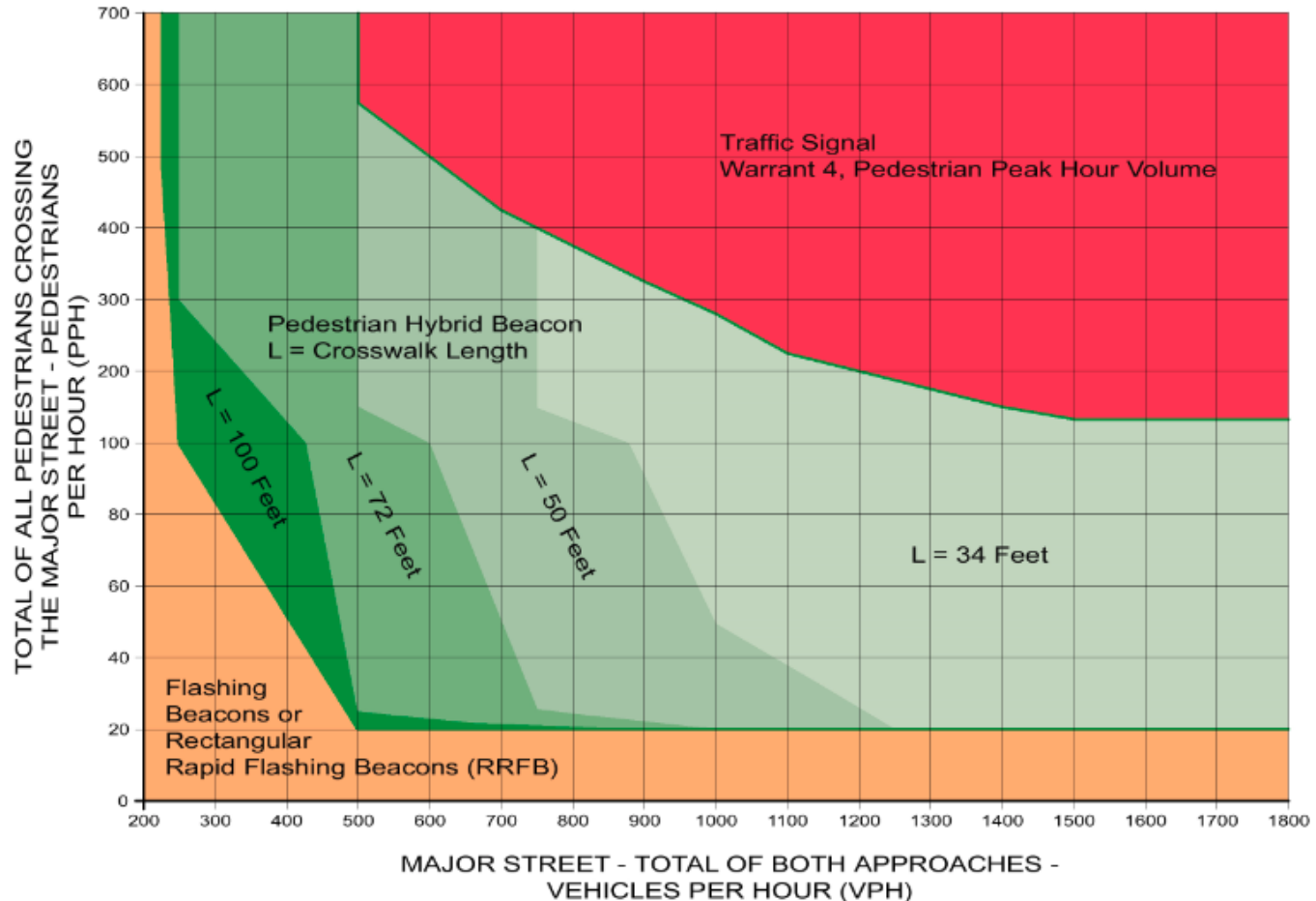
Design Considerations for Mid-block Crosswalks

- The location should be conducive to providing pedestrian safety and convenient for pedestrian access.
- The location must provide adequate stopping sight distance; i.e., parking restrictions near the marked mid-block crosswalk required.
- If sidewalks connecting the crosswalk to pedestrian generators and attractors are not already present, they should be provided.
- Crosswalk illumination shall be provided on all newly constructed mid-blocks or uncontrolled approach crosswalks except in environmentally sensitive areas or on facilities open during daylight hours only.
- When volumes exceed 12,000 ADT or where crossing distances exceed 60', a refuge island or raised median should be provided unless controlled by pedestrian signal or pedestrian hybrid beacon.
- Marked crosswalks are important for pedestrians with vision loss.
- Locations with nearby bus stops should be actively considered.

Mid-block Crosswalk Treatment Selection

Traffic Engineering Manual 3.8

Guidelines for the Installation of Pedestrian Treatments on High-Speed Roadways
Speeds greater than 35 mph



Enhanced Crossing Treatments

- Curb Extensions
- In-Pavement Warning Lights
- Pedestrian Hybrid Beacons (PHB) and Pedestrian Signals
- Pedestrian Refuge Islands
- Raised Crosswalks

Curb Extensions

- Curb extensions significantly improve pedestrian crossings by reducing the pedestrian crossing distance.
- Visually and physically narrowing the roadway, improving the ability of pedestrians and motorists to see each other.
- Reduce the time that pedestrians are in the street, and allowing space for the installation of a curb ramp.



In-pavement Warning Lights

- In-pavement LED Solar products have evolved and are becoming more effective with less maintenance issues.
- Studies show short term improvements in driver yielding to peds and better yielding at night.
- Lights are generally visible to only the first car in a platoon.
- Headlights from oncoming traffic may obscure a driver's view of the entire crossing.
- Lights do not indicate direction of ped travel or if people are crossing simultaneously from both sides.



Pedestrian Hybrid Beacons and Pedestrian Signals

- Must meet MUTCD warrants.
- Must have R10-23 sign.
- Minimum Yellow Change Interval 3 sec. max 6 sec.
- Recommended minimum signal spacing of 600 ft.
- If within coordinated system, convert to full pedestrian signal.
- Install High Emphasis crosswalk and stop bars in accordance with DS17346.
- Install advance warning and regulatory signs for better compliance. (CMF 0.453)



Pedestrian Refuge Islands

- Allow pedestrians a safe place to stop at the mid-point of the roadway before crossing the remaining distance.
- Enhance the visibility of pedestrian crossings, particularly at unsignalized crossing points.
- Reduce the speed of vehicles approaching pedestrian crossings.
- Can be used for access management for vehicles (allowing only right-in/right-out turning movements).
- Provide space for supplemental signage on multi-lane roadways.
- Effective on multi-lane roads



Raised Crosswalks

- Reduces vehicle speed
- Enhances pedestrian visibility
- Typically used for midblock crossings
- Eliminates the need for curb ramps



Crash Modification Factors

NCHRP 17-56

Development of Crash Modification Factors
for Uncontrolled Pedestrian Crossing Treatments

Treatment	Crash Type	Recommended CMF		Study Basis
		Estimate	Standard error	
Refuge Island	Pedestrian	0.685	0.183	Median 2 Studies
	Total	0.742	0.071	Cross-section
	All Injury	0.714	0.082	Cross-section
	Rear End/Side Swipe Total	0.741	0.093	Cross-section
	Rear End/Side Swipe Injury	0.722	0.106	Cross-section
Advance Stop (AS)	Pedestrian	0.750	0.230	Median 2 Studies
	Total	0.886	0.065	Before-after
	Rear End/Side Swipe Total	0.800	0.076	Before-after
PHB	Pedestrian	0.453	0.167	Median 2 Studies
PHB+AS	Pedestrian	0.432	0.134	Median 2 Studies
	Total	0.820	0.078	Before-after
	Rear End/Side Swipe Total	0.876	0.111	Before-after
RRFB	Pedestrian	0.526	0.377	Cross-section

Rectangular Rapid Flashing Beacons (RRFBs)

- On December 21, 2017, the FHWA [terminated Interim Approval 11](#), which permitted the optional use of rectangular rapid flashing beacons.
- All highway agencies, including those agencies that previously received the FHWA's approval to use rectangular rapid flashing beacons under Interim Approval 11, are prohibited from installing any new rectangular rapid flashing beacons.
- Any existing rectangular rapid flashing beacons that are already installed may remain in place until they reach the end of their useful service life.
- FHWA believes it is in the public interest for these agencies to complete the projects that have documentation of RRFBs with procurements issued and/or construction plans underway prior to FHWA's December 21, 2017, notice.

Alternatives to RRFB

Highlighted LED Signs

- Uses modified FDOT Approved Product List (APL) product
- Push-button Activated
- Configured to flash once per second
- Synchronized wig-wag pattern
- Both sides of an approach to a marked crosswalk
- Does not require additional FHWA approval



Alternatives to RRFB

Flashing Beacon Assembly

- Uses modified FDOT APL products
- Push-button Activated
- Unique FDOT flash pattern (under development)
- Both sides of an approach to a marked crosswalk
- Statewide experimental basis



R1-6a Gateway Treatment at Crosswalks

R1-6a In-Street Pedestrian Signs

- Very positive national research findings—including 2014 (Van Houten) and 2016 Michigan DOT and Western Michigan U.
- Edge line placement in combination with center line and lane line (Gateway effect) provides greater driver compliance than typical center line or edge line placement per MUTCD guidelines.
- R1-6 signs in “gateway” effect also increases driver compliance (yield) rates similar to more expensive treatments such as RRFBs.



R1-6 Gateway Treatment at Crosswalks

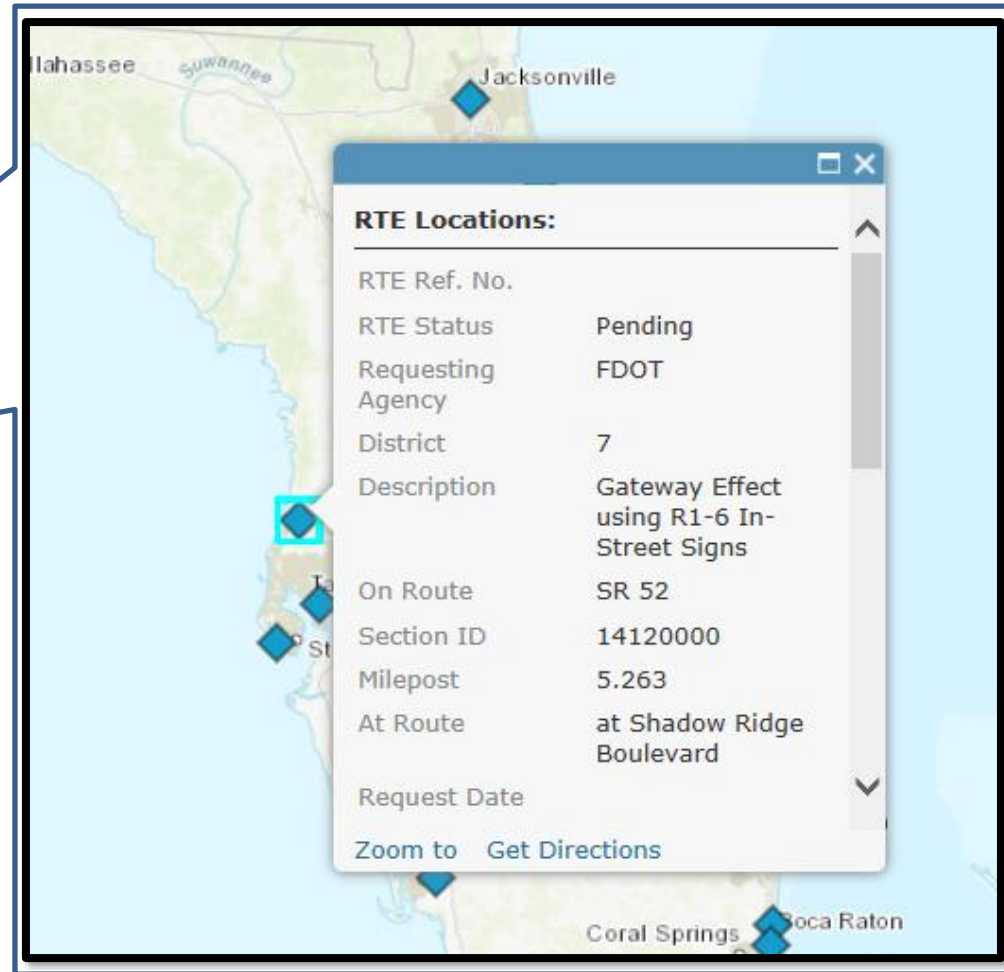
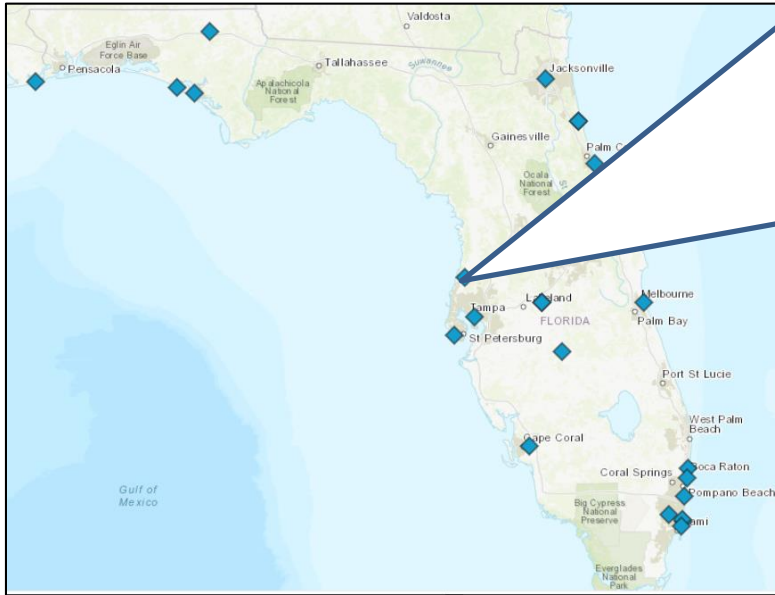
- Very low-cost and quick deployment.
- To be used only at non-signalized marked crosswalks.
- Narrowness of gap between signs has substantial effect on driver compliance as well as shown to reduce speeds.
- Edge line placement (gutter/curb/shoulder) requires FHWA request to experiment through Central Office.



R1-6 Gateway Treatment at Crosswalks

FHWA

Request to Experiment (RTE)



- 29 Gateway Locations in FL
- Approved by FHWA
- Tracking with **NEW** eTraffic online App
(will be viewable from FDOT website soon)

Updated School Zone Standards

Florida's School Zone Updates:

- ***Manual on Speed Zoning for Highways, Streets and Roads***
 - New chapter created for school zones
- Includes statewide requirement to install flashing beacons at all school zones.
- Provides guidelines and standards on when and where to consider a school zone.
- Clarifies and updates school zone signing and marking specifications and standards

Updated School Zone Standards

Establishing School Zones:

- School zones are determined based on an engineering study of the specific site.
- At a minimum, the engineering study should include:
 - ***Vehicle Spot Speed Study*** (Figure 7-1 of SZM),
 - ***Gap Study (Manual on Uniform Traffic Studies (MUTS) Chapter 8)***,
 - ***Pedestrian and Bicycle Volume Sheet Form (MUTS Chapter 9)***.

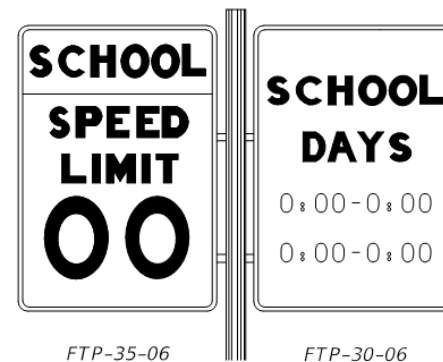
Updated School Zone Standards

Overview of Major Changes:

- S5-1 School Zone With Flashing Beacon is required
- Static time of day signs permissible only for:
 - Low Volume side streets that approach a main road where a school zone is located
 - As a supplemental sign entering a marked school zone location



S5-1 Flashing Beacon

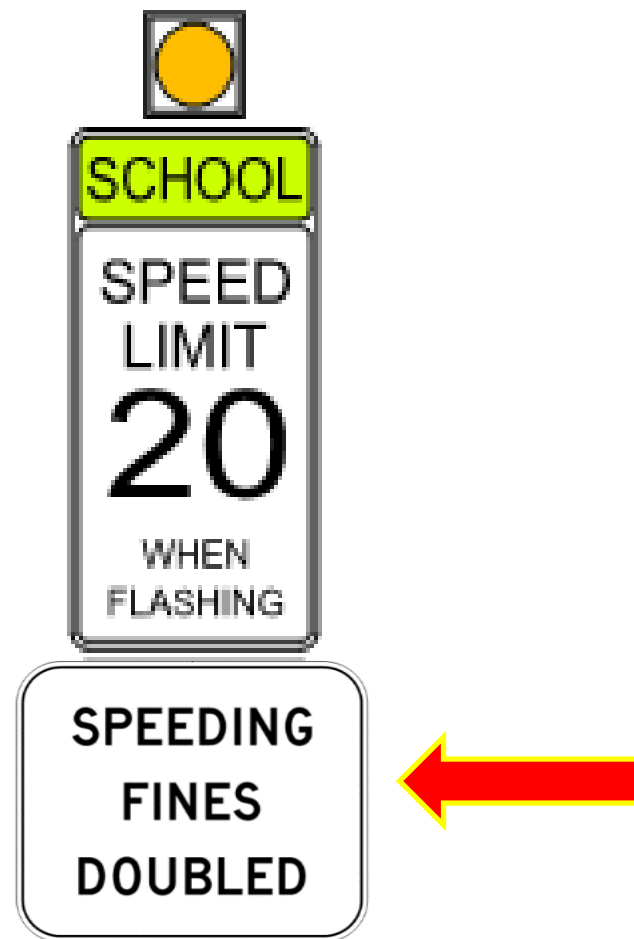


***Static Signs Not Permitted
unless Supplemental***

Updated School Zone Standards

Overview of Major Signing and Pavement Marking Changes

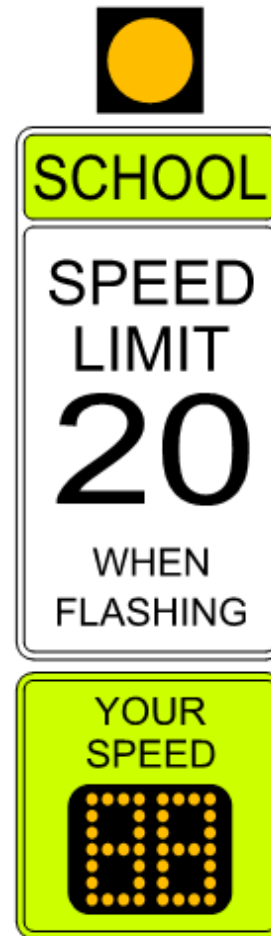
- SPEEDING FINES DOUBLED signs
- Placed at beginning of School Zones on same pole with S5-1 (School Sign)



Updated School Zone Standards

Overview of Major Signing and Pavement Marking Changes

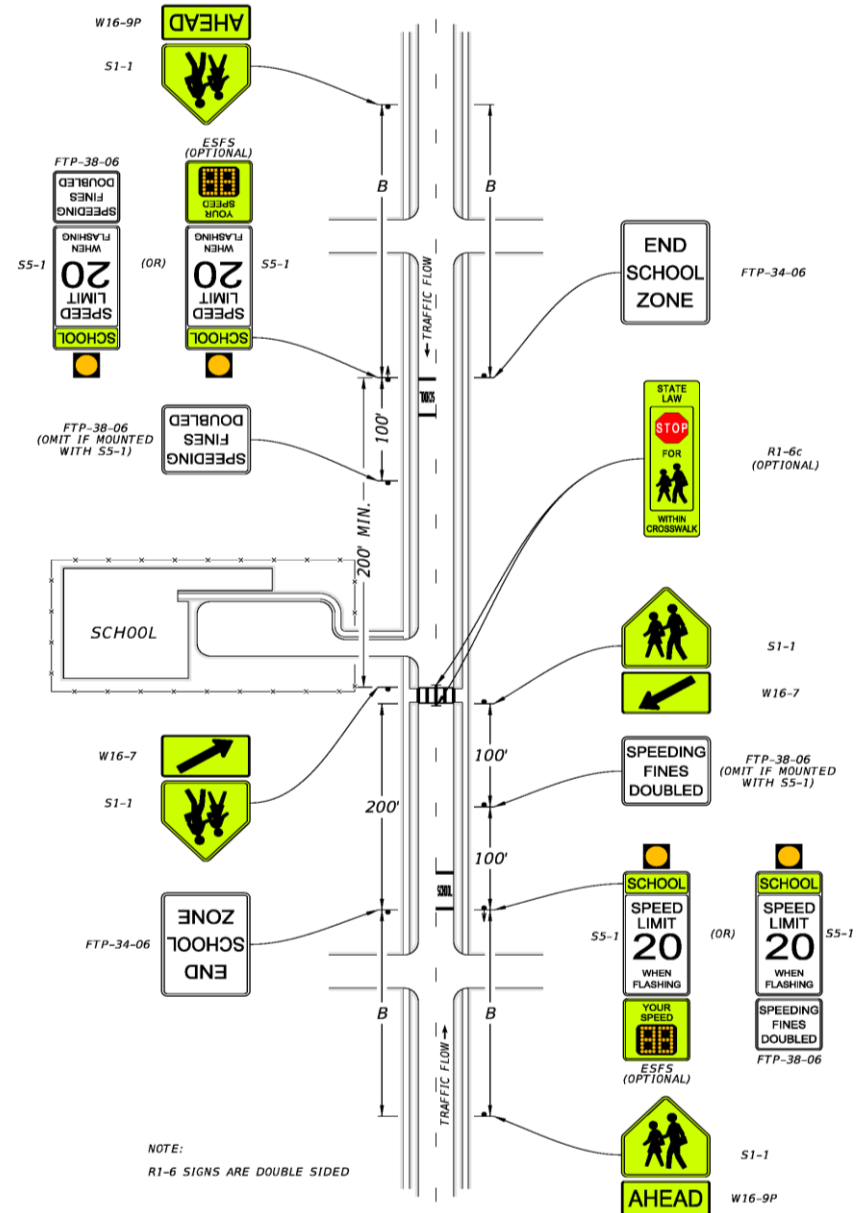
- Electronic Speed feedback signs permitted (optional)
- Placed directly under the S5-1
- SPEEDING FINES DOUBLED sign placed 100' beyond the S5-1 Assembly



Updated School Zone Standards

School Zone Layouts

- Must follow new FDOT Speed Zoning Manual requirements.
- Standardized placement of school zone signs and crossing signs
- Optional Fluorescent Green sign sheeting, electronic speed feedback signs and R1-6a in-street signs.
- Effective July 1, 2017



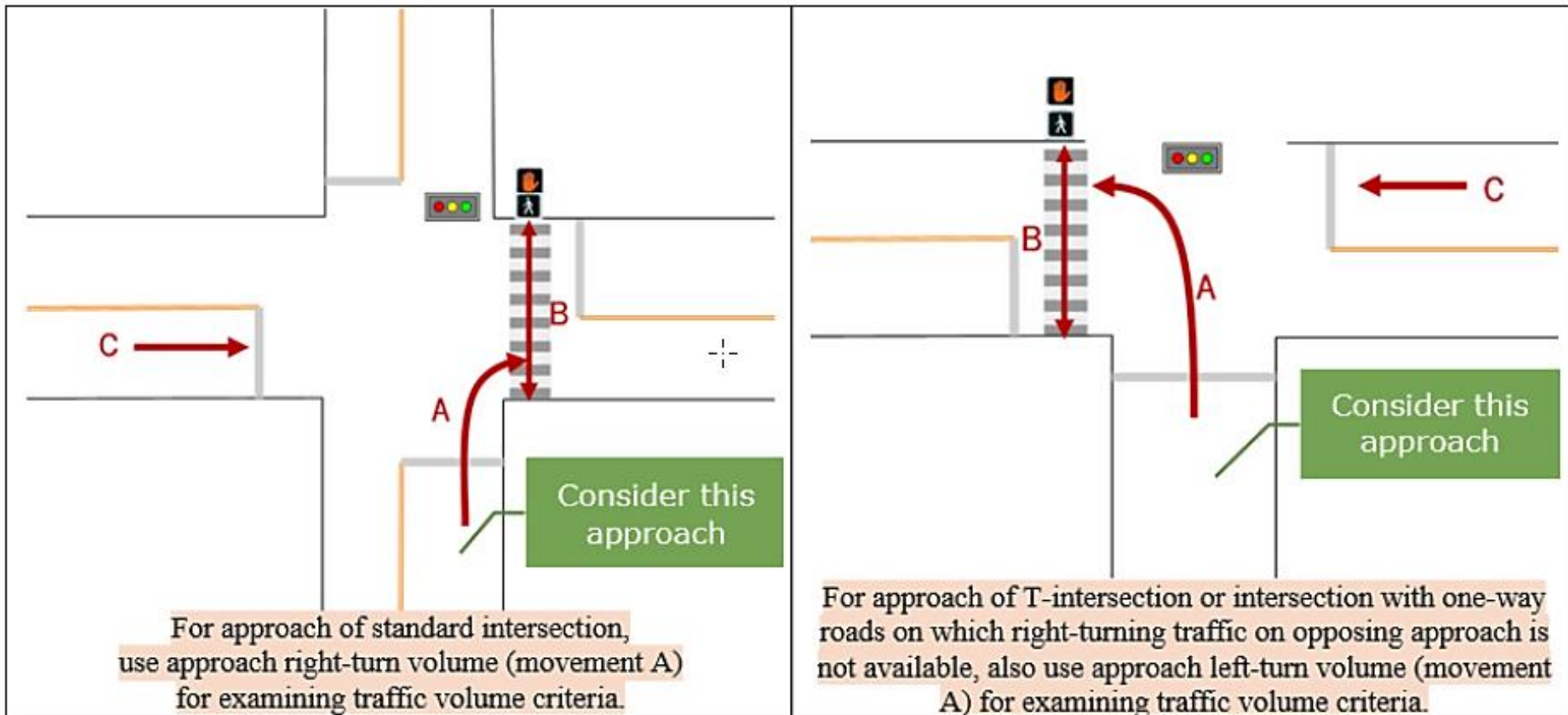
Leading Pedestrian Interval (LPI)

Intersections are where vehicles and pedestrians are most likely to interact

- FDOT/USF CUTR developed statewide LPI guidelines
- LPI Definition:
 - A Walk signal is given a few seconds before the traffic light turns green, giving pedestrians a head start and alerting drivers to pedestrians' presence.
- Research results:
 - A low-cost measure that can help
 - Eleven (11) Intersections tested in Florida
 - Pedestrian-vehicle conflicts were reduced with no appreciable reduction in vehicle throughput (majority of locations)
 - In some cases, the LPI cleared the crosswalk more quickly and slightly reduced the average waiting time for a right turn.

Leading Pedestrian Interval (LPI)

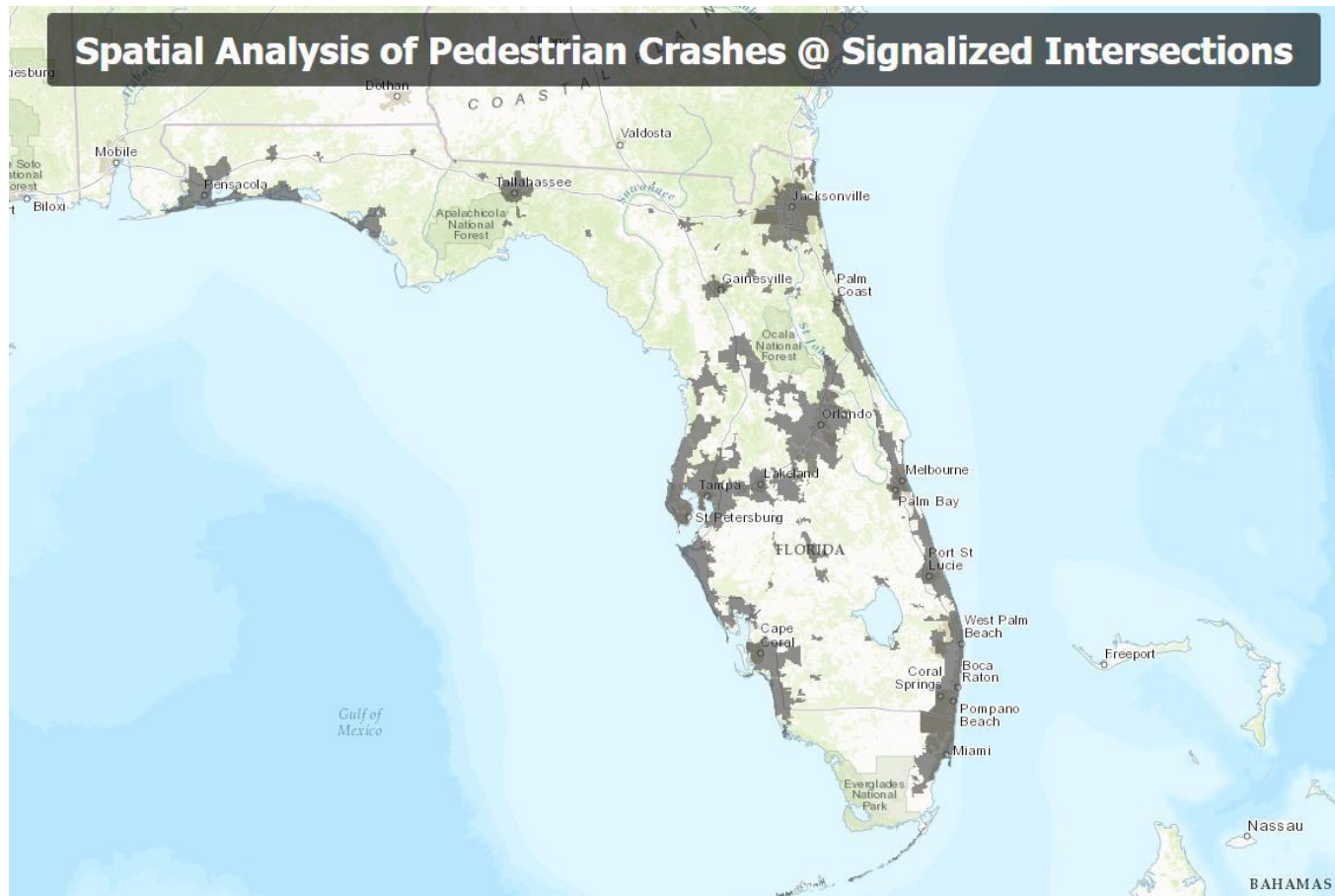
LPI Research Example:



Traffic movement on approach for LPI suitability assessment.

Intersection Retrofit Lighting Initiative

Addressing Nighttime Pedestrian Crashes at Signalized Intersections



Intersection Retrofit Lighting Initiative

Addressing Nighttime Pedestrian Crashes at Signalized Intersections

FDOT has developed a lighting retrofit program and standards:

- Pedestrian Lighting Retrofits initiated in 2014 with 20 Intersections
- Program expanded in 2016 with ***\$100 million over 3-5 years***
 - Corridor approach, not spot intersections
- Developed design retrofit criteria for intersection lighting
 - Roadway Design Memorandum 16-02
 - Design methodology created for Intersection Lighting Retrofits
 - Updated with Roadway Design Bulletin 17-09

Intersection Retrofit Lighting Initiative

Addressing Nighttime Pedestrian Crashes at Signalized Intersections

Intersection Retrofit Funding Options Over 5 Years					
District	No. of Crashes	% of Total Crashes	\$100,000,000 Allocation	No. of Intersections	Avg. B/C Ratio
1	237	7.34%	\$7,340,000	187	40.5
2	316	9.79%	\$9,790,000	249	38.4
3	206	6.40%	\$6,400,000	163	37.9
4	662	20.51%	\$20,510,000	522	40.0
5	557	17.26%	\$17,260,000	440	41.0
6	762	23.61%	\$23,610,000	601	46.8
7	487	15.09%	\$15,090,000	384	46.2
Total	3227	100.00%	\$100,000,000	2546	41.5

Intersection Retrofit Lighting Initiative

Addressing Nighttime Pedestrian Crashes at Signalized Intersections

The Vertical Illuminance required for the Lighting Retrofit criteria only applies to the Near Side Movement

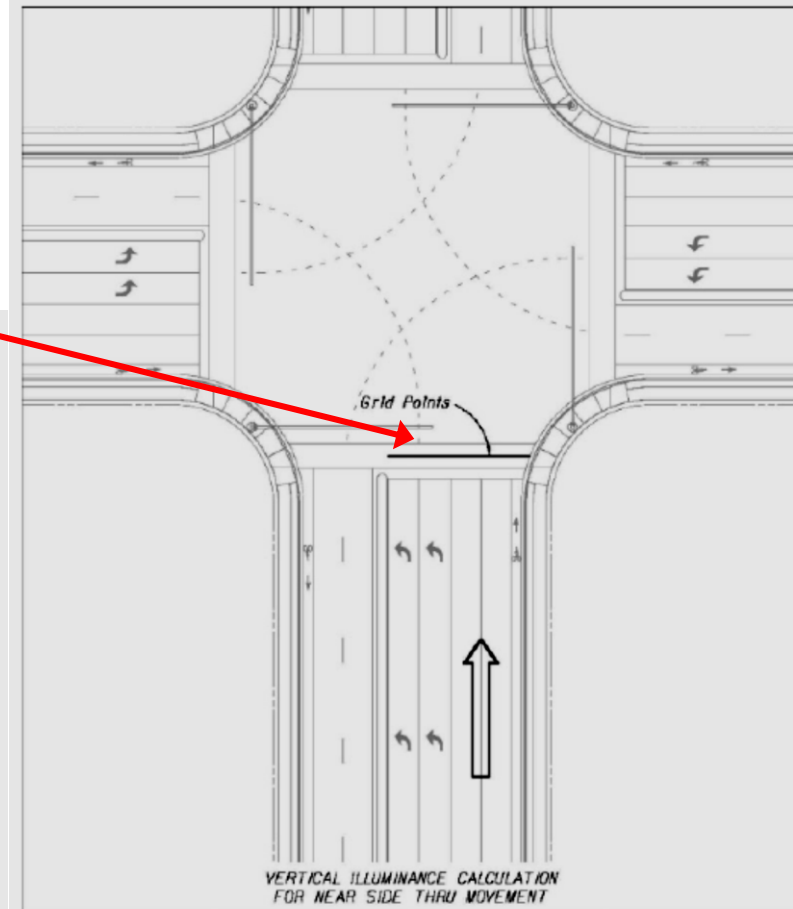
Table 7.3.3 Pedestrian Lighting at Signalized Intersections

ARTERIALS AND COLLECTORS	ILLUMINATION LEVEL AVERAGE INITIAL FOOT CANDLE		ILLUMINATION UNIFORMITY RATIOS ₁	
	Project Type	Horizontal (H.F.C.)	Vertical (V.F.C.)	Avg./Min.
New and Reconstruction	3.0	2.3	4:1 or Less	10:1 or Less
Lighting Retrofit	1.5 ₂	1.5 ₂		

Notes:

- (1) Illumination Uniformity Ratios do not apply to V.F.C.
- (2) The Lighting Retrofit average initial foot candles of 1.5 is a target. When this value cannot be obtained, provide the highest value possible, but not less than 1.0.

Figure 7.3.1 Vertical Illuminance Calculation for Near Side Movement



Intersection Retrofit Lighting Initiative

Addressing Nighttime Pedestrian Crashes at Signalized Intersections

FDOT is also testing signal mast arm mounted LED fixtures for pedestrian lighting retrofits at signalized intersections:

- Currently under testing in Sarasota (US 41 at Club Drive)



Intersection Control Evaluation Procedure

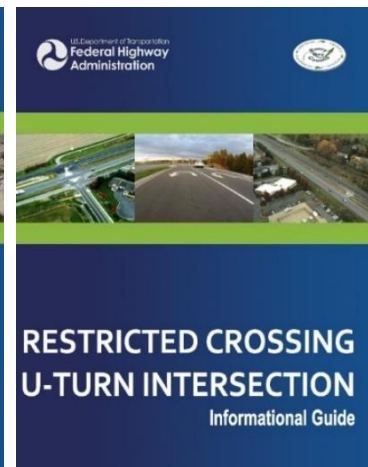
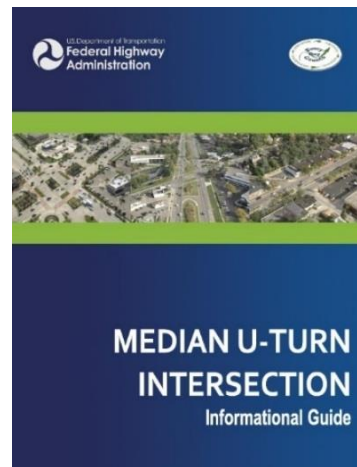
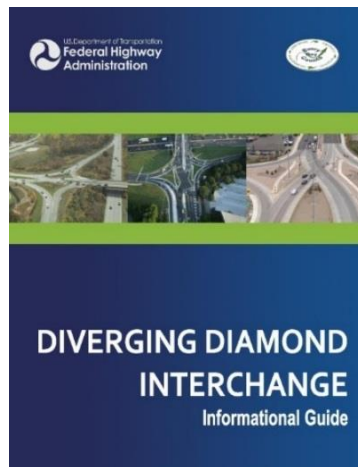
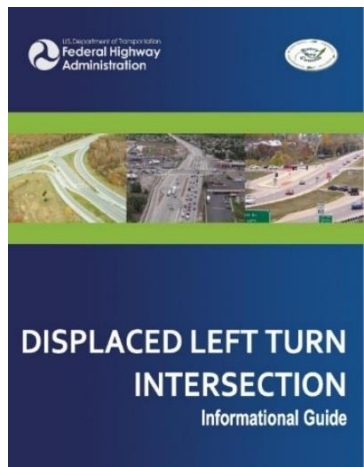
FDOT has developed a new procedure and Manual on Intersection Control Evaluations...

What is an Intersection Control Evaluation (ICE)?

A new FDOT initiative implementing a **consistent and objective intersection evaluation process** that is built upon performance-based criteria for determining the “best value” geometric design and traffic control ***for a given intersection/interchange.***

Intersection Control Evaluation Procedure

- Raise awareness/increase use of alternative intersections, including roundabouts
- Context sensitive to all context classifications, safety, and road users.
- Supports the SHSP by addressing one of the 13 emphasis areas: *Intersection Safety*
- Quantitative Analysis to select intersection control types
- FDOT Developed ICE Manual and Tools
 - ICE Manual Approved and Published November 1, 2017
 - Spreadsheet tools developed to support safety, operations and benefit-cost analyses



Intersection Control Evaluation Procedure

ICE is REQUIRED when:

- New signalization is proposed
- Major reconstruction of existing signalized intersection is proposed
- Adding exclusive left turns, adding intersection legs
- Conversion of directional or bi-directional median opening to full median opening
- Driveway/Connection permit applications for Category E, F, G
- District Design Engineer (DDE) and District Traffic Operations Engineer (DTOE) consider an ICE a good fit for the project

ICE is Required for State Roads and Encouraged for Local Roads

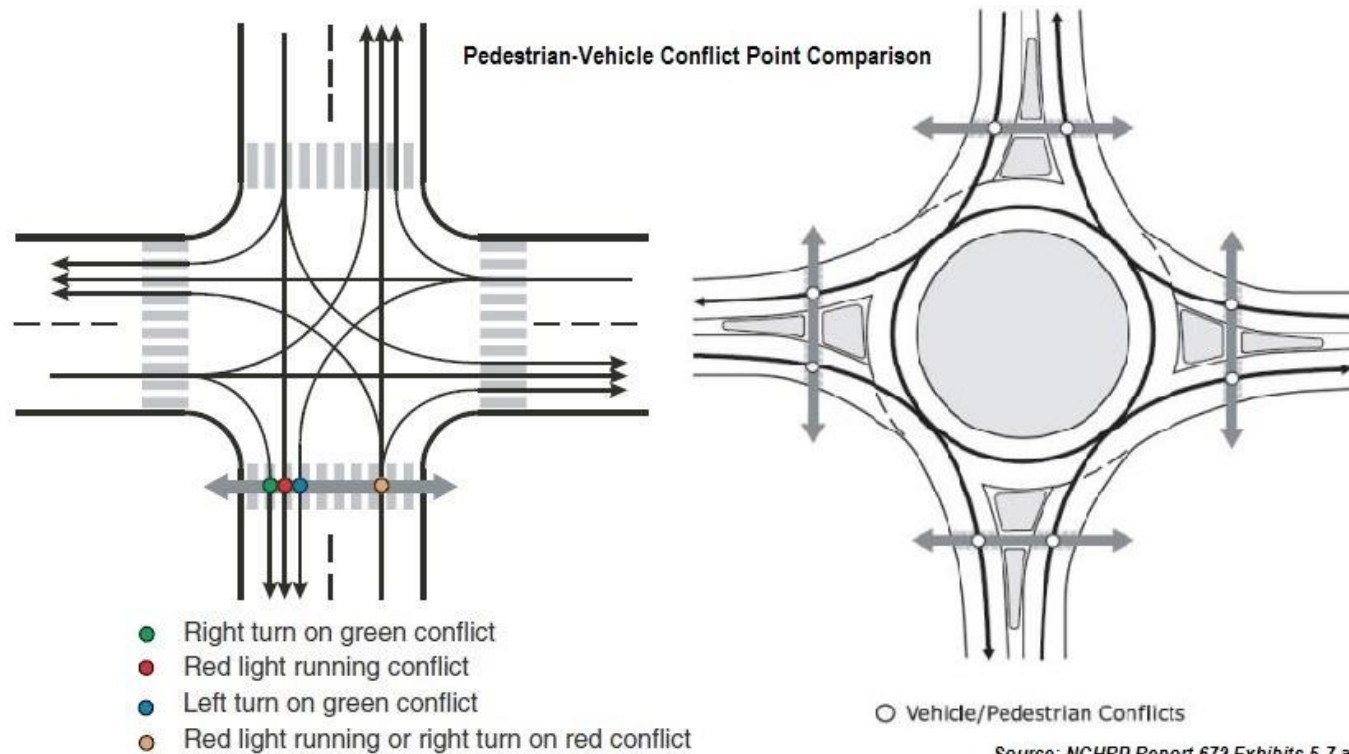
Intersection Control Evaluation Procedure

Types of Alternative Intersections Analyzed by the ICE Procedure:

- Roundabout
- Median U-turn (MUT)
- Signalized Restricted Crossing U-turn (RCUT)
- Unsignalized Restricted Crossing U-turn (JCUT)
- Jughandle
- Displaced Left Turn
- Continuous Green Tee
- Quadrant Roadway

The #1 Goal is to Reduce Fatalities and Serious Injuries!

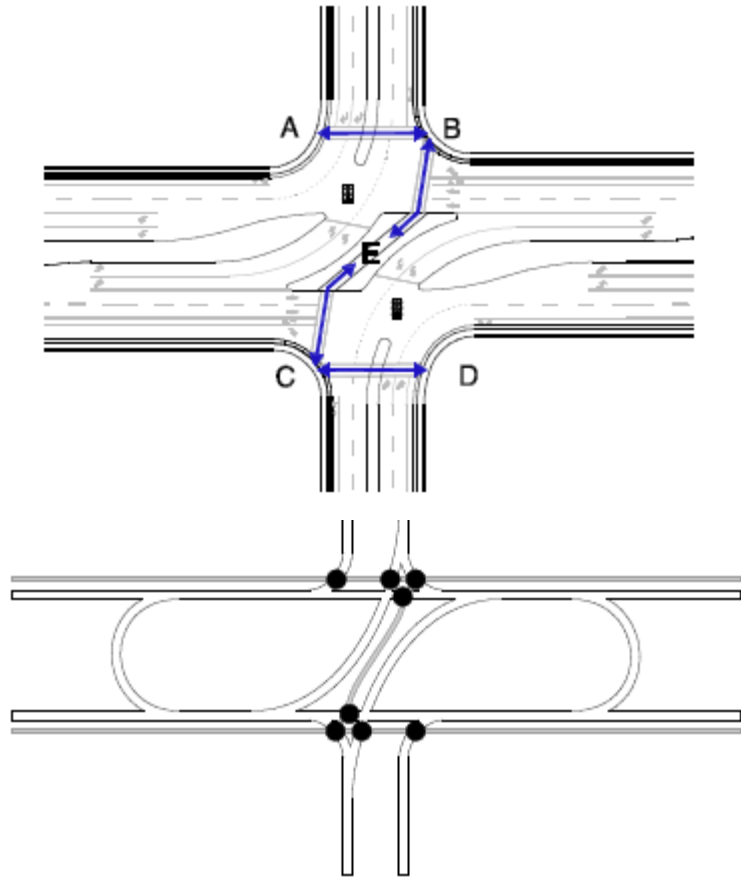
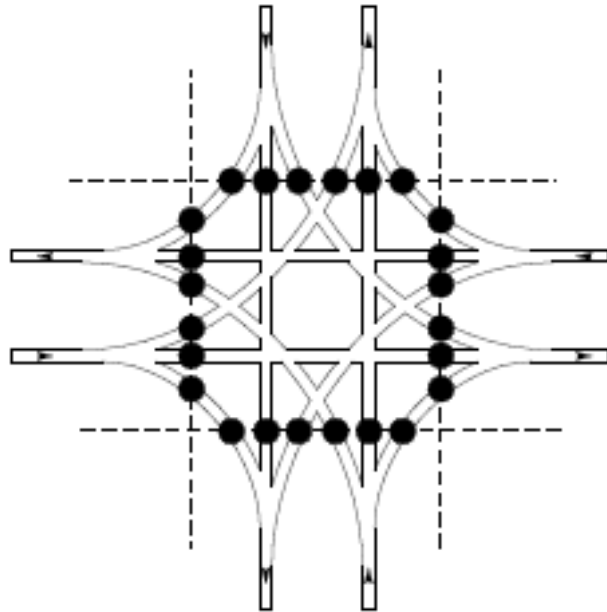
Intersection Control Evaluation Procedure



Source: NCHRP Report 672 Exhibits 5-7 and 5-8

Roundabouts provide a 50% or more reduction in Pedestrian-Vehicle conflict points

Intersection Control Evaluation Procedure



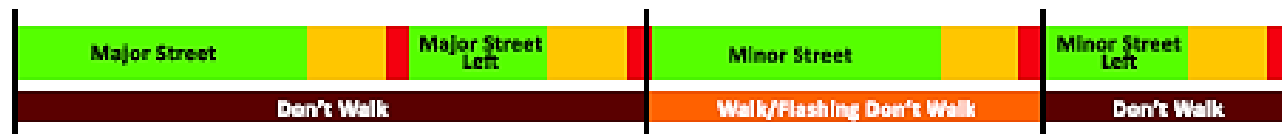
RCUTS reduce Pedestrian-Vehicle
conflict points from 24 to 8

Intersection Control Evaluation Procedure

RCUT with Pedestrian Facilities



Intersection Control Evaluation Procedure



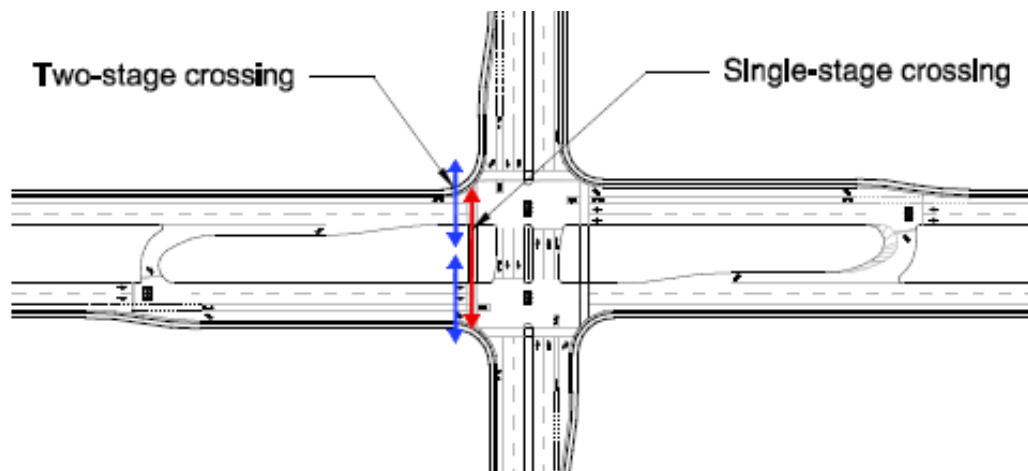
Typical Conventional Intersection Signal Cycle

MUTS reduce cycle length, allow 2-phase signals and offer longer walk times



MUT Intersection Signal Cycle

MUTS reduce Pedestrian-Vehicle conflict points from 24 to 16



New Technologies for Pedestrian Safety

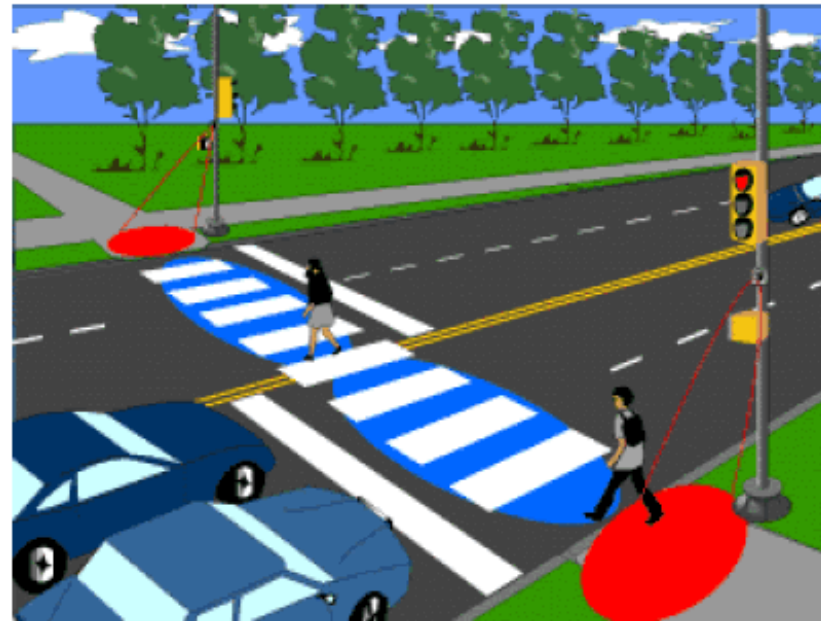
Passive Pedestrian Technology

Connected Vehicle (CV) Applications for Pedestrians

Passive Pedestrian Detection

What is Passive Pedestrian Detection?

- *To detect the presence of pedestrians in a stationary or moving state at the curbside of and/or in a pedestrian crossing by means other than those requiring physical actuation by the pedestrian*
(Source: FHWA)
- Various Means of Detection
 - Infrared
 - Ultrasonic
 - Microwave radar
 - Video imaging
 - Piezometric sensors
 - Smartphone application

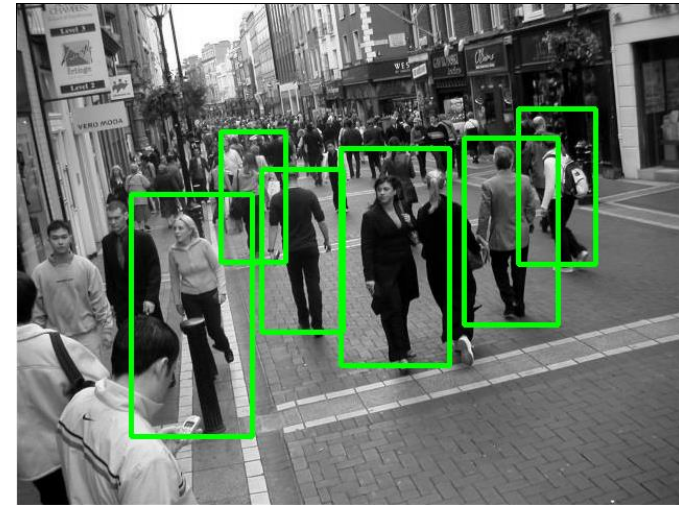


Source: FHWA

Passive Pedestrian Detection

How Does Passive Pedestrian Detection Work?

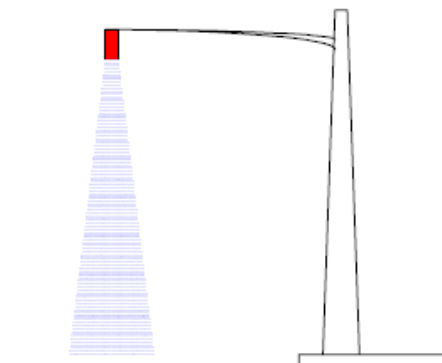
- Road users aren't required to push the button
- Detector tracks pedestrian movement and assigns pedestrian phase and monitors:
 - Counts
 - Speed
 - Direction
- Detectors can adjust signal timings by granting extension of green time for safe crossing
- Detection radars may not be needed if the smartphone app is running in the background via cellular communications



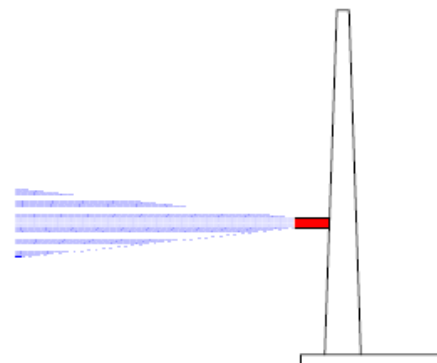
Passive Pedestrian Detection

Detection Configuration

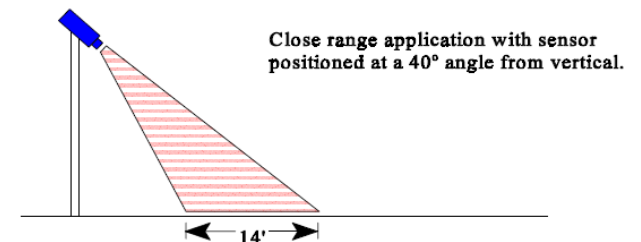
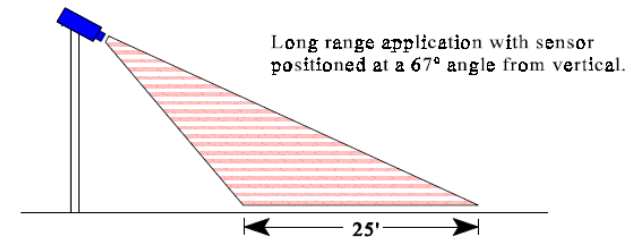
- Smartphone application does not require detector, but requires Road Side Units (RSUs)
- Video detection uses back-end software program to track and monitor pedestrian activity
- Radar and infrared detection configuration includes:



Vertical Firing



Side Firing



Passive Pedestrian Detection

USDOT SmartCross Research – Ongoing

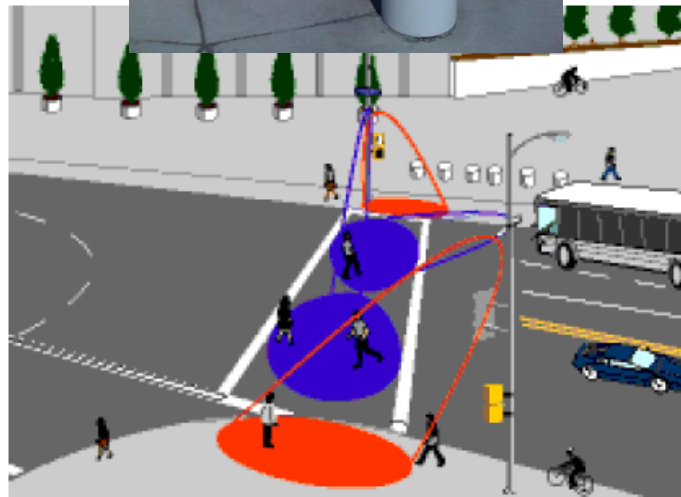
- A smartphone application named SmartCross for pedestrian detection
- Geared for handicapped or elderly pedestrians
- Alerts pedestrian to the presence of an intersection and status of the light for pedestrian crossing
- App communicates two-way with the signal controllers via web-based cellular communications and requests green extension if needed
- App communicates with the vehicles to alert pedestrian presence via on-board units



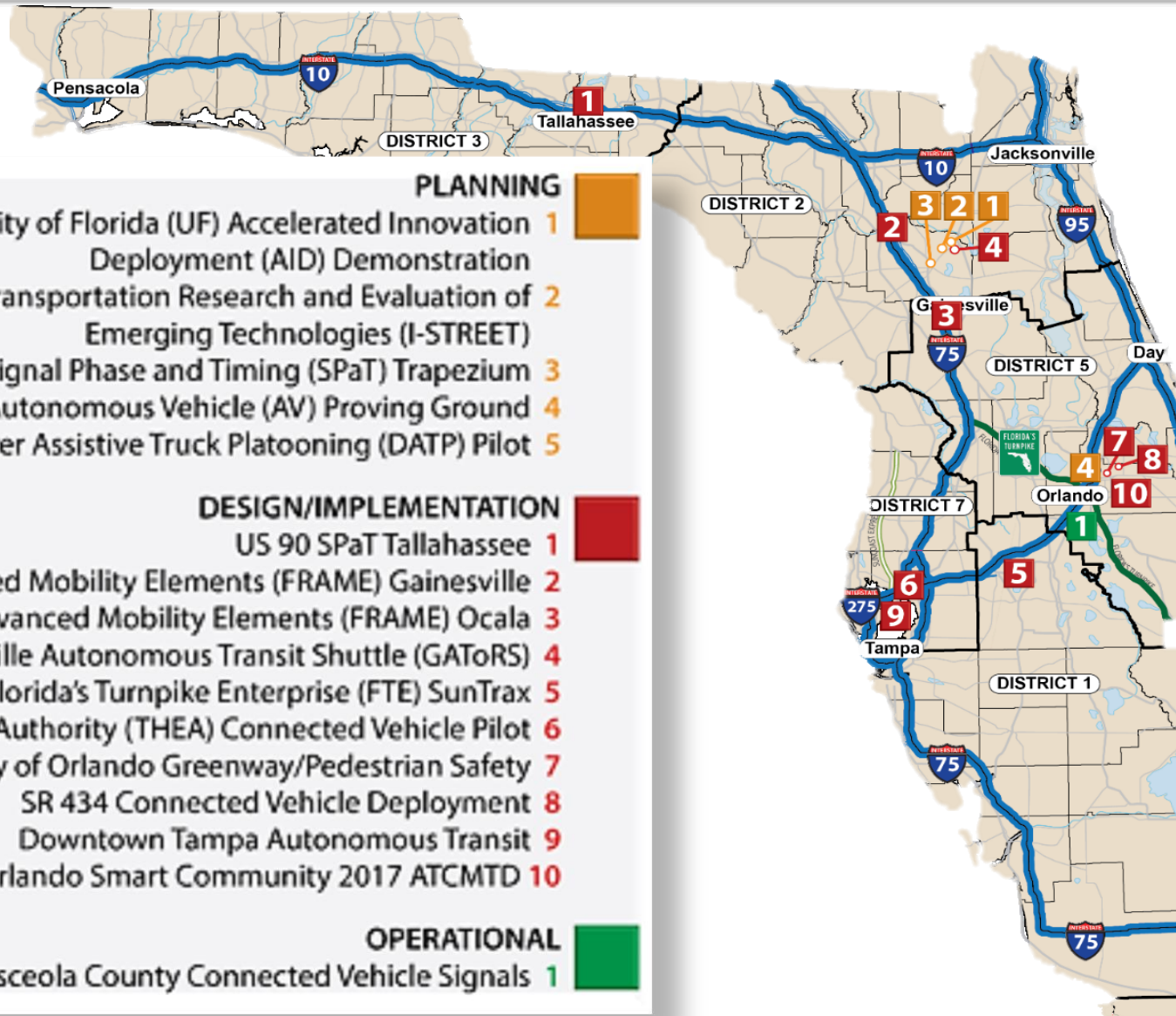
Passive Pedestrian Detection

Passive Pedestrian Detection Systems

- FDOT testing new technologies in conjunction with UF and City of Gainesville.
- Updated Standard Specification 665 to include passive detection features.
- Thermal passive detector also being added.



Connected Vehicle (CV) Applications



- | | | |
|--|------------------------------|---|
| | PLANNING |  |
| University of Florida (UF) Accelerated Innovation Deployment (AID) Demonstration | 1 | |
| Implementing Solutions from Transportation Research and Evaluation of Emerging Technologies (I-STREET) | 2 | |
| Gainesville Signal Phase and Timing (SPaT) Trapezium | 3 | |
| Central Florida Autonomous Vehicle (AV) Proving Ground | 4 | |
| Driver Assistive Truck Platooning (DATP) Pilot | 5 | |
| | DESIGN/IMPLEMENTATION |  |
| US 90 SPaT Tallahassee | 1 | |
| I-75 Florida's Regional Advanced Mobility Elements (FRAME) Gainesville | 2 | |
| I-75 Florida's Regional Advanced Mobility Elements (FRAME) Ocala | 3 | |
| Gainesville Autonomous Transit Shuttle (GAToRS) | 4 | |
| Florida's Turnpike Enterprise (FTE) SunTrax | 5 | |
| Tampa Hillsborough Expressway Authority (THEA) Connected Vehicle Pilot | 6 | |
| City of Orlando Greenway/Pedestrian Safety | 7 | |
| SR 434 Connected Vehicle Deployment | 8 | |
| Downtown Tampa Autonomous Transit | 9 | |
| Orlando Smart Community 2017 ATCMTD | 10 | |
| | OPERATIONAL |  |
| Osceola County Connected Vehicle Signals | 1 | |

Connected Vehicle (CV) Applications

Tampa-Hillsborough Expressway Authority (THEA)

- Tampa is one of the first cities in the nation to test and deploy CV technology on real streets in live traffic.
- THEA selected by USDOT for CV pilot project focusing on urban issues using:
 - 1,500 private vehicles
 - 10 buses and 10 streetcars.
- Pedestrian safety featured as a prominent use case (Use Case No. 3) – CV application for midblock crosswalk on East Twiggs Street at the Hillsborough County Courthouse.
- Equipment includes vehicle On-board Units (OBUs), Human/Machine Interfaces (HMIs) Roadside Units (RSUs) and LiDAR



Connected Vehicle (CV) Applications

District 5 ATCMTD Grant

- Received the Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant.
- Requested \$11.9 million
- Three program areas:
 - PedSafe
 - GreenWay
 - Smart community



Connected Vehicle (CV) Applications

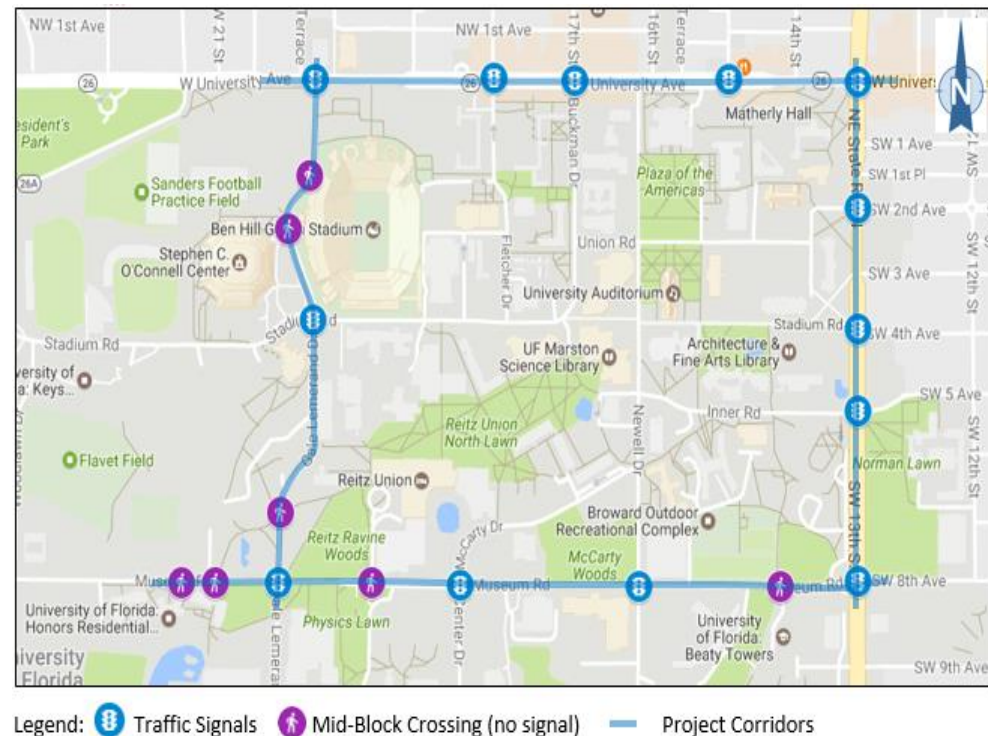
AID Grant - University of Florida (UF) Test Bed

- Accelerated Innovation Deployment (AID) grant
- University of Florida (UF) and City of Gainesville connected vehicle pilot project:

- 13 traffic signals
- 7 midblock crossings

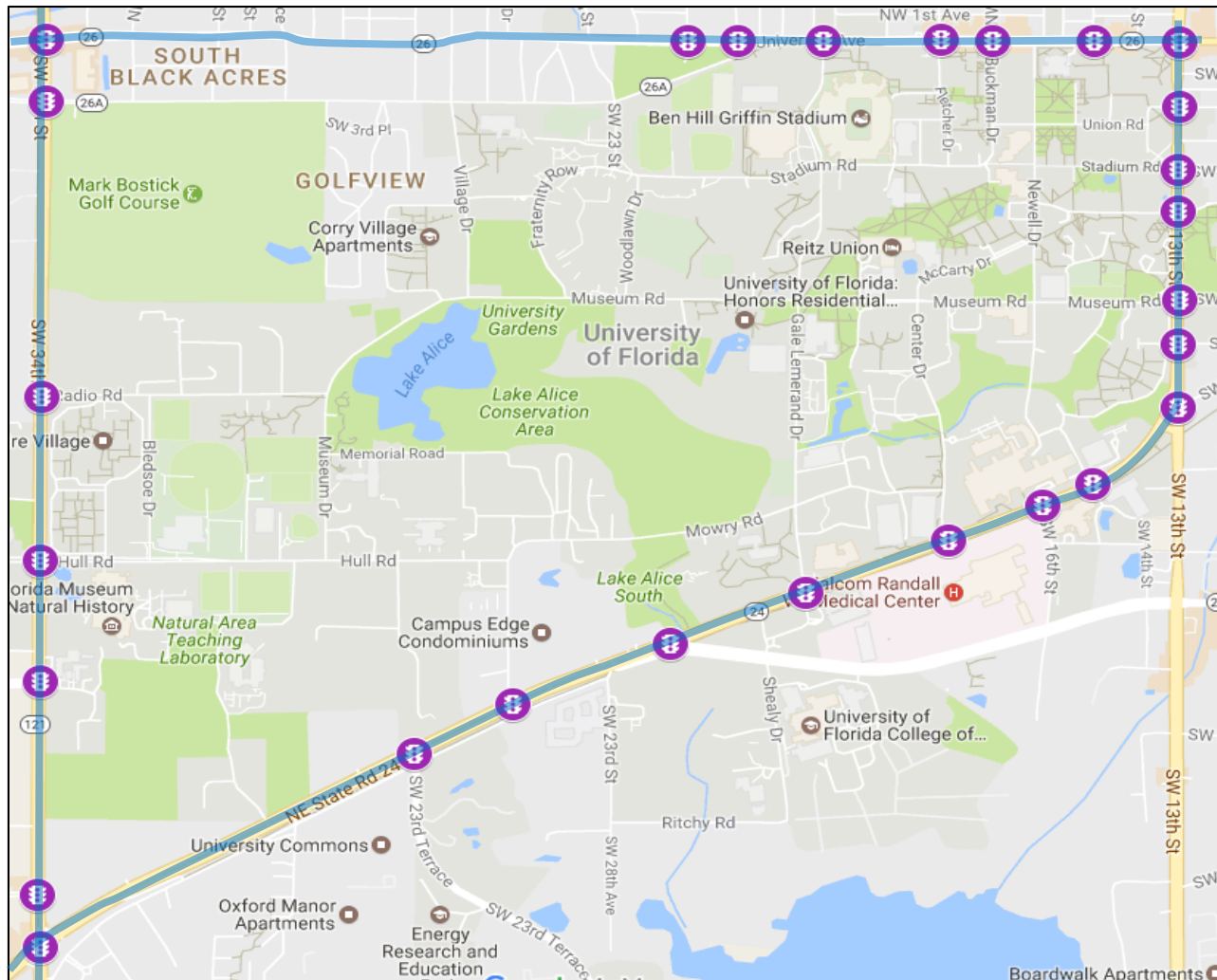
To test:

- Passive pedestrian/bicyclist detection
- Real-time notification to transit, motorists, and pedestrians/bicyclists
- SPaT data broadcasting w/active pedestrian/bicyclist detection via roadside units



Connected Vehicle (CV) Applications

Gainesville SPaT Trapezium Project



Legend

-  Traffic Signals (27)
-  Project Corridor



Florida Department of
TRANSPORTATION

Improving Pedestrian Safety *with Engineering and Technology*

Thank You!

Questions?