Development of Statewide Guidelines for Implementing Leading Pedestrian Intervals in Florida
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Outline

- Introduction
- Project Background
- Project Objectives
- Project Tasks, Associated Activities, and Findings
- LPI Warrants, Implementation Guidelines and Examples
- Summary of Research Conclusions
- Recommendations
Introduction

- The content of the webcast is based on a recent completed FDOT BDV25-977-22 project.
- This project focused on developing statewide leading pedestrian interval (LPI) implementation guidelines to determine the suitability and effectiveness of LPI implementation at signalized intersections.
- Key research team members are:
  - Dr. Pei-Sung Lin (PI)
  - Dr. Zhenyu Wang
  - Dr. Cong Chen
  - Dr. Rui Guo
- This webcast will highlight all aspects of the project including major project tasks, findings, LPI warrants, illustrated examples, LPI implementation guidelines, and recommendations.

Project Background

- Pedestrian safety is one of the top priorities in Florida.
- Many pedestrian crashes occurred at signalized intersections in Florida.
- One low-cost technique to separate pedestrians and turning vehicles in time is Leading Pedestrian Intervals (LPis).
- Many transportation agencies were interested in implementing LPI but need LPI implementation guidelines.
- There was a need for an integrated effort to develop statewide guidelines for the implementation of LPis in Florida.
Project Objectives

1. Obtain knowledge, experience, and guidance for LPI implementation from:
   - literature review
   - traffic agency interviews
   - recommendations from field experts
   - consultation with FDOT District operations staff
   - pilot test

2. Develop simple and robust guidelines for LPI warrants, implementation, and operations in Florida

Project Tasks, Associated Activities and Findings

- Task 1: Literature Review
- Task 2: Collection of Information and Input for LPI Guideline Development
- Task 3: Development of Preliminary LPI Implementation Guidelines
- Task 4: Before Study of LPI Implementation
  - Subtask 4.1: Establishment of Minimum Number of Sites
  - Subtask 4.2: Data Collection before LPI Implementation
- Task 5: Data Validation, Compilation, and Analysis
  - Subtask 5.1: Assistance in LPI implementation at Identified Sites
  - Subtask 5.2: Data Collection after LPI Implementation
  - Subtask 5.3: Before-and-After Analysis
- Task 6: Finalization of LPI Implementation Guidelines
- Task 7: Draft Final Report and Closeout Teleconference
- Task 8: Final Report
Task 1: Literature review

<table>
<thead>
<tr>
<th>Task 1: Literature review</th>
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<tbody>
<tr>
<td><strong>Pros of LPI</strong></td>
</tr>
<tr>
<td>Increase visibility of crossing pedestrians and give pedestrians priority</td>
</tr>
<tr>
<td>Increase pedestrian perception of safety</td>
</tr>
<tr>
<td>Require adjustments to existing signal timing that are relatively low cost</td>
</tr>
<tr>
<td><strong>Cons of LPI</strong></td>
</tr>
<tr>
<td>Potentially increase vehicle delay</td>
</tr>
<tr>
<td>Motorists and pedestrians may be confused shortly after LPI implementation</td>
</tr>
<tr>
<td>May raise driver complaints if pedestrians are not present when LPI is on</td>
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</table>
Task 2: Collection of Information and Input for LPI Guideline Development

The research team collected information and input from experienced traffic agency engineers and/or managers through:

1) **LPI online survey**
   - Reasons for implementation of LPIs
   - Criteria or internal guidelines used to determine implementation of LPIs
   - Percentage of pedestrian crash changes after implementation of LPIs
   - Percentage of pedestrian-vehicle conflict changes after implementation of LPIs
   - Successful experiences or complications with LPI implementation
   - Lessons learned from LPI implementation
   - Perceptions and reactions from the general public on LPI implementation

2) **Phone interviews with engineers/managers** from City of Tampa (FL), City of Clearwater (FL), City of Lakeland (FL), City of Albany (NY), and DC.

3) **Discussions with FDOT District Traffic Operations Representatives**

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<tr>
<th>Organization</th>
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<td>Central Office</td>
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<td>Rick Morrow</td>
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<td>Evelin Legecevic, Esteban Espinal, Elio Espino</td>
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<td>Turnpike District</td>
<td>Even Eshevarria</td>
</tr>
<tr>
<td>CUTR</td>
<td>Pei-Sung Lin, Rui Guo, Kristin Larsson</td>
</tr>
</tbody>
</table>

*Note: Several provided input and feedback through emails
Task 2: Collection of Information and Input for LPI Guideline Development

1. Consider the following factors for LPI implementation criteria
   - Citizen complaints
   - Crash and conflicts between pedestrians and turning vehicles
   - Turning vehicle volume at the specific approach
   - Pedestrian volume or activity (regarding signal control, land use, etc.)
   - Irregular intersection features (visibility issue)
   - Considered left-turning vehicles at T-intersection and one-way roads

2. Consider the following concerns of LPI implementation
   - Pedestrian compliance/behavior varies
   - Obvious negative impacts on vehicular delay and progression at signalized intersections
   - Pedestrian behavior of pushing pedestrian button but leaving before LPI starts

3. Consider the following supplemental needs
   - “No Turn On Red” sign or blank-out “No Turn On Red” sign
   - Accessible pedestrian signals (APS)
   - Education about LPI

Task 3: Development of Preliminary LPI Implementation Guidelines

Preliminary LPI Implementation Guidelines

1. Consider the following factors for LPI implementation criteria
   - Citizen complaints
   - Crash and conflicts between pedestrians and turning vehicles
   - Turning vehicle volume at the specific approach
   - Pedestrian volume or activity (regarding signal control, land use, etc.)
   - Irregular intersection features (visibility issue)
   - Considered left-turning vehicles at T-intersection and one-way roads

2. Consider the following concerns of LPI implementation
   - Pedestrian compliance/behavior varies
   - Obvious negative impacts on vehicular delay and progression at signalized intersections
   - Pedestrian behavior of pushing pedestrian button but leaving before LPI starts

3. Consider the following supplemental needs
   - “No Turn On Red” sign or blank-out “No Turn On Red” sign
   - Accessible pedestrian signals (APS)
   - Education about LPI

As an example, approach turning vehicle volume (Vmt at corner A) = 1000 veh, pedestrian volume at corner A = 200 per day, and turning traffic volume of cross street (Vmt corner C) = 400 veh/day (consider LPI for the corner)

As an example, approach turning vehicle volume (Vmt at corner C) = 1000 veh, pedestrian volume at corner C = 200 per day, and turning traffic volume of cross street (Vmt corner A) = 400 veh/day (consider LPI for the corner)

As an example, approach turning vehicle volume (Vmt at corner B) = 1000 veh, pedestrian volume at corner B = 200 per day, and turning traffic volume of cross street (Vmt corner A) = 400 veh/day (consider LPI for the corner)

For mixed traffic volumes, approach turning vehicle volume (Vmt at corner A) = 1000 veh/minute, LPI for pre-peak period < 30s before intersection onset, and pre-peak period > 30s before and 1 zone after signal onset

Step II: LPI Directive Recommendations

1a. Internal delay be estimated of 0 to 5 seconds.
1b. Initial decision on implementation or clear bulb rollout of the foot in the direction of turning traffic, or decrease visibility of pedestrians in turning traffic

Step IV: Supplemental Design Recommendations for LPI Implementation

12. Right-turn-on-red prohibitions... “No Turn on Red” sign or blank-out “No Turn on Red” sign
13. Accessible pedestrian signals (APS)
14. Right-of-way at left

Note: Each table in this document provides a brief overview of the factors to consider, with more detailed guidelines available in the referenced source materials.
Task 4: Before Study of LPI Implementation

4.1 Establishment of Minimum Number of Sites (9 sites, 11 approaches)

1. East leg (northbound right turn), E Fletcher Ave @ USF Palm Dr, Tampa, FL [District 7]
2. West leg (southbound right turn), E Kennedy Blvd @ N Tampa St, Tampa, FL [District 7]
3. West leg (southbound right turn), E Fletcher Ave @ N Nebraska Ave, Tampa, FL [District 7]
4. South leg (eastbound right turn), W University Ave @ NW 13th St, Gainesville, FL [District 2]
5. South leg (eastbound right turn) and north leg (eastbound left turn), SR A1A @ 178th St, Sunny Isles Beach, FL [District 6]
6. North leg (westbound right turn), US 41 @ Laurel Rd, Nokomis, FL [District 1]
7. West leg (southbound right turn), US 1 @ E Broward Blvd, Fort Lauderdale, FL [District 4]
8. South leg (eastbound right turn) and east leg (northbound right turn), E Tennessee St @ E Monroe St, Tallahassee, FL [District 3]
9. East Leg (northbound right turn), SR 200 @ SW 60th Ave, Ocala, FL [District 5]

Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

1. East leg (northbound right turn), E Fletcher Ave @ USF Palm Dr, Tampa, FL [District 7]

Field data collection (GoPro view)
Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

2. West leg (southbound right turn), E Kennedy Blvd @ N Tampa St, Tampa, FL (District 7)

Field data collection (GoPro view)

Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

3. West leg (southbound right turn), E Fletcher Ave @ N Nebraska Ave, Tampa, FL (District 7)

Field data collection (GoPro view)
Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

4. South leg (eastbound right turn), W University Ave @ NW 13th St, Gainesville, FL (District 2)

Field data collection (GoPro view)

Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

5. South leg (eastbound right turn) and north leg (eastbound left turn), SR A1A @ 178th St, Sunny Isles Beach, FL (District 6)

Field data collection (GoPro view)
Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

6. North leg (westbound right turn), US 41 @ Laurel Rd, Nokomis, FL (District 1)

Field data collection (GoPro view)

Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

7. West leg (southbound right turn), US 1 @ E Broward Blvd, Fort Lauderdale, FL (District 4)

Field data collection (GoPro view)
Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

8. South leg (eastbound right turn) and east leg (northbound right turn), E Tennessee St @ E Monroe St, Tallahassee, FL (District 3)

Field data collection (GoPro view)

Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

9. East Leg (northbound right turn), SR 200 @ SW 60th Ave, Ocala, FL (District 5)

Field data collection (GoPro view)
Task 4: Before Study of LPI Implementation

4.2 Data Collection before LPI Implementation

Data Summary for E. Tennessee St at E Monroe St (Tallahassee, FL) Eastbound Right Turn before LPI Implementation

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Task 5: After Study of LPI Implementation and Analyses

5.1 Assistance in LPI implementation at Identified Sites

CUTR coordinated with each district and local transportation agencies to implement LPIs on identified approaches, including:

- Data collection schedule
- LPI implementation schedule
- LPI parameters
Task 5: After Study of LPI Implementation and Analyses

5.2 Data Collection after LPI Implementation

Example of “After” Data Collection (GoPro view)

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<th>Time Period</th>
<th>Ped. Crossed</th>
<th>Accidents</th>
<th>Ped killed</th>
<th>Veh killed</th>
<th>Veh injured</th>
<th>Ped injured</th>
<th>Right Turn</th>
<th>Ped volume</th>
<th>Ped volume</th>
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Data Summary for E Tennessee St at E Monroe St (Tallahassee, FL) Eastbound Right Turn after LPI Implementation

During “WALK” Signal Equal to LPI

During “DON’T WALK” Signal (Inside)

Hourly Statistics
Task 5: After Study of LPI Implementation and Analyses

5.3 Before-and-After Analysis

<table>
<thead>
<tr>
<th></th>
<th>6 Hour Data</th>
<th>Percentage of Veh Non Yield LPI</th>
<th>Percentage of Veh Non Yield Total</th>
<th>Percentage of Conflicts LIPI</th>
<th>Number of Conflicts LIPI</th>
<th>Number of Conflicts Total</th>
<th>Percentage of Conflict Reduction LIPI</th>
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<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
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<td>53.3%</td>
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B = Before, A = After

Task 5: After Study of LPI Implementation and Analyses

5.3 Before-and-After Analysis

Before-after Vehicle Delay Simulation Analysis

Traffic Delay Simulation Results for E Kennedy Blvd @ N Tampa St (Tampa, FL)

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<thead>
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<th>Approach</th>
<th>Total Delay (sec)</th>
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<td>Before LPI</td>
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<td>Westbound left turn</td>
<td>19.3</td>
</tr>
<tr>
<td>Westbound through</td>
<td>18.6</td>
</tr>
<tr>
<td>Southbound through</td>
<td>24.3</td>
</tr>
<tr>
<td>Southbound right turn</td>
<td>24.9</td>
</tr>
<tr>
<td>Entire westbound</td>
<td>18.7</td>
</tr>
<tr>
<td>Entire southbound</td>
<td>24.4</td>
</tr>
</tbody>
</table>

E Kennedy Blvd @ N Tampa St, Tampa, FL (Two one-way roads)
Task 5: After Study of LPI Implementation and Analyses

5.3 Before-and-After Analysis

Before-and-After Vehicle Delay Simulation Analysis

Traffic Delay Simulation Results for SR A1A @ 178th St, Sunny Isles Beach, FL

<table>
<thead>
<tr>
<th>Approach</th>
<th>Total Delay (sec)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Before LPI</td>
</tr>
<tr>
<td>Eastbound left turn</td>
<td>47.4</td>
</tr>
<tr>
<td>Eastbound right turn</td>
<td>8.5</td>
</tr>
<tr>
<td>Northbound left turn</td>
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</tr>
<tr>
<td>Northbound through</td>
<td>7.4</td>
</tr>
<tr>
<td>Southbound through/right turn</td>
<td>16.5</td>
</tr>
<tr>
<td>Entire southbound</td>
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<tr>
<td>Entire northbound</td>
<td>10.9</td>
</tr>
<tr>
<td>Entire southbound</td>
<td>65.5</td>
</tr>
</tbody>
</table>

SR A1A @ 178th St, Sunny Isles Beach, FL (T-intersection, most congested of all sites)

5.4 LPI Utilization Efficiency (To avoid driver complaints about pedestrian push-and-leave)

<table>
<thead>
<tr>
<th>Approach</th>
<th>LPI Utilization Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Cycles with No Pod</td>
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<tr>
<td>Fletcher @ USF Palm</td>
<td>1</td>
</tr>
<tr>
<td>Kennedy @ Tampa</td>
<td>10</td>
</tr>
<tr>
<td>Fletcher @ Nebraska</td>
<td>16</td>
</tr>
<tr>
<td>Gainesville</td>
<td>1</td>
</tr>
<tr>
<td>Sunny Isles Beach Site Right Turn</td>
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</tr>
<tr>
<td>Sunny Isles Beach Site Left Turn</td>
<td>62</td>
</tr>
<tr>
<td>Nickerson</td>
<td>0</td>
</tr>
<tr>
<td>Fort Lauderdale</td>
<td>79</td>
</tr>
<tr>
<td>Tallahassee East Leg</td>
<td>4</td>
</tr>
<tr>
<td>Tallahassee South Leg</td>
<td>3</td>
</tr>
<tr>
<td>Ocala</td>
<td>0</td>
</tr>
</tbody>
</table>

* Fletcher @ Nebraska: low pedestrian volume and long green phase for intersecting approach
* SIB Left Turn: LPI triggered together on both left and right turns, most pedestrian cross right
* Fort Lauderdale: pedestrian signal were pre-timed during the daytime, triggered automatically
Task 6: Finalization of LPI Implementation Guidelines

Efforts were made to improve the accuracy and applicability of the statewide LPI implementation guidelines, including,

- LPI warrants were re-organized and presented in an easy way following MUTCD.
- Quantitative thresholds for these warrants were calibrated based on before-after analysis findings.
- LPI Length calculation was re-defined based on peer studies (Fayish & Gross, 2010; Federal Highway Administration, 2001; Kubilins & Branyan, 2015; Saneinejad & Lo, 2015)
- Additional supplemental design recommendations.

Task 6: Finalization of LPI Implementation Guidelines

The refined LPI implementation guidelines include the following LPI warrants:

- Warrant 1, Approach Crash Frequency
- Warrant 2, Reported Visibility Issue
- Warrant 3, Vehicle Non-Yielding Behavior
- Warrant 4, Vehicle Peak-hour
- Warrant 5, Pedestrian Peak-hour
- Warrant 6, Four-Hour Vehicular and Pedestrian Volume
- Warrant 7, Eight-Hour Vehicular and Pedestrian Volume
- Warrant 8, School Crossing

Note: Warrant 3 is considered by FDOT as the key warrant for LPI implementation.
Task 6: Finalization of LPI Implementation Guidelines

Warrant 1, Approach Crash Frequency

Support:
01 An Average Crash Frequency warrant is intended for application at an approach of intersection at which a pedestrian-vehicle crash is the principal reason to consider implementing an LPI.

Standard:
02 The implementation of an LPI shall be considered at an approach of intersection if an engineering study finds that the following condition is met: Average Crash Frequency between turning vehicles on green and pedestrians legally crossing the street on the associated crosswalk with the pedestrian “Walk” signal indication on the approach of the intersection ≥1 per year (in last 3 years).

Task 6: Finalization of LPI Implementation Guidelines

Warrant 2, Reported Visibility Issue

Support:
01 A Reported Visibility Issue Warrant is intended for application at an approach of an intersection at which reported visibility issues for pedestrians on the crosswalk being seen by turning vehicle drivers is the principal reason to consider implementing an LPI.

Standard:
02 The need for an LPI shall be considered if a visibility issue of blocked driver view of pedestrians on the crosswalk due to obstructions or poor sight distance at an approach of an intersection is reported and then verified by an engineering study.
Task 6: Finalization of LPI Implementation Guidelines

Warrant 3, Vehicle Non-Yielding Behavior

Support:
01 A Vehicle Non-Yielding Behavior Warrant is intended for application at an approach of an intersection at which vehicle non-yielding behavior to pedestrians legally in a crosswalk during the "Walk" phase is the principal reason to consider implementing an LPI.
02 Two conditions, Condition A regarding number of pedestrian-vehicle conflicts and Condition B regarding compromised pedestrians due to vehicle non-yielding behavior, are both considered. If either Condition A or Condition B is satisfied, then Warrant 3 is satisfied. If neither Condition A nor Condition B is satisfied, then Warrant 3 is not satisfied.

Standard:
03 The need for an LPI shall be considered if vehicle non-yielding behavior to pedestrians during the "Walk" signal indication at an approach of the intersection is reported and one of the following conditions is satisfied:
A: Average number of conflicts between pedestrians and turning vehicles during the pedestrian "Walk" signal indication ≥3 per day on the studied approach based on field observations of 3 days.
B: Percentage of compromised pedestrians starting at onset of the "Walk" signal at the crosswalk of the studied approach ≥10%.

Vehicle Movement Definitions

Traffic movement on approach for LPI suitability assessment.
### Task 6: Finalization of LPI Implementation Guidelines

#### Warrant 4, Vehicle Peak-hour

**Support:**
01 A Vehicle Peak-hour Warrant is intended for use at an approach of an intersection at which traffic conditions are such that for a minimum of 1 hour of an average day, the high vehicle volume induces potentially significant interactions between vehicles and crossing pedestrians and creates potential risk for pedestrian safety.

**Standard:**
02 An LPI should be applied at signalized intersections that attract or discharge large numbers of vehicles over a short time. The need for an LPI should be considered at the studied approach of an intersection when an engineering study finds that the following vehicular and pedestrian conditions are satisfied:

- For vehicular traffic peak hour of an average day, approach turning vehicle volume (movement A) \( \geq 130/\text{hour} \), pedestrian volume at crosswalk (movement B) \( \geq 25/\text{hour} \).
- If either turning vehicle volume (movement A) \( \geq 130/\text{hour} \) or pedestrian volume at crosswalk (movement B) \( \geq 25/\text{hour} \), but not both, is satisfied, and through traffic volume of cross street (movement C) \( \geq 500/\text{hour/lane} \) is also satisfied.

#### Warrant 5, Pedestrian Peak Hour

**Support:**
01 A Pedestrian Peak-hour Warrant is intended for use at an approach of an intersection at which traffic conditions are such that for a minimum of 1 hour of an average day, the high pedestrian volume induces significant interactions between vehicles and crossing pedestrians and creates potential risk for pedestrian safety.

**Standard:**
02 An LPI shall be applied in situations that attract or discharge large numbers of pedestrians over a short time.

The need for an LPI shall be considered at the studied approach of an intersection when an engineering study finds that the following vehicular and pedestrian conditions is satisfied:

- For pedestrian volume peak hour of an average day, approach turning vehicle volume (movement A) \( \geq 100/\text{hour} \), pedestrian volume at crosswalk (movement B) \( \geq 50/\text{hour} \).
- If either turning vehicle volume (movement A) \( \geq 100/\text{hour} \) or pedestrian volume at crosswalk (movement B) \( \geq 50/\text{hour} \), but not both, is satisfied, and through traffic volume of cross street (movement C) \( \geq 400/\text{hour/lane} \) is also satisfied.
**Task 6: Finalization of LPI Implementation Guidelines**

### Warrant 6, Four-Hour Vehicular and Pedestrian Volume

**Support:**
01 Four-Hour Vehicular and Pedestrian Volume Warrant conditions are intended to be applied in situations in which large volumes of vehicles and pedestrians over any 4 hours of a day are the principal reason to consider implementing an LPI.

**Standard:**
02 The need for an LPI shall be considered at the studied approach of an intersection when an engineering study finds that the following vehicular and pedestrian condition is satisfied for each of any 4 hours of an average day:

- Approach turning vehicle volume (movement A) ≥ 105/hour, pedestrian volume at crosswalk (movement B) ≥ 30/hour.
- If either turning vehicle volume (movement A) ≥ 105/hour or pedestrian volume at crosswalk (movement B) ≥ 30/hour, but not both, is satisfied, and through traffic volume of cross street (movement C) ≥ 400/hour/lane is also satisfied.

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### Warrant 7, Eight-Hour Vehicular and Pedestrian Volume

**Support:**
01 Eight-Hour Vehicular and Pedestrian Volume Warrant conditions are intended to be applied in situations in which large and consistent volume of vehicles and pedestrians is the principal reason to consider implementing an LPI.

**Standard:**
02 The need for an LPI shall be considered at the studied approach of an intersection when an engineering study finds that the following vehicular and pedestrian conditions is satisfied for each of any eight hours of an average day:

- Approach turning vehicle volume (movement A) ≥ 100/hour, pedestrian volume at crosswalk (movement B) ≥ 25/hour.
- If either turning vehicle volume (movement A) ≥ 100/hour or pedestrian volume at crosswalk (movement B) ≥ 25/hour, but not both, is satisfied, and through traffic volume of cross street (movement C) ≥ 400/hour/lane is also satisfied.
Task 6: Finalization of LPI Implementation Guidelines

Warrant 8, School Crossing

Support:
01 A School Crossing Warrant is intended for application at locations at which school students crossing a street is the principal reason to consider implementing an LPI. For the purpose of this warrant, “school students” include elementary school through university students.

Standard:
02 The need for an LPI shall be considered at the studied approach of an intersection when an engineering study finds that the following vehicular and pedestrian condition is satisfied at an intersection with a school crossing:

- Approach turning vehicle volumes (movement A) ≥ 50/hour (consider LPI for 1 hour before and 30 minutes after school start time and 30 minutes before and 1 hour after school end time).

Task 6: Finalization of LPI Implementation Guidelines

LPI Implementation

Standard:
01 An LPI should be minimum of 3 seconds in duration.
02 LPI timing should allow pedestrians to clear the width of one lane in the direction of moving traffic (and the width of a parking lane, if any) to increase the visibility of pedestrians to turning traffic.

Guidance:
03 A minimum of 3-second LPI duration is required. The following formula can be used to design LPI duration:

\[ LPI = \frac{(ML + PL)}{W} \]

where:
- \( LPI \) = number of seconds (rounded value) between onset of “Walk” signal for pedestrians and green indication for vehicles
- \( ML \) = distance on crosswalk to clear width of one moving lane, in ft
- \( PL \) = width of parking lane, if any, in ft
- \( W \) = walking speed (3.5 ft/s for pedestrian clearance calculation suggested by MUTCD, or 3.0 ft/s for aging population suggested by FHWA)
Task 6: Finalization of LPI Implementation Guidelines

Options:
04 Transportation engineers should determine whether to implement an LPI for a whole day or on a time-of-day basis.
05 An electronic blank-out “No Turn on Red” sign should be considered to restrict concurrent right turns during “Walk” intervals along with LPI implementation.
06 Extended LPI should be considered at approaches with large portions of users with slower crossing speeds (children, older adults, persons with physical disabilities), or at approaches where the pedestrian detector location is not immediately adjacent to the curb (or, if no pedestrian detector is present, a location 6 feet from the face of the curb or from the edge of the pavement may be considered for calculating extended LPI).
07 The use of an Accessible Pedestrian Signal (APS) (MUTCD Sections 4E.09–4E.13) should be considered if an LPI is used, as vision-impaired pedestrians use the sound of moving traffic to start crossing.
08 Education about LPI operation should be considered—for example, using a different background color (other than white) for a push button sign plate with a short message such as “Ped Head Start” for crosswalks with the LPI feature.
09 Conducting field observations and safety improvement evaluations after LPI implementation should be considered, and potential further adjustments in signal timing and coordination could be applied based on engineering judgment.
10 Lengthy traffic signal cycles should be avoided to reduce pedestrian wait time and increase pedestrian compliance behavior with pedestrian signals.

Illustrative Example

Consider if an LPI is needed on the west leg crosswalk (northbound left turn)

Fact Summary
• In a downtown CBD
• Two one-way roads, 10 ft travel lane width for all approaches
• 8 ft parking lane on both sides of K street
• 8 ft parking lane on the right side of F street
• No pedestrian crash in last 3 years
• Pre-timed traffic and pedestrian signals in all approaches
• No visibility issue reported
• Vehicle Non-yielding behavior was reported
Task 6: Finalization of LPI Implementation Guidelines

Illustrative Example

Approach Traffic Volume and Conflicts (Related to LPI Warrant Analysis)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Left Turn Volume (NB)</th>
<th>Ped Volume*</th>
<th>Ped-veh Conflicts</th>
<th>Intersect Traffic Volume (WB)</th>
<th>Intersect Traffic Per Lane (WB)</th>
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</thead>
<tbody>
<tr>
<td>8:00-9:00</td>
<td>221</td>
<td>109</td>
<td>2</td>
<td>1357</td>
<td>339</td>
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<td>9:00-10:00</td>
<td>153</td>
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<td>1</td>
<td>1249</td>
<td>312</td>
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<tr>
<td>10:00-11:00</td>
<td>163</td>
<td>107</td>
<td>0</td>
<td>1191</td>
<td>298</td>
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<tr>
<td>11:00-12:00</td>
<td>194</td>
<td>212</td>
<td>3</td>
<td>1048</td>
<td>262</td>
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<tr>
<td>16:00-17:00</td>
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<td>1</td>
<td>1123</td>
<td>281</td>
</tr>
</tbody>
</table>

Task 6: Finalization of LPI Implementation Guidelines

Warrant Analysis

• **Warrant 1 Average Crash Frequency**
  There were no crashes occurred between turning vehicles on green and pedestrian legally crossing the street during “Walk” signal in the past three years, Warrant 1 Average Crash Frequency is **NOT MET**.

• **Warrant 2 Reported Visibility Issue**
  Since there is no reported visibility issue at the target approach, Warrant 2 Reported Visibility Issue is **NOT MET**.

• **Warrant 3 Vehicle Non-Yielding Behavior**
  The average number of conflicts between pedestrian and turning vehicles during pedestrian “Walk” signal is **11.7 per day**. Therefore, Warrant 3 Vehicle Non-Yielding Behavior is **MET**.
Task 6: Finalization of LPI Implementation Guidelines

Warrant Analysis

- **Warrant 4 Vehicle Peak-hour**

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Left Turn Volume (NB)</th>
<th>Ped Volume*</th>
<th>Intersect Traffic Volume (WB)</th>
<th>Intersect Traffic Per Lane (WB)</th>
<th>Warrant Met? (Yes/No)</th>
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<td>281</td>
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</table>

*Count bicyclists as pedestrians

Therefore, Warrant 4 Vehicle Peak-hour is **MET**.

Task 6: Finalization of LPI Implementation Guidelines

Warrant Analysis

- **Warrant 5 Pedestrian Peak Hour**

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Left Turn Volume (NB)</th>
<th>Ped Volume*</th>
<th>Intersect Traffic Volume (WB)</th>
<th>Intersect Traffic Per Lane (WB)</th>
<th>Warrant Met? (Yes/No)</th>
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<td>10:00-11:00</td>
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<tr>
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<td>194</td>
<td>212</td>
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<td>1053</td>
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<td>113</td>
<td>1123</td>
<td>281</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Count bicyclists as pedestrians

Therefore, Warrant 5 Pedestrian Peak-hour is **MET**.
Task 6: Finalization of LPI Implementation Guidelines

Warrant Analysis

• **Warrant 6, Four-Hour Vehicular and Pedestrian Volume**

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Left Turn Volume (NB)</th>
<th>Ped Volume*</th>
<th>Intersect Traffic Volume (WB)</th>
<th>Intersect Traffic Per Lane (WB)</th>
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<td>113</td>
<td>1123</td>
<td>281</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Count bicyclists as pedestrians

Therefore, Warrant 6 Four-Hour Vehicular and Pedestrian volume is MET.

---

Task 6: Finalization of LPI Implementation Guidelines

Warrant Analysis

• **Warrant 7, Eight-Hour Vehicular and Pedestrian Volume**

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Left Turn Volume (NB)</th>
<th>Ped Volume*</th>
<th>Intersect Traffic Volume (WB)</th>
<th>Intersect Traffic Per Lane (WB)</th>
<th>Warrant Met? (Yes/No)</th>
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<tbody>
<tr>
<td>8:00-9:00</td>
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<td>72</td>
<td>1249</td>
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</tr>
<tr>
<td>14:00-15:00</td>
<td>165</td>
<td>141</td>
<td>1086</td>
<td>272</td>
<td>Yes</td>
</tr>
<tr>
<td>15:00-16:00</td>
<td>135</td>
<td>102</td>
<td>1053</td>
<td>263</td>
<td>Yes</td>
</tr>
<tr>
<td>16:00-17:00</td>
<td>114</td>
<td>120</td>
<td>1149</td>
<td>287</td>
<td>Yes</td>
</tr>
<tr>
<td>17:00-18:00</td>
<td>172</td>
<td>113</td>
<td>1123</td>
<td>281</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Count bicyclists as pedestrians

Therefore, Warrant 7 Eight-hour vehicular and pedestrian volume is MET.
Task 6: Finalization of LPI Implementation Guidelines

Warrant Analysis

**Warrant 8, School Crossing**

Since this intersection is not within a school zone, Warrant 8 School Crossing is **NOT MET**.

<table>
<thead>
<tr>
<th>Warrant</th>
<th>Warrant Met? (Yes/No)</th>
<th>Warrant</th>
<th>Warrant Met? (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warrant 1</td>
<td>No</td>
<td>Warrant 5</td>
<td>Yes</td>
</tr>
<tr>
<td>Warrant 2</td>
<td>No</td>
<td>Warrant 6</td>
<td>Yes</td>
</tr>
<tr>
<td>Warrant 3</td>
<td>Yes</td>
<td>Warrant 7</td>
<td>Yes</td>
</tr>
<tr>
<td>Warrant 4</td>
<td>Yes</td>
<td>Warrant 8</td>
<td>No</td>
</tr>
</tbody>
</table>

Based on the above results, an **LPI is recommended at the target approach**.

**LPI Implementation Recommendation**

- The suggested LPI duration is: \( LPI = \frac{(ML+PL)}{W} = \frac{10+8}{3.5} = 5.1 \) seconds. Considering the pedestrians with lower crossing speeds and the distance between the curb and pedestrian waiting locations, a LPI of 6 seconds is recommended.
- An Accessible Pedestrian Signal (APS) (MUTCD Sections 4E.09–4E.13) should be considered.
- Traffic engineers should conduct field observations and safety improvement evaluations after LPI implementation, and provide potential further adjustments in signal timing and coordination as needed.

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Tasks 7-8: Draft and Final Report and Project Closeout Teleconference

- Draft final report
- Closeout Teleconference
- Final report
Summary of Research Conclusions

- The research team conducted intensive collection of LPI guideline information through 1) literature review, 2) online surveys, 3) interviews, and 4) teleconference discussions from experience in-state and out-of-state engineers.
- The research team obtained the input and guidance for LPI implementation guidelines from FDOT district representatives.
- The research team developed a preliminary LPI implementation guideline based on the collected information input.
- The research team successfully conducted before-after data collection and analysis to test LPI suitability and effectiveness.

Summary of Research Conclusions

- Before-after data analysis provided valuable insights in LPI safety performance and operational influence:
  - LPI was effective in reducing pedestrian-vehicle conflicts during the first few seconds of “Walk” signal in 5 of 6 testing approaches with “before” conflicts.
  - Vehicle non-yielding behavior improvement after LPI varied due to different traffic volume and signal timing configurations.
  - LPI induced slightly increase or decrease in average total delay per vehicle on different approaches, showing a trivial adverse or even favorable influence.
- LPI achieved percentages of utilization above 85% (7 approaches), 70%-85% (2 approaches), and 60%-70% (1 approach) at different locations when traffic and pedestrian volumes are close to or exceed those specified in warrants.
- The LPI implementation guidelines were further refined based on before-after data analysis and findings.
Summary of Research Conclusions

- Proper implementations of LPIs demonstrated promising safety effects in reducing the number of vehicle-pedestrian conflicts at five of the six (83%) testing approaches during the first few seconds equal to LPI length. The percentage of vehicle-pedestrian conflict reduction ranged from 25% to 100%.
- The implementation of LPIs showed mixed results of drivers’ yielding behaviors.
- The implementation of LPIs showed minor impact to traffic operations.
- LPI Warrants are useful for a successful LPI implementation.
- Proper implementation of LPI will improve pedestrian safety at signalized intersections.

Summary of Research Conclusions

For LPI Implementation

- Left-turn traffic volume should be used for traffic volume warrant analysis at T-intersections or intersection with one-way roads.
- It is recommended to implement “No Turn on Red” or “Turning Vehicles Yield to Pedestrians” along with LPI to maximize safety effect.

Dual blank-out “No Turn on Red”/“Yield to Pedestrian” sign
Summary of Research Conclusions

For LPI Implementation

- Extended LPI should be considered at approaches with large portions of users with slower crossing speeds, or where the pedestrian detector location is not immediately adjacent to the curb.

- An Accessible Pedestrian Signal (APS) (MUTCD Sections 4E.09–4E.13) should be considered if an LPI is used. (Also see State of Florida Traffic Engineering Manual Section 3.7)

  - Accessible pedestrian signals shall have both audible and vibrotactile walk indications.
  - Vibrotactile walk indications shall be provided by a tactile arrow on the pushbutton that vibrates during the walk interval.
  - Accessible pedestrian signals shall have an audible walk indication during the walk interval only.
  - The accessible walk indication shall have the same duration as the pedestrian walk signal except when the pedestrian signal rests in walk.
Recommendations

- 1) Historical pedestrian-vehicle crash records, 2) reported visibility issue, and 3) reported vehicle non-yielding behavior, are given higher priority than 4) traffic and pedestrian volume in consideration of LPI.

- Potential increase in travel delay by LPI should be evaluated based on engineering experience. An LPI should not be implemented if significant delay or congestion will occur.

- Field observations are recommended to estimate the proportion of pedestrians with slower crossing speeds.

- Transportation engineers should determine whether to implement an LPI for the whole day or on a time-of-day basis.

- Educational outreach should be considered to let local residents be familiar and get used to new LPI implementations.

- Adjustments should be applied as needed to maximize LPI safety effectiveness and utilization after implementation.

Thank You!

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