Using Technology to Evaluate and Improve Pedestrian and Bicycle Safety

Georgia Walks Summit 2019

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Overview

1. Background Research
2. Compliance Evaluation
3. Device Evaluation
4. Alternative Data
5. Device Specification
6. Recommendations
Purpose

RTOP should consider all multimodal needs. This was voiced by many stakeholders.
Goal

Analyze technology applications that improve operations and safety for non-motorized users, in a context sensitive and data-driven manner.
Background Research
Background Research

- Identify existing state or local agency specifications related to bicycle and pedestrian technology.

- Colorado DOT and Minnesota DOT have mature bicycle and pedestrian state wide count programs.

- Formalized bicycle and pedestrian counter specifications were not found to be prevalent.

**Bicycle and Pedestrian Data Collection Guidebooks Reviewed**

National Cooperative Highway Research Program (NCHRP)

California DOT (CalTrans)

Colorado DOT (CDOT)

Delaware DOT (DelDOT)

Florida DOT

Minnesota DOT (MnDOT)

Oregon DOT

Portland Bureau of Transportation

San Diego Association of Governments (SANDAG)

Utah Department of Transportation (UDOT)

Washington DOT (WSDOT)
# Background Research

Table 3-1. Comparison of common pedestrian and bicycle counting methods: user characteristics and site characteristics.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Passive Infrared</th>
<th>Active Infrared</th>
<th>Pneumatic Tubes</th>
<th>Inductive Loops</th>
<th>Piezoelectric Sensor</th>
<th>Passive IR + Inductive Loops</th>
<th>Radio Beam (One Frequency)</th>
<th>Radio Beam (High/Low Frequency)</th>
<th>Automated Video</th>
<th>Manual Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of users counted</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All facility users</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pedestrians only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bicycles only</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pedestrians vs. bicycles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bicycles vs. automobiles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Characteristics collected</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different user types</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Direction of travel(^1)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>User characteristics(^4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Types of sites counted</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple-use trail segments</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sidewalk segments</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bicycle lane segments</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cycle track segments</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Shared roadway segments</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Roadway crossings (detect from median(^3))</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Roadway crossings (detect from end of crosswalk)</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Intersections (identify turning movements)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Notes:
1. Existing “automated video” systems may not use a completely automated counting process; they may also incorporate manual data checks of automated video processing.
2. Includes manual counts from video images.
3. Technologies noted as “Yes” have at least one vendor that uses the technology to capture directionality.
4. User characteristics include estimated age, gender, helmet use, use of wheelchair or other assistive device, pedestrian and bicyclist behaviors, and other characteristics.
5. Roadway crossings at medians potentially have issues with overcounting due to people waiting in the median. Median locations were not tested during this project.
Background Research

CALTRANS MUTCD

- Minimum Bicycle Signal timing
- Bicycle detection was made a requirement at:
  - New and modified bike path approaches
  - New signalized intersections
- Guidance of detection systems to install
  - Loops
  - Video detection
  - Push button

Figure 4D-111 (CA). Examples of Detection Systems (Sheet 1 of 3)

NOTES:
1. Typical technology neutral limit line detection locations. See Section 4D.105 (CA).
2. Typical presence detection locations. See Section 4D.103 (CA).
3. Typical advance detection locations.
4. A bicyclist pushbutton may be used to activate a traffic signal to supplement the required limit line detection. A pushbutton should be located so it is convenient to use by bicyclists. See Section 95.11 for bicycle regulatory signs.
Compliance Evaluation
Mid-Block Crossing Compliance Evaluation

Data collection and analysis focused on:

• Pedestrian crossing location compliance
• Pedestrian crosswalk signal compliance
• Driver crosswalk compliance

Motivating better behavior
Measure the actual outcome associated with the risk for the pedestrian

Goal
Provide recommendations for mid-block crossing treatments and operational parameters to improve compliance
Evaluating Compliance

19 sites

- 12 Pedestrian Hybrid Beacon (PHB)
- 7 Rectangular Rapid Flash Beacon (RRFB)

Source: Portland Bureau of Transportation
### Evaluating Compliance

Observed location characteristics

<table>
<thead>
<tr>
<th>Vehicle posted speed</th>
<th>Roadway width</th>
<th>Pedestrian refuge area</th>
<th>Pedestrian daily volume</th>
<th>Vehicle daily volume</th>
<th>Distance to nearest ped refuge</th>
<th>Distance from stop bar to crosswalk</th>
</tr>
</thead>
</table>

#### Sample Table

<table>
<thead>
<tr>
<th>Location</th>
<th>Device Type</th>
<th>Speed Limit (mph)</th>
<th>Weekday 12-hour Pedestrian + Bicycle Volume</th>
<th>Weekday 12-hour Vehicle Volume</th>
<th>Roadway Width (ft)</th>
<th>Number of Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>XXXX Road</td>
<td>PHB or RRFB</td>
<td>X</td>
<td>X</td>
<td>X,XXX</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Sample of Field Data Collection: Inventory and Activity Levels

PHB – Atlanta, GA – Ponce de Leon Ave. between Somerset Ter. And Bonaventure Ave.

<table>
<thead>
<tr>
<th>Speed Limit (mph)</th>
<th>Environment:</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Individual Cross Time (s):</td>
<td>14.3</td>
<td>Crossing Distance (ft):</td>
</tr>
<tr>
<td>Avg. Wait Time (s):</td>
<td>7.5</td>
<td>Number of Lanes:</td>
</tr>
<tr>
<td>% Button Activation:</td>
<td>34</td>
<td>Street Lights within 20 ft:</td>
</tr>
<tr>
<td>Weekday 12-hr Ped-Bike Vol:</td>
<td>172</td>
<td>Ped. Detection Type(s):</td>
</tr>
<tr>
<td>Weekday 12-hr Veh. Vol:</td>
<td>24,166</td>
<td>Ped. Service Type(s):</td>
</tr>
</tbody>
</table>

Typical Weekday Hourly Crossing Activity Levels (September 2018)

- Vehicle Volume
- Ped/Bike Volume
Sample of Field Data Collection: Pedestrian & Driver Behavior

Crosswalk Users and Behavior
- 97% Pedestrian
- 3% Cyclist
- 14% Group
- 86% Individual

Driver Behavior
- 95% Crosswalk Compliant (Stopped before X-Walk)
- 5% Noncompliant (Part of vehicle in X-Walk)
- 81% Stop Bar Compliant (Stopped before stop bar)
- 19% Noncompliant (Stopped after stop bar)

Note: This location is a 2-stage crossing but compliance is only measured for one stage. Crossing time is measured across both directions.
Median Refuge Area

Median refuge areas resulted in a lower rate of pushbutton actuation and pedestrian signal compliance

- Pedestrian signal average compliance: 49% (median) vs 72% (no median)
- Push button activation average compliance: 63% (median) vs 77% (no median)

The lower compliance rates represents a higher level of pedestrian comfort

A median is the first treatment for consideration, and provides the primary benefit at a mid-block crossing
PHB Pedestrian Pushbutton Compliance

Influenced by presence of pedestrian refuge area

Rule of thumb: compliance at less than 50% should be evaluated further
PHB Pedestrian Signal Compliance

Influenced by presence of pedestrian refuge area

Rule of thumb: compliance at less than 50% should be evaluated further
Rule of thumb: compliance at less than 70% should be evaluated further.
Driver Compliance at Crosswalk

Rule of thumb: compliance at less than 70% should be evaluated further
Correlation Analysis

Correlations involving compliance were evaluated based on the following values:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pedestrian Compliance</th>
<th>Driver Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian Wait Time</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Speed Limit</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Average 12-hour Traffic Volume</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Roadway Width</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Distance to Nearest Pedestrian Refuge</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Correlations where the $R^2$ value exceeded 0.1

Field Review

Video Data Analysis
Vehicle Volume and Pedestrian Signal Compliance

- Pedestrians are more likely to wait for the ped signal phase on roads with higher vehicle volume
- Pedestrian signals substantially reduce the risk profile for the pedestrian in a high vehicle volume environment
Speed Limit and Vehicle Crosswalk Compliance

- Corridors with a higher posted speed limit tend to comply more with the crosswalk
- Pedestrian crossing visibility is a key ingredient for appropriate driver reaction, such as signal heads located over the vehicle lanes
Device Evaluation
Device Evaluation

Scan the industry for devices that focus on pedestrian and bicycle applications now available. Review device applications now available. Test devices in the field for their effectiveness. Accuracy Analysis

Devices

• Eco-Counter ZELT
• FLIR TrafiOne
• Miovision SmartView 360
• Iteris Vantage Next
• Wavetronix SmartSensor Matrix
• GRIDSMART
Device Demonstration

Multiple vendors were invited to participate in the demonstration.

Two companies agreed to deploy products for evaluation

• Iteris Vantage Next
• GRIDSMART Bell Camera

Vehicle, bicycle, and pedestrian **counting**

Vehicle, bicycle, and pedestrian **detection**

**Counting**
Detecting the number of pedestrians and/or bicyclists in a zone

**Detection**
Notifies the presence of a pedestrian and/or bicycle and actuates appropriate phase(s) for traffic control device(s) at the intersection
Device Demonstration Sites

GRIDSMART Site

1. Mast Arm
2. Cabinet
3. Bicycle Lanes

Iteris Site

1. Mast Arm
2. Cabinet
3. Bicycle Lanes
GRIDSMART Bell Camera System

108° Fisheye Camera

GS2 Processor

Gridsmart Client
Iteris Vantage Next Camera

Vantage Next Camera
SDLC Card and Processor

Vantage Live Interface
## Device Functionality

### Counting
- **Pedestrians**: X
- **Bicyclists**: X
- **Vehicles**: X

### Reporting
- **Volume by Mode**
  - 5 min intervals: X
  - 15 min intervals: X
  - 30 min intervals: X
  - 60 min intervals: X

### Other Reports
- **Turning Movement Count**: X
- **Vehicle Classification**: X
- **Volume**: X
- **Incident***: X
- **Raw Export**: X
- **Weekly Volume**: X
- **Green Occupancy**: X
- **Red Occupancy**: X
- **% Arrivals on Red**: X
- **% Arrivals on Green**: X
- **Speed**: X

### Export Functionality
- **Remote Download**: X
- **Automated Reporting**: X

<table>
<thead>
<tr>
<th></th>
<th>Iteris Vantage Next</th>
<th>GRIDSMART Bell Camera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counting</td>
<td>Pedestrians: X</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Bicyclists: X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Vehicles: X</td>
<td>X</td>
</tr>
<tr>
<td>Reporting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume by Mode</td>
<td>5 min intervals: X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 min intervals: X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>30 min intervals: X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>60 min intervals: X</td>
<td>X</td>
</tr>
<tr>
<td>Other Reports</td>
<td>Turning Movement Count: X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vehicle Classification: X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volume: X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incident*: X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Raw Export: X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekly Volume: X</td>
<td>X</td>
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<tr>
<td></td>
<td>Green Occupancy: X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Red Occupancy: X</td>
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<td></td>
<td>% Arrivals on Red: X</td>
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</tr>
<tr>
<td></td>
<td>% Arrivals on Green: X</td>
<td></td>
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<tr>
<td></td>
<td>Speed: X</td>
<td>X</td>
</tr>
<tr>
<td>Export Functionality</td>
<td>Remote Download: X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Automated Reporting: X</td>
<td></td>
</tr>
</tbody>
</table>
Accuracy Evaluation

Processing vehicle, bicycle, and pedestrian counts

Weighted Average Percentage Deviation Method

Application to the specification

Weighted Average Percentage Deviation (WAPD)
To account for the low volume bias of the AAPD measure, a volume-weighted accuracy measure is also calculated, as:

\[ WAPD = \sum_{t=1}^{n} \left( \frac{A_t - M_t}{M_t} \times \frac{M_t}{\sum_{j=1}^{n} M_j} \right) \]
Alternative Data
Near Collision - Brisk Synergies

From an early but relevant study

- **Post Encroachment Time (PET)**
  - PET <= 3 second is considered **Near Collision**

- Safety analysis at 3 locations
  - 5th St at Spring St
  - 10th St at Techwood Dr
  - 13th St and Peachtree St

- **All-WALK phase findings**
  - 75% reduction in pedestrian conflicts
  - Average speed of vehicles increased by approximately 4 mph
  - Bicyclists not moving through the intersection during the pedestrian phase increased from 8% to 20%
Alternate Data Collection

AirSage Data

- AirSage Activity Density Pedestrian Identification (ADPI) Data
- Data sets evaluated were for September 2018 and May 2017
Passive Data Collection

Insights

• Weekdays, Saturday, or Sunday per hour block of time.
• Counts are not defined as individual sightings but rather an extrapolated (weighted) number of people passing by at slow speeds
Passive Data Collection

Lessons Learned

• Check for accuracy
• ADPI data set is currently best suited for corridor analysis, not intersection analysis, as shown in the map here
Device Specification
## Specification Components

### Primary Features

<table>
<thead>
<tr>
<th>Performance-based approach</th>
<th>Accuracy requirements</th>
<th>Invasive and non-invasive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software</td>
<td>Installation (on existing structures)</td>
<td>Cabinet requirements</td>
</tr>
</tbody>
</table>
Specification for Pedestrian and Bicycle Technology

Device options under development

- Passive pedestrian and bicycle detection
- Pedestrian and bicycle counting
- Travel time
- Near conflicts
Device Technology

Technology options that may be used by devices

- Connected Vehicle
- GPS
- Inductive Loop
- Lidar
- Piezo
- Radar, Aerial-based
- Radar, Pavement-base
- Video, Thermal
- Video, Conventional
- Video, Stereo
- Wireless Re-Identification
Recommendations
Recommendations (under development)

Mid-block crosswalks

• Operational parameters
• Visibility guidance
• Behavior thresholds

Devices

• Specification

Programming

• Performance measures
• State-wide program

Source: https://www.litro.co.uk/2013/10/a-monster-fed-by-money-frieze-art-fair-2013/
Questions?
Thank you!

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