Tools for Pedestrian and Bicycle Volume Data Collection

NCHRP 07-19

January 29, 2015

Source: Tony Hull
Presentation Overview

- Introduction
- Project and guidebook overview
- Non-motorized count applications
- Setting up a non-motorized counting program
- Cleaning, correcting, and expanding raw count data
- Field testing of automated counting technologies
- Final thoughts
- Questions and answers
Speakers

- Kelly Laustsen, Kittelson & Associates (webinar moderator)
- Paul Ryus, Kittelson & Associates
- Robert Schneider, University of Wisconsin-Milwaukee
- Tony Hull, consultant
- Frank Proulx, UC Berkeley SafeTREC
Learning Objectives

- How to use NCHRP Report 797 as a resource for supporting a non-motorized count program
- Potential applications for count data
- Steps involved in setting up a count program
- Relative strengths and weaknesses of a variety of non-motorized counting methods and technologies
Project and Guidebook Overview
NCHRP 07-19 Research Team

- Kittelson & Associates, Inc.
- University of Wisconsin—Milwaukee
- UC Berkeley, SafeTREC
- Toole Design Group
- McGill University
- Quality Counts, LLC
Project Purpose

- Address lack of pedestrian and bicycle volume data
- Assess data collection technologies and methods
- Develop guidance for practitioners
Key Differences: Motorized & Non-motorized Counting

- Pedestrian and bicycle volumes are more variable than motorized vehicle volumes
  - Relatively low ped/bike volumes relative to auto volumes
  - Weather effects

Auto (top) and bike (bottom) volumes on freeway and nearby shared path in Minneapolis
Sources: MnDOT, NCHRP 07-19 counting
Key Differences: Motorized & Non-motorized Counting

- Pedestrian and bicycle trips are often shorter and made for different purposes
  - Greater sensitivity to adjacent land uses
  - Potentially different peaking characteristics

Source: Paul Ryus
Key Differences: Motorized & Non-motorized Counting

- Motor vehicles tend to be easier to detect than pedestrians and bikes
  - Cars: large, separated metal objects in lanes
  - Peds & bikes:
    - Smaller objects
    - May travel in groups
    - May travel outside designated spaces
    - Peds and bikes may use same facility

Source: NCHRP 07-19 data collection videos
Key Differences: Motorized & Non-motorized Counting

- More limited experience with non-motorized counting technology
  - Differences in technologies
  - Differences in vendor implementations of the same technology
  - New technologies entering the market

Source: NCHRP 07-19 testing
Research Approach

- Conduct literature review
- Develop work plan
- Survey and outreach
- Field test counting technologies
- Produce guidance document for practitioners
Products

- NCHRP Report 797
  - Guidance for practitioners
- NCHRP Web-only Document 205
  - Documentation of the research effort
Final Report (NCHRP WoD 205) Contents

1. Project Background
2. State of the Practice
   • Literature review, survey results
3. Research Approach
   • Counting technology, test site selection
4. Findings & Applications
   • Detailed testing results
5. Conclusions & Suggested Research
   Practitioner survey form
   Practitioner survey results
   Non-motorized count programs described in the literature

Appendices
Guidebook (NCHRP Report 797) Topics

- Count applications with case studies
- Planning and implementing a count program, with checklists and case studies
- Correcting raw count data for to account for site- and product-specific counting errors
- Expanding short-term count data to estimate longer-duration volumes
- Typical applications, strengths/limitations, relative cost, installation needs, and accuracy of counting technologies
Guidebook (NCHRP Report 797) Contents

Quick Start Guide
1. Introduction
2. Non-Motorized Count Data Applications
3. Data Collection Planning and Implementation
4. Adjusting Count Data
5. Sensor Technology Toolbox

Case Studies

Appendices

Manual Pedestrian and Bicyclist Counts: Example Data Collector Instructions
Count Protocol Used for NCHRP Project 07-19
Day-of-Year Factoring Approach
Related Topics Not Covered

- Product-specific (by name) results
- Sampling and forecasting methods
  - Bluetooth and WiFi detection
  - GPS data collection
  - Radio frequency ID (RFID) tags
  - Bike sharing data
  - Pedestrian signal actuation buttons
  - Surveys
  - Presence detection
  - Trip generation

Sources: SFCTA CycleTracks app (top), Paul Ryus (bottom)
Related Work

- **FHWA Traffic Monitoring Guide (TMG)**
  - 2013 edition includes chapter on non-motorized traffic
  - Guidance on data reporting formats
  - NCHRP research complements FHWA guide
Related Work

- National Bicycle and Pedestrian Documentation Project
  - First large-scale repository for data
  - Provides resources on conducting counts
  - Cited by many practitioners as an influence in count program development
Non-motorized Count Applications
Pedestrian & Bicycle Counting Purposes

- General purposes
  - Measure facility usage
  - Evaluate before & after
  - Analyze safety
  - Identify user characteristics
  - Estimate network volumes
  - Prioritize projects

- Technical applications
  - Identify activity patterns

Source: Tony Hull
Measure Facility Usage

- Transportation system monitoring program
- Typically requires collecting counts at set locations and regular intervals
- Critical for tracking progress, measuring success

Change in walking and bicycling activity at Washington State count sites, 2009–2012

Figure 1 - Daily bicycle and pedestrian trips at annual benchmark locations. From 2007 to 2013, the number of bicyclists counted increased 76% and the number of pedestrians increased 24%.

Source: City of Minneapolis Pedestrian & Bicycle Count Report, 2013
Evaluate Before-and-After Volumes

- Measure volumes before and after facility is opened
- Forecast usage of planned facilities

Before-and-after bicycle facility usage: buffered bicycle lanes on Pennsylvania Ave., Washington, DC

Evaluate Before-and-After Volumes

- Count at control sites
  - Differentiate between increase due to new facility and community-wide increase in volume

Hypothetical: Average of other nearby counts
Analyze Safety

- Quantifying exposure
  - *Challenge*: in general, more pedestrian & bicycle activity at a location → more reported crashes
  - Variety of methods proposed to quantify exposure
  - One method compares pedestrian–vehicle collisions to average annual pedestrian volumes
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Source: Robert Schneider
### Alameda County, CA Pedestrian Risk Analysis

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Source: Robert Schneider
Oakland Reported Intersection Pedestrian Crashes (1996-2005)

Absolute number of crashes suggests safety problem is in downtown Oakland

Source: Robert Schneider
But the highest risk per pedestrian crossing is along major arterial roads.

Source: Robert Schneider
Identify User Characteristics

- **Demographics**
  - Gender
  - Age
  - Disabilities

- **Behaviors**
  - Helmet use
  - Looking before crossing
  - Yielding to pedestrians
Identify User Characteristics

Estimate Network Volumes

Source: City of Minneapolis Pedestrian & Bicycle Count Report, 2013
Estimate Network Volumes

- Multimodal travel demand modeling is an emerging field
- Potential to estimate demand over a large area and forecast influence of infrastructure changes

Source: City of Berkeley, CA Pedestrian Master Plan
Prioritize Projects

- Identify high-priority locations for improvements
  - Counts & estimated network volume can be used as a demand factor for ranking locations
Know Your Purpose for Counting

- Understanding the ultimate use(s) of the data is important for establishing the count method
  - *Document changes over time*: Select representative locations throughout a community
  - *Analyze safety*: Use intersection counts to count potential conflicts with motor vehicles
  - *Identify user characteristics*: Use manual counts to capture socioeconomic characteristics and behaviors
Identify Activity Patterns

- Develop expansion factors
  - Extrapolate short-duration counts over longer time periods
  - Identify patterns of use at specific locations (due to land use, socioeconomic, and other characteristics)
  - Identify how usage patterns vary by weather conditions
Why Are Activity Patterns Important?

- Manual & automated strategy recommended in the TMG and NCHRP Report 797
  - Use continuous count patterns from several automated count locations to estimate volumes at other locations with short counts
## Common Strategy: Manual & Automated

<table>
<thead>
<tr>
<th>Count Duration</th>
<th>Geographic Coverage</th>
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<td></td>
<td>A Few Locations</td>
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<td>Continuous</td>
<td>Automated</td>
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<td>Short-Term</td>
<td>Manual</td>
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### Bicycle Activity Patterns: Utilitarian vs. Recreational

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<td><strong>Weekend</strong></td>
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<td><strong>Daily Profile</strong></td>
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#### Primarily Utilitarian (PU)

Utilitarian locations exhibit two distinct weekday peaks, much like automobile commuter patterns, and have much higher ridership during the week than on the weekend. The weekend profile builds smoothly to a single PM peak. In general, they maintain the highest ridership in the winter.

#### Mixed – Utilitarian (MU)

Mixed-utilitarian locations still exhibit two peaks at the hourly level on weekdays, though the level of ridership between the peaks may be slightly higher than at primarily utilitarian locations. The difference between weekday and weekend ridership is much less pronounced, and may even be negligible. Weekend ridership builds gradually to a PM peak, similar to primarily utilitarian locations. They may retain less ridership in the winter than PU locations.

#### Mixed-Recreational (MR)

Mixed-recreational tend to maintain a consistent level of daily ridership throughout the week. However, unlike mixed-utilitarian, their hourly profiles do not exhibit two distinct commuting peaks. Still, their early AM ridership during the workweek may be slightly higher than primarily recreational locations. The daily profile may exhibit slightly higher ridership on the weekend. Ridership at these locations is generally considerably lower than PU or MU locations in the winter.

*Source: Miranda-Moreno, Nosal, Schneider, and Proulx (2013)*
Why Are Activity Patterns Important?

- Key reason: factoring
  
  - *Example*: Estimate the daily volume from a one-hour count of 100 bicyclists on Wed. from 12 to 1 p.m.
Bicycle Activity Patterns: Utilitarian vs. Recreational

<table>
<thead>
<tr>
<th>Type</th>
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</table>

Utilitarian locations exhibit two distinct weekday peaks, much like automobile commuter patterns, and have much higher ridership during the week than on the weekend. The weekend profile builds smoothly to a single PM peak. In general, they maintain the highest ridership in the winter.

Recreational locations tend to maintain a consistent level of daily ridership throughout the week. Mixed-recreational locations show a similar pattern, with a slightly higher level of ridership during the week and a lower level on the weekend. However, unlike mixed-utilitarian locations, their hourly profiles do not exhibit two distinct commuting peaks. Still, their early AM ridership during the workweek may be slightly higher than primarily recreational locations. The daily profile may exhibit slightly higher ridership on the weekend. Ridership at these locations is generally considerably lower than PU or MU locations in the winter.

**Source:** Miranda-Moreno, Nosal, Schneider, and Proulx (2013)
We need these data fields!

Institutionalize Pedestrian & Bicycle Data

- A multimodal transportation system requires collecting data for all modes of transportation
- Establish baseline data that can be used for multiple purposes: safety, user characteristics, etc.

### Mainline Traffic Volume
- **Id**: 177
- **RTE**: 64
- **PM**: 17.961
- **DIST**: 4
- **CO**: ALA
- **inx_main**: 2
- **inx_inters**: 2
- **inx_cros**: 2
- **inx_highwa**: U
- **inx_mainli**: 9200
- **inx_xstree**: 1350
- **Ped_Main**: ???
- **Ped_XStree**: ???
Setting Up a Non-motorized Counting Program
State of the Practice

- Counting programs and current count practices
  - Limited established count programs in the U.S., but lots of interest
  - Need and desire for guidance
  - Manual counts most common in current practice
Current Methods of Bicycle Counting

- Fiber optic pressure sensors: 0%
- Laser scanner: 1%
- Infrared cameras: 3%
- Piezoelectric strips: 4%
- Active infrared: 12%
- Automated video counters: 19%
- Passive infrared: 23%
- Inductive loops: 27%
- Pneumatic tubes: 31%
- Manual counts: 87%

Source: NCHRP 07-19 survey
NCHRP 7-19 Survey Findings

- There is no standard approach for initiating a count program
- Practitioners are looking for more guidance
  - Choosing devices
  - Selecting locations
  - Count intervals and duration
  - Temporal/seasonal adjustments
Challenge: No Standard Approach

- Where to start:
- When and where to count?
- How long to count?
- How frequently to count?
- What to count?
- Site/mode challenges
- Who should be counting?

Source: Tony Hull
Types of Counts

- **Intersection count**
  - Operational characteristics
  - Complex to conduct

- **Screenline count**
  - Volume data
  - Less complex
Challenge: Site/Mode Characteristics

<table>
<thead>
<tr>
<th>Motor vehicle data collection</th>
<th>Bicycle and pedestrian data collection</th>
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</thead>
<tbody>
<tr>
<td>Widely collected</td>
<td>Sparsely collected</td>
</tr>
<tr>
<td>Easy to track vehicle movements</td>
<td>Difficult to track and tabulate movements</td>
</tr>
<tr>
<td>Predictable patterns and routes</td>
<td>Unpredictable paths of travel</td>
</tr>
<tr>
<td>Years of trend data to analyze</td>
<td>Weather and seasonal impacts</td>
</tr>
<tr>
<td></td>
<td>Lack of historical data</td>
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</tbody>
</table>
Motor Vehicle Data Collection

Constrained; somewhat predictable

Source: Tony Hull
Bicycle Data Collection

Constrained environments easy to monitor

Complex environments harder to define

Source: Tony Hull
Pedestrian Data Collection

Constrained environments easy to monitor

People tend to make their own path

Source: Tony Hull
Counting System

- Sensor technology is one piece of the counting system
  - Data processing
  - Data storage
  - Power supply
  - Transmission of data
  - Data management QA/QC
Passive Infrared (IR)

- Detect pedestrians and cyclists by the infrared radiation (heat) patterns they emit
- Passive infrared sensor placed on one side of facility
- Widely used and tested

Source: Toole Design Group
Active Infrared (IR)

- Transmitter and receiver with IR beam
- Counts caused by “breaking the beam” 

Source: Steve Hankey, University of Minnesota
Pneumatic Tubes

- One or more tubes are stretched across roadway or path
- When a bicycle rides over tube, pulse of air passes through tube to detector

Source: Karla Kingsley
Inductive Loops

- Generate a magnetic field that detect metal parts of bicycle passing over loop
- In-pavement or temporary loops (on surface)
Piezoelectric Sensor

- Emit an electric signal when physically deformed to detect bicyclists
- Typically embedded in pavement across travel way

Source: MetroCount
Radio Beam

- Transmitter and receiver emit a radio signal that detect a user when the beam is broken
- Not previously tested in literature
- Some devices count bikes and peds separately

Source: Karla Kingsley
Combination

- Use one technology to detect all others plus another technology to detect bicyclists only
- Provide bicycle and pedestrian counts separately
  - Example:
    - Passive IR: pedestrians
    - Loop detector: bicycles

Source: Tony Hull
Manual Counts

- Most common type of counting, to date
- Capture many different locations
- Record pedestrian & bicyclist characteristics
- Can count roadway crossings
- Expensive
- Short counts may not expand accurately

Source: Robert Schneider
Technologies Not Tested by NCHRP 07-19

- Thermal
- Fiberoptic pressure sensors
- Radar
- Laser scanners
- Pressure and acoustic sensors
Pedestrian & Bicycle Count Program Overview

- Chapter 3 of NCHRP Report 797
  - Plan the count program
  - Implement the count program

- Complements Chapter 4 of the TMG
Plan the Count Program

- Specify the data collection purpose
- Identify data collection resources
- Select count locations & determine timeframe
- Consider available counting methods
Match Sites with Appropriate Counting Methods

- Most technologies count screenlines...few methods can count roadway crossings
- Know the type of data that you will be getting

Source: Robert Schneider

Source: Lindsay Arnold
Implement the Count Program

- Obtain necessary permissions
- Procure counting devices
- Inventory and prepare devices
- Train staff
- Install and validate devices
- Calibrate devices
- Maintain devices
- Manage count data
- Clean and correct count data
Obtain Permission

- Think about permission **early** in the process
- Understand installation details
- Who owns right-of-way, buildings, poles? Multiple organizations?
- Ask whether or not a permit is necessary. Consider informal e-mail approval.

*Source: Frank Proulx*
Procure Counting Devices

- Learn about equipment specs and vendor services
  - Out-of-box readiness?
  - Additional equipment needs? (wrenches, batteries, mobile device for communication...)
  - Warranty?
  - Installation time? Self vs. contractor?
  - Security/durability?
  - Data downloading?
  - Data format?
  - Performance history?
  - Installation support?
  - Calibration support?
  - Customer support?

Source: Tony Hull
Inventory and Prepare Devices

Source: Tony Hull
Train Staff

Source: Lindsay Arnold
<table>
<thead>
<tr>
<th>INSTALLATION CHECKLIST: ADVANCE PREPARATION</th>
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<tbody>
<tr>
<td><strong>Site visit to identify the specific installation location.</strong> Specifically, note poles that will be used, where pavement will be cut, or where utility boxes will be installed to house electronics. Verify that no potential obstructions (e.g., vegetation) or sources of interference (e.g., doorway, bus stop, bicycle rack) are present.</td>
</tr>
<tr>
<td><strong>Obtain and document necessary permissions.</strong> Permits or permissions may include right-of-way encroachment permits, pavement cutting permits or bonds, landscaping permits, or interagency agreements. Obtaining these permissions may take up to several months, particularly if other agencies are involved.</td>
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<tr>
<td><strong>Create a site plan.</strong> Develop a detailed diagram of the planned installation on an aerial photo or ground-level image documenting the intended equipment installation locations and anticipated detection zone (after installation this will be useful for validating equipment either visually or with video monitoring). This diagram may be useful for obtaining installation permissions and working with contractors. Figure 3-6 provides an example site plan.</td>
</tr>
<tr>
<td><strong>Hire a contractor</strong> if necessary (or schedule appropriate resources from within the organization).</td>
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<tr>
<td><strong>Arrange an on-site coordination meeting</strong> involving all necessary parties (e.g., staff representing the organization installing the counter, permitting staff, contractors). If possible, a vendor representative should be on hand or available by phone. It may take several weeks to find a suitable time when everyone is available.</td>
</tr>
<tr>
<td><strong>Check for potential problems.</strong> Problems with the site may include interference from utility wires, upcoming constructions projects, hills, sharp curves, nearby illicit activity, and nearby insect and animal activity. Some of these conditions can be identified from imagery, but they should also be evaluated in the field.</td>
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</table>
Installation Plan
Midtown Greenway - Minneapolis

- Camera Mount: telescope from Fence 30 – 50’ west of detection zone
- Cut loops for installation 15-20’ east of post.
- Install surface loops 5-8’ west of post
- Existing radio and passive IR beam count devices
  - Install radio beam on post and fence
  - Install Tube Counters 5-8’ east of post

Source: Tony Hull
Calibrate Devices

- Check counts immediately after installation
- Check counts 2-3 days after installation
- Check counts every 3-6 months
- Adjust sensitivity of detection?

Illustrative Comparison of Pneumatic Tube Accuracy Before and After Calibration
Maintain Devices

- Check devices every 3-6 months
- Clean device; check for obstructions

Source: Tony Hull
Manage Count Data

- Spreadsheet vs. vendor-specific software
- Cloud data storage?
- Connection to motorized count database?
Clean and Correct Data

- Review data to identify problems
- Potential causes
  - Blocked sensor
  - Multiple counts of same person
  - Equipment malfunction (power, sensitivity)
  - Incorrect initial installation
Adjusting Raw Count Data
Three Types of Data Adjustments

- Cleaning
- Correcting
- Expanding (extrapolating)

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<th>Cleaned Count</th>
<th>Corrected Count</th>
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<td>10:00</td>
<td>95</td>
<td>95</td>
<td>106.4</td>
<td>106.4</td>
</tr>
<tr>
<td>11:00</td>
<td>105</td>
<td>105</td>
<td>117.6</td>
<td>117.6</td>
</tr>
<tr>
<td>12:00</td>
<td>130</td>
<td>130</td>
<td>145.6</td>
<td>145.6</td>
</tr>
<tr>
<td>13:00</td>
<td>0</td>
<td>115</td>
<td>128.8</td>
<td>128.8</td>
</tr>
<tr>
<td>14:00</td>
<td>100</td>
<td>100</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>15:00</td>
<td>125</td>
<td>125</td>
<td>140</td>
<td>140</td>
</tr>
</tbody>
</table>
Hypothetical Raw Data from 24-hour Count
Unusual Data Patterns
Adjustment 1: Clean Data
Adjustment 2: Correct Data

+X% to correct for undercounting
Adjustment 3: Expand Data
Adjustment 3: Expand Data

Extrapolated Data (one weekday represents all weekdays)
Tests of Automated Counting Technologies
NCHRP 07-19 Technology Testing Approach

- Focus on testing and evaluating commercially available automated counting technologies
- Assess types of sensor technologies as opposed to specific products
- Cover a range of facility types, traffic mix, and geographic locations
- Evaluate accuracy through the use of manual count video data reduction
Portland, OR

- 5th Avenue (downtown) sidewalk
  - Passive infrared
  - Radio beam
San Francisco, CA

- Fell Street bicycle lane and adjacent sidewalk
  - Passive infrared
  - Pneumatic tubes
  - Inductive loops
Minneapolis, MN

- Midtown Greenway multiuse path
  - Active infrared
  - Passive infrared
  - Radio beam
  - Inductive loops
  - Pneumatic tubes
Video Data Collection

- Camera installed with counters for ~5 days
- Second deployment targeting desired conditions
- 3,000 hours of video collected
## Summary of Data Collected

<table>
<thead>
<tr>
<th>Condition</th>
<th>Passive Infrared</th>
<th>Active Infrared</th>
<th>Pneumatic Tubes</th>
<th>Inductive Loops</th>
<th>Inductive Loops (Facility)</th>
<th>Piezo-electric</th>
<th>Radio Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total hours of data</td>
<td>298</td>
<td>30</td>
<td>160</td>
<td>108</td>
<td>165</td>
<td>58</td>
<td>95</td>
</tr>
<tr>
<td>Temperature (°F) (mean/SD)</td>
<td>70 / 15</td>
<td>64 / 26</td>
<td>71 / 9</td>
<td>73 / 12</td>
<td>71 / 17</td>
<td>72 / 10</td>
<td>74 / 10</td>
</tr>
<tr>
<td>Hourly user volume (mean/SD)</td>
<td>240 / 190</td>
<td>328 / 249</td>
<td>218 / 203</td>
<td>128 / 88</td>
<td>200 / 176</td>
<td>128 / 52</td>
<td>129 / 130</td>
</tr>
<tr>
<td>Nighttime hours</td>
<td>30</td>
<td>3</td>
<td>10</td>
<td>13</td>
<td>19</td>
<td>15.75</td>
<td>3.5</td>
</tr>
<tr>
<td>Rain hours</td>
<td>17</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Cold hours (&lt;30 °F)</td>
<td>12</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hot hours (&gt;90 °F)</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Thunder hours</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Undercounting

Overcounting

"Perfect accuracy" line

Undercounting
Active Infrared Counter Validation Data

(Somewhat accurate, very precise)
(Somewhat accurate, but not precise)
Accuracy Calculations

- \( APD = \frac{1}{n} \sum_{t=1}^{n} \frac{A_t - M_t}{M_t} \)

- \( AAPD = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{A_t - M_t}{M_t} \right| \)

- \( r = \frac{\sum_{t=1}^{n} (M_t - \bar{M})(A_t - \bar{A})}{\sqrt{\sum_{t=1}^{n} (M_t - \bar{M})^2} \sqrt{\sum_{t=1}^{n} (A_t - \bar{A})^2}} \)

Where \( A_i \) is the automated count in period \( i \) and \( M_i \) is the manual count in period \( i \).
Passive Infrared

- Easy installation
- Mounts to existing pole/surface or in purpose-built pole
- Potential false detections from background
- Possible undercounting due to occlusion

Source: Frank Proulx
Passive Infrared Findings

- APD = -8.75%, AAPD = 20.11%, \( r = 0.9502 \)
- Differences between products
- Correction function:
  \[ V = 1.137 \times A \]
  \[ V = 1.313 \times A - 3.995 \times \frac{A^2}{10^4} \]
- Accuracy not affected by high temperatures
Active Infrared

- APD = -9.11%; AAPD = 11.61%; r = 0.9991
- Single device tested – accurate and highly precise
- Correction Functions:
  \[ V = 1.139 \times A \]
  \[ V = 1.413 \times A + 0.868 \times \frac{A^2}{10^4} - 3.93 \times 10^{-3} \times A \times T \]
Pneumatic Tubes

- Tested BSCs – bicycle-specific counters
- Primarily tested tubes on multi-use paths and bicycle lanes
- Issues with site on 15th Avenue in Minneapolis
Pneumatic Tubes

- Fairly high accuracy at very high volumes
- Site and device specific effects
- Accuracy rates not observed to decline with aging tubes
- Correction function: 
  \[ V = 1.135 \times A \]
Radio Beam

- Tested two products, one that distinguished bicyclists and pedestrians (product A)
  - Required mounting devices 10 feet apart
Radio Beam

- Product B higher accuracy
- Product A – low precision and lower accuracy
- Occlusion errors
- Temperature, lighting, rain issues
Inductive Loops

- Permanent (in ground) or temporary (on surface)
- Bypass errors
  - Cyclists passing outside bike lane
  - Loops leaving gaps in detection zone
Inductive Loops

- APD = 0.55%; AAPD = 8.87%; r = 0.9938
- Errors with age of loops not detected
- No substantial difference between permanent and temporary loops
- Correction Function: \( V = 1.050 \times A \)
Inductive Loops

- Need to mitigate bypass errors
Piezoelectric Strips

- APD=-11.36%; AAPD = 26.60%; \( r = 0.6910 \)
- Tested one existing device, due to difficulties procuring equipment
- Caution – data from single device not installed by research team
- Correction Function: \( V = 1.059 \times A \)
Combination Counter

- APD = 18.65%; AAPD = 43.78%; r = 0.9916
- Passive infrared + inductive loops
- Each device also assessed separately
- Inferred pedestrian volumes (Total – bikes)
- Correction:

\[ V = 1.256 \times A \]
\[ V = 1.809 \times A - 7.53 \times 10^{-3} \times A \times T \]
Research Conclusions

- **Factors influencing accuracy**
  - Proper calibration and installation
  - Occlusion
  - Vendor differences

- **Factors not found to influence accuracy**
  - Age of inductive loops or pneumatic tubes
  - Temperature (except possibly active IR)
  - Snow/rain (limited data)
**Research Conclusions**

- **Automated counter accuracy:**

<table>
<thead>
<tr>
<th>Device</th>
<th>Undercounting Rate</th>
<th>Total Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Infrared (2 products)</td>
<td>8.75%</td>
<td>20.11%</td>
</tr>
<tr>
<td>Active Infrared</td>
<td>9.11%</td>
<td>11.61%</td>
</tr>
<tr>
<td>Pneumatic Tubes</td>
<td>17.89%</td>
<td>18.50%</td>
</tr>
<tr>
<td>Radio Beam</td>
<td>18.18%</td>
<td>48.15%</td>
</tr>
<tr>
<td>Inductive Loops</td>
<td>0.55%</td>
<td>8.87%</td>
</tr>
<tr>
<td>Piezoelectric Strips</td>
<td>11.36%</td>
<td>26.60%</td>
</tr>
</tbody>
</table>
Final Thoughts
Non-motorized Count Applications

- Non-motorized counts document the usage of pedestrian and bicycle facilities and can support many other types of analyses.
- Need for non-motorized count data likely to grow as regions and states expand their use of non-motorized performance measures.
Planning and Developing a Count Program

- Specify the data collection purpose(s)
  - Consider existing and future needs
- Identify available resources
  - Many programs started small and grew over time
- Consider a mix of short- and long-term counts
  - A small number of permanent count stations can support a large number of short-term counts
Performing Counts

- Creating a local correction factor for a counter/count site is a worthwhile investment
  - Site-specific differences
  - Differences in vendor implementations of a particular counting technology

- Count data from most counters tested could be readily corrected to produce good volume estimates
How NCHRP Report 797 Can Help

- Quick start guide covers the essentials
- Step-by-step guidance on planning and developing a program
  - Includes helpful checklists
- Case studies of successful non-motorized count programs and applications
- How to adjust raw count data
- Descriptions of 14 counting methods and technologies
For More Information

- **NCHRP Report 797**
  - TRB Bookstore

- **NCHRP Web-only Document 205**:
  - [http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w205.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w205.pdf)
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Questions and Answers