Creating Seasonal and Daily Adjustment Factors for Non-motorized Traffic in Colorado

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Overview

• Motivation
• Traffic Monitoring
• Non-Motorized Traffic Monitoring in Colorado
• Creating Seasonal Adjustment Factors for Colorado
• Conclusions & Recommendations
Why measure walking & biking?

*If we don’t count it, it doesn’t count.*
Why measure walking & biking?

• Funding & policy decisions
• To show change over time
• Facility design
• Planning (short-term, long-term, regional...)
• Economic impact
• Public health
• Safety
How has Colorado used counts?

• Demonstrates need for snow clearing
• Identifies key bicycle corridors for bicycle facility improvements.

Other Uses:
• Safety studies
• Measuring economic benefits
• Funding
TRAFFIC MONITORING PROGRAMS
Colorado’s Continuous Counters

Legend
- Automated Traffic Recorder
Colorado’s Short Duration Traffic Counts

[Image of a map showing traffic counts]

Use AADT to Estimate VMT

Sum (AADT X Segment Length) over network to compute Vehicle Miles Traveled (VMT)
Can we apply these methods to biking and walking?
AADB: Annual Average Daily Bicyclists

AADT for bicyclists!
Traffic Monitoring Guide 2013: Chapter 4 for Non-motorized Traffic
Bicycle and Pedestrian Traffic Monitoring in Colorado
The TMG 2013 Approach

1. **Inventory & QA/QC**
2. **Permanent Count Program**
3. **Short Duration Count Program**
4. **Apply Factors**
5. **Annual Average Daily Bicycle or Pedestrian Traffic**

[http://www.pdx.edu/ibpi/count](http://www.pdx.edu/ibpi/count)
Permanent Counters

• Pedestrian & Bicycle

Infrared

Inductive Loop

• Bicycle

Video Detection
All Colorado Continuous Counters

- 45 stations with enough data to study (2010-2012)
  - 21 bicyclist only count stations
  - 24 bicyclists and pedestrians combined stations

Denver Metro Area
Annual Average Daily Bicyclists (AADB)

Volume Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>200</td>
</tr>
<tr>
<td>Medium</td>
<td>600</td>
</tr>
<tr>
<td>High</td>
<td>1,000</td>
</tr>
</tbody>
</table>
The TMG 2013 Approach

Permanent Count Program

Inventory & QA/QC

Short Duration Count Program

Apply Factors

Annual Average Daily Bicycle or Pedestrian Traffic

http://www.pdx.edu/ibpi/count
Permanent Count Program

http://www.pdx.edu/ibpi/count
Hourly Commute Pattern

City of Boulder Example (Bikes only)
Hourly Non-commute Pattern

Source: Pam Johnson, PSU
Monthly Pattern for Bike/Ped

With Outliers removed

Percent of AADT

Month

With Outliers removed

Dillon Dam Path
Four Mile
Officers Gulch
Swan Mt
Arbaney Kittle
EmmaRGT
EofAspen
HunterCrk
WoodyCrk
Dawson Butte
Glendale
Greenland
Hidden Mesa
Spruce Meadows
Spruce Mt
Rock Creek
CCHolly-2011
KC470
Broomfield Combo
Permanent Count Program

Permanen Count Program

SELECT SITES & INSTALL

NEED MORE STATIONS?

GROUP STATIONS

LOOK FOR PATTERNS

COMPUTE FACTORS
12 Possible groups

3 Daily Patterns

Commute

In Between

Non-Commute
12 Possible groups

3 Daily Patterns
- Commute
- In Between
- Non-Commute

2 Weekly Patterns
- Commute
- Non-Commute
12 Possible groups

3 Daily Patterns
- Commute
- In Between
- Non-Commute

2 Weekly Patterns
- Commute
- Non-Commute

2 Annual Patterns
- Commute
- Non-Commute
12 Possible groups

3 Daily Patterns
- Commute
- In Between
- Non-Commute

2 Weekly Patterns
- Commute
- Non-Commute

2 Annual Patterns
- Commute
- Non-Commute
12 Possible groups

3 Daily Patterns  
Commute  
In Between  
Non-Commute

2 Weekly Patterns  
Commute

2 Annual Patterns  
Commute  
Non-Commute  
Non-Commute
12 Possible groups

3 Daily Patterns

Commute

In Between

Non-Commute

2 Weekly Patterns

Commute

Non-Commute

2 Annual Patterns

Commute

Non-Commute
**Weekly Pattern**

**Location**

- **Higher Weekends?**
  - Yes → **Rural Mtn Trail?**
    - Yes → **Group 1:** High weekends, High monthly variation
    - No → **Group 2:** High weekends, Low monthly variation
  - No → **Group 3:** High weekdays, Low monthly variation

**Groups**

- **Group 1:** High weekends, High monthly variation
- **Group 2:** High weekends, Low monthly variation
- **Group 3:** High weekdays, Low monthly variation

**Locations**

- Mountain Non-Commute
- Urban Plains Non-commute
- Commute
Permanent Count Program

- Select sites & install
- Look for patterns
- Need more stations?
- Group stations
- Compute factors
Seasonal Adjustment Factors

Adapted from Traffic Monitoring Guide

\[ \text{AADB} = C_{\text{known}} \times D \times M \]

\[ C_{\text{known}} = \text{24-hour count} \]
\[ D = \text{Daily Factor} \]
\[ M = \text{Monthly Factor} \]
Monthly Factor

\[ M = \frac{AADB}{MADB} \]

June

\[ = \frac{500}{1,000} = 0.5 \]

The average day in July is double the AADB.

where

\[ MADB = \text{Ave daily bike count in that month} \]
## Colorado Monthly Factors

<table>
<thead>
<tr>
<th>Groups:</th>
<th>Mountain Non-Commute</th>
<th>Urban Plains Non-Commute</th>
<th>Commute</th>
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<tr>
<td>January</td>
<td></td>
<td></td>
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<td>February</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>2.2</td>
<td>1.1</td>
<td>1.1</td>
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<tr>
<td>May</td>
<td>1.0</td>
<td>0.8</td>
<td>0.9</td>
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<tr>
<td>June</td>
<td><strong>0.5</strong></td>
<td>0.8</td>
<td>0.7</td>
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<tr>
<td>July</td>
<td>0.4</td>
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<td>0.8</td>
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<tr>
<td>August</td>
<td>0.5</td>
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<td>0.7</td>
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<tr>
<td>September</td>
<td>0.7</td>
<td>0.8</td>
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<td>October</td>
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<td>1.0</td>
<td>1.0</td>
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<tr>
<td>November</td>
<td>1.5</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>December</td>
<td>2.5</td>
<td>2.3</td>
<td></td>
</tr>
</tbody>
</table>
Bike/Ped and Motorists Factors

Percent of AADT

- Mountain
- Non-Commute
- Urban Plains
- Non-Commute
- Commute
- Recreational Motorists

Day of the Week:
- Sunday
- Monday
- Tuesday
- Wednesday
- Thursday
- Friday
- Saturday
Bike/Ped and Motorist Factors

Percent of AADT

- Mountain
- Non-Commute
- Urban Plains
- Non-Commute
- Commute
- Recreational Motorists
Factoring in North America

• National Bicycle and Pedestrian Documentation Project (Alta & ITE)
• Lindsey et al. in Minneapolis
• Schneider et al. in the Bay area
• Milligan et al. in Winnepeg
• Seamless Travel Project in San Diego, Alta
• Miranda-Moreno et al. in Montreal
The TMG 2013 Approach

Permanent Count Program

Inventory & QA/QC

Short Duration Count Program

Apply Factors

Annual Average Daily Bicycle or Pedestrian Traffic
VMT for bicycles
Conclusions & Recommendations
Conclusions & Recommendations

• Need continuous counters!

• Non-motorized traffic
  – Is more variable than motorized
  – Has different patterns from motorized.

• Integrate non-motorized traffic counts into motorized traffic data for preservation and access
On-line Guide

www.pdx.edu/ibpi/count
Questions?

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## 1. What Are You Counting?

<table>
<thead>
<tr>
<th>Technology</th>
<th>Bicyclists Only</th>
<th>Pedestrians Only</th>
<th>Pedestrians &amp; Bicyclist Combined</th>
<th>Pedestrians &amp; Bicyclist Separately</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inductance Loops(^1)</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>○</td>
<td>$$</td>
</tr>
<tr>
<td>Magnetometer(^2)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>$$-$$</td>
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<tr>
<td>Pressure Sensor(^2)</td>
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<td>○</td>
<td>○</td>
<td>$$</td>
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<tr>
<td>Radar Sensor</td>
<td>○</td>
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<td>○</td>
<td>○</td>
<td>$$-$$</td>
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<tr>
<td>Seismic Sensor</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>$$</td>
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<tr>
<td>Video Imaging: Automated</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>$$-$$</td>
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<tr>
<td>Infrared Sensor (Active or Passive)(^3)</td>
<td>○</td>
<td>●</td>
<td>●</td>
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<td>$$-$$</td>
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<tr>
<td>Pneumatic Tubes</td>
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<td>○</td>
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<td>$$-$$</td>
</tr>
<tr>
<td>Video Imaging: Manual</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td>$$-$$$</td>
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<tr>
<td>Manual Observers</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>$$-$$$</td>
</tr>
</tbody>
</table>

○ Indicates what is technologically possible.
● Indicates a common practice.
\(^1\) Indicates a common practice, but must be combined with another technology to classify pedestrians and bicyclists separately.
\(^2\) Indicates relative cost per data point.
\(^3\) Requires specific mounting configuration to avoid counting cars in main traffic lanes or counting pedestrians on the sidewalk.

**Source:** Federal Highway Administration.

Bicycle Counts

- **Continuous**: Hourly Counts 24/7
- **Short-term**: One hour to one month

![Inductive Loop](image1)

![Video Detection](image2)

- Video Image Recognition
- Microwave
- Infrared

![Manual](image3)

![Pneumatic Tube Counters](image4)
Passive Infrared Counters

Metro - TRAFx
Inductive loop counters in bike lanes
Combined Bicycle and Pedestrian Continuous Counter

EcoCounter
Inductive loop counters on street
Inductive loop counters on street
Daily Patterns for Bicycle Only

Percent of AADT

Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday
Strange Facts

• In rural areas, bicycle only stations had AADT 3X higher than bike & ped stations
Minimize Error in AADT

SHORT-TERM COUNTS
Why daily counts?

![Average Hourly Count Graph](chart.png)

The graph shows the average hourly count over a 24-hour period. The peak activity occurs in the late afternoon and early evening, from 3:00 PM to 8:00 PM, with a sharp decline in the late evening and early morning hours.
Why daily counts?

Average Hourly Count

12:00 AM 3:00 AM 6:00 AM 9:00 AM 12:00 PM 3:00 PM 6:00 PM 9:00 PM

Arrow indicating a rise from 12:00 PM to 6:00 PM, followed by a decline after 6:00 PM.
Why daily counts?
Why annual average?
Why annual average?
The Problem

Cities and Counties

Bicycle counts live here and die here.

State Agencies

Some bicycle counts live here.

Federal (FHWA)

No bicycle counts live here.

TMAS
The Solution

Cities and Counties

State Agencies

Federal (FHWA)

bike counts

bike counts

TMAS
State Traffic Monitoring

• Required by FHWA (MAP21):
  – all urban and rural principal arterial roadways
  – all intermodal connector roadways
  – the strategic defense highway network

• Historically used to allocate federal funds to state DOTs.
State Traffic Monitoring

Continuous Counters
Commonly inductive loops

Short-term Counters
Commonly pneumatic tubes

Method to Calculate Annual Average Daily Traffic (AADT)

- **Continuous Counts**
  - Compute Factors
    - $D = \text{Daily Factor}$
    - $M = \text{Monthly Factor}$

- **Short-term Counts**
  - Compute AADT
    - $AADT = \text{Short-term count} \times D \times M$

- **Estimated AADT**
Compute AADB

- I know AADB at 25 continuous count stations.
Compute AADB

• I know AADB at 25 continuous count stations.
• I conduct 24-hour counts at 100 more stations.
Grouping Method

1. Determine daily patterns by day of week for the short term count data available at a given site.
2. If the location has high weekends, is it a mountain location on a recreational trail?
3. Locations with low weekend patterns are expected to also follow the pattern of less variation by month.
Short-term Counters

About 6 portable infrared counters:

• Rotated around the state
  – By request
  – About 30 sites

• Each site over 1 week, usually at least one month
AADB Error with Length of Short-term Counts

Average Absolute % Difference vs. Short-term Count Length (hours)

1 week
Group by Traffic Patterns

% of Annual Average Daily Pedestrians and Bicyclists (AADPB)

Commute
Mixed
Non Commute

Hour
Group by Traffic Patterns

Percent of Annual Average Daily Bicyclists (AADB)

- Non-Commute
- Mixed
- Commute

Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday
How many counters/group?

![Graph showing precision of monthly factors vs number of counters. The graph includes data points for non-commute factors, commute counters, and an average line.](image-url)
## Colorado Count Stations

<table>
<thead>
<tr>
<th></th>
<th>Bicycle Only</th>
<th>Bicycle &amp; Pedestrian</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Stations</strong></td>
<td>21</td>
<td>24</td>
<td>45</td>
</tr>
<tr>
<td><strong>Average AADT</strong></td>
<td>401</td>
<td>182</td>
<td>284</td>
</tr>
</tbody>
</table>

- **Rural**: 51%
- **Mountains**: 31%
- **On Paths**: 84%