DESIGN AND IMPLEMENTATION OF PEDESTRIAN AND BICYCLE-SPECIFIC DATA COLLECTION METHODS IN OREGON

Pilot Study Report

SPR 754
DESIGN AND IMPLEMENTATION OF PEDESTRIAN AND BICYCLE-SPECIFIC DATA COLLECTION METHODS IN OREGON

Pilot Study Report

SPR 754

by

Miguel Figliozzi, Chris Monsere, Krista Nordback,
Pamela Johnson, Bryan Blanc
Portland State University
Department of Civil and Environmental Engineering

for

Oregon Department of Transportation
Research Section
555 13th Street NE, Suite 1
Salem OR 97301

and

Federal Highway Administration
400 Seventh Street, SW
Washington, DC 20590-0003

June 2014
**Abstract**

Although there is a growing need to access accurate and reliable pedestrian and bicycle data, there is no statewide system to collect data or plan future data collection efforts in the state of Oregon. To address these issues this research conducted a comprehensive review of pedestrian and bicycle data collection methods and counting technologies. Oregon data sources were also compiled and AADT estimation techniques were reviewed and applied to Oregon data. A pilot study was conducted to test bicycle and pedestrian counting methods at signalized intersections with 2070 controllers. The report also provides a summary of recommendations regarding factoring methods and the implementation of a statewide non-motorized data collection system.
<table>
<thead>
<tr>
<th>Symbol</th>
<th>When You Know</th>
<th>Multiply By</th>
<th>To Find</th>
<th>Symbol</th>
<th>When You Know</th>
<th>Multiply By</th>
<th>To Find</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LENGTH</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>LENGTH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in</td>
<td>inches</td>
<td>25.4</td>
<td>millimeters</td>
<td>mm</td>
<td>mm</td>
<td>millimeters</td>
<td>0.039</td>
<td>inches</td>
</tr>
<tr>
<td>ft</td>
<td>feet</td>
<td>0.305</td>
<td>meters</td>
<td>m</td>
<td>m</td>
<td>meters</td>
<td>3.28</td>
<td>feet</td>
</tr>
<tr>
<td>yd</td>
<td>yards</td>
<td>0.914</td>
<td>meters</td>
<td>m</td>
<td>m</td>
<td>meters</td>
<td>1.09</td>
<td>yards</td>
</tr>
<tr>
<td>mi</td>
<td>miles</td>
<td>1.61</td>
<td>kilometers</td>
<td>km</td>
<td>km</td>
<td>kilometers</td>
<td>0.621</td>
<td>miles</td>
</tr>
<tr>
<td><strong>AREA</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>AREA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in²</td>
<td>square inches</td>
<td>645.2</td>
<td>millimeters squared</td>
<td>mm²</td>
<td>mm²</td>
<td>millimeters squared</td>
<td>0.0016</td>
<td>square inches</td>
</tr>
<tr>
<td>ft²</td>
<td>square feet</td>
<td>0.093</td>
<td>meters squared</td>
<td>m²</td>
<td>m²</td>
<td>meters squared</td>
<td>10.764</td>
<td>square feet</td>
</tr>
<tr>
<td>yd²</td>
<td>square yards</td>
<td>0.836</td>
<td>meters squared</td>
<td>m²</td>
<td>m²</td>
<td>meters squared</td>
<td>1.196</td>
<td>square yards</td>
</tr>
<tr>
<td>ac</td>
<td>acres</td>
<td>0.405</td>
<td>hectares</td>
<td>ha</td>
<td>ha</td>
<td>hectares</td>
<td>2.47</td>
<td>acres</td>
</tr>
<tr>
<td>mi²</td>
<td>square miles</td>
<td>2.59</td>
<td>kilometers squared</td>
<td>km²</td>
<td>km²</td>
<td>kilometers squared</td>
<td>0.386</td>
<td>square miles</td>
</tr>
<tr>
<td><strong>VOLUME</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>VOLUME</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fl oz</td>
<td>fluid ounces</td>
<td>29.57</td>
<td>milliliters</td>
<td>ml</td>
<td>ml</td>
<td>milliliters</td>
<td>0.034</td>
<td>fluid ounces</td>
</tr>
<tr>
<td>gal</td>
<td>gallons</td>
<td>3.785</td>
<td>liters</td>
<td>L</td>
<td>L</td>
<td>liters</td>
<td>0.264</td>
<td>gallons</td>
</tr>
<tr>
<td>ft³</td>
<td>cubic feet</td>
<td>0.028</td>
<td>meters cubed</td>
<td>m³</td>
<td>m³</td>
<td>meters cubed</td>
<td>35.315</td>
<td>cubic feet</td>
</tr>
<tr>
<td>yd³</td>
<td>cubic yards</td>
<td>0.765</td>
<td>meters cubed</td>
<td>m³</td>
<td>m³</td>
<td>meters cubed</td>
<td>1.308</td>
<td>cubic yards</td>
</tr>
<tr>
<td><strong>NOTE:</strong> Volumes greater than 1000 L shall be shown in m³.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MASS</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>MASS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>oz</td>
<td>ounces</td>
<td>28.35</td>
<td>grams</td>
<td>g</td>
<td>g</td>
<td>grams</td>
<td>0.035</td>
<td>ounces</td>
</tr>
<tr>
<td>lb</td>
<td>pounds</td>
<td>0.454</td>
<td>kilograms</td>
<td>kg</td>
<td>kg</td>
<td>kilograms</td>
<td>2.205</td>
<td>pounds</td>
</tr>
<tr>
<td>T</td>
<td>short tons (2000 lb)</td>
<td>0.907</td>
<td>megagrams</td>
<td>Mg</td>
<td>Mg</td>
<td>megagrams</td>
<td>1.102</td>
<td>short tons (2000 lb)</td>
</tr>
<tr>
<td><strong>TEMPERATURE (exact)</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>TEMPERATURE (exact)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>°F</td>
<td>Fahrenheit</td>
<td>(F-32)/1.8</td>
<td>Celsius</td>
<td>°C</td>
<td>°C</td>
<td>Celsius</td>
<td>1.8C+32</td>
<td>Fahrenheit</td>
</tr>
</tbody>
</table>

*SI is the symbol for the International System of Measurement
ACKNOWLEDGEMENTS

This pilot study and data analysis would not have possible without the valuable and enthusiastic support of Tiffany Slauter, ODOT Region 1 Signal Manager. Tiffany’s presence at the data collection site to inspect controllers and equipment and her time to collect and provide relevant 2070 data was indispensable to ensure the completion of the pilot study.

Successful completion of the pilot study also required support and coordination with ODOT’s Traffic Systems Monitoring Unit. The PSU research team is thankful for the support provided by Don Crownover who leads the Traffic Systems Monitoring Unit and by the crew members that supported the data collection effort: Steve Chance (supervising the ODOT crew), Jacob Carringer (ODOT video setup), and Raymond Herrera (tubes installation). We also acknowledged the support provided by PSU graduate students Sam Thompson and Adam Moore. Bruce Moody, TAC member and FHWA staff, produced a video documenting part of the pilot data collection effort. Any errors or omissions are the sole responsibility of the authors.

DISCLAIMER

This document is disseminated under the sponsorship of the Oregon Department of Transportation and the United States Department of Transportation in the interest of information exchange. The State of Oregon and the United States Government assume no liability of its contents or use thereof.

The contents of this report reflect the view of the authors who are solely responsible for the facts and accuracy of the material presented. The contents do not necessarily reflect the official views of the Oregon Department of Transportation or the United States Department of Transportation.

The State of Oregon and the United States Government do not endorse products of manufacturers. Trademarks or manufacturers’ names appear herein only because they are considered essential to the object of this document.

This report does not constitute a standard, specification, or regulation.
**TABLE OF CONTENTS**

1.0 INTRODUCTION .................................................................................................................. 1

2.0 SITE SELECTION ................................................................................................................ 3
   2.1 SITE SELECTION CRITERIA .......................................................................................... 3
   2.2 POTENTIAL DATA COLLECTION SITES ..................................................................... 3
      2.2.1 SE Powell Boulevard (Hwy 26) and 26th Avenue, Portland, OR ......................... 3
      2.2.2 NE Couch Street and NE Grand Avenue (OR-99E) ............................................ 6
      2.2.3 99W and Hall Boulevard, Tigard OR ................................................................. 8
      2.2.4 Possible Short Term Counting Site: 99W and SW Greenburg Road, Tigard, OR .... 10
   2.3 FINAL SITE SELECTION .............................................................................................. 11

3.0 PRE-PILOT STUDY SITE VISIT ....................................................................................... 13
   3.1 VIDEO SETUP ............................................................................................................. 13
   3.2 VALIDATION OF PEDESTRIAN PHASES ................................................................. 15
   3.3 VALIDATION OF BICYCLE LOOP DETECTORS ...................................................... 15
   3.4 PRE-SITE VISIT DURATION ....................................................................................... 15

4.0 PEDESTRIAN COUNTS .................................................................................................... 17
   4.1 DATA COLLECTION .................................................................................................... 17
   4.2 VIDEO RESULTS ....................................................................................................... 18
   4.3 DATA VALIDATION .................................................................................................... 21
   4.4 ESTIMATION OF 99W AND SW HALL BOULEVARD 2012 PEDESTRIAN AADT ...... 22
   4.5 CONVERTING AADP TO AADT ................................................................................. 27
      4.5.1 AADT calculations at other 2070 intersections .................................................... 27
      4.5.2 AADT calculations at other nearby intersections without 2070 controllers ......... 28

5.0 BICYCLE COUNTS ........................................................................................................... 30
   5.1 INDUCTIVE LOOPS .................................................................................................. 30
      5.1.1 Data Collection ................................................................................................... 30
      5.1.2 Video Results .................................................................................................... 31
      5.1.3 The impacts of Loop Sensitivity and Location .................................................... 32
      5.1.4 Inductive Loop Recommendations ..................................................................... 38
   5.2 PNEUMATIC TUBES .................................................................................................. 42
      5.2.1 Data Collection ................................................................................................... 42
      5.2.2 Video Analysis Results ...................................................................................... 44
      5.2.3 Tube Data Validation ......................................................................................... 44
      5.2.4 Pneumatic Tubes Recommendations .................................................................. 45

6.0 DISCUSSION ..................................................................................................................... 48

7.0 REFERENCES .................................................................................................................... 50
LIST OF TABLES

Table 2.1: Summary of Potential Data Collection Sites ............................................................... 12
Table 4.1: Video Counts vs. 2070 Pedestrian Phase Counts Summary ........................................ 21
Table 4.2: OR-99W and Hall Boulevard 2012 day-of-week (DOW) & monthly pedestrian AADP ............................................................................................................................................... 25
Table 4.3: OR-99W and Hall Boulevard 2012 weekday DOW & DOM pedestrian AADP ........ 25
Table 4.4: OR-99W and Hall Boulevard 2012 weekend DOW & DOM pedestrian AADP ........ 26
Table 4.5: OR-99W and Hall Boulevard 2012 Pedestrian Actuation AADP Factors .................. 26
Table 5.1: Video Counts vs. 2070 Counts Summary (8/29-8/30) ................................................. 33
Table 5.2: Video Counts vs. 2070 Counts Summary (10/24 – 10/25) .......................................... 38
Table 5.3: Results of video analysis for pneumatic tube counters ................................................ 44

LIST OF FIGURES

Figure 2.1: SE Powell Boulevard and 26th Avenue ....................................................................... 4
Figure 2.2: Bicycle Facilities 26th Avenue at Powell Boulevard .................................................. 5
Figure 2.3: Pedestrian Facilities at Powell Boulevard and 26th Avenue ........................................ 5
Figure 2.4: NE Couch Street and Grand Avenue (OR-99E) ........................................................... 6
Figure 2.5: Inductive Loops on NE Couch Street .......................................................................... 7
Figure 2.6: Bicycle Facilities on NE Couch Street at Grand Avenue (OR-99E) ............................ 7
Figure 2.7: 99W and Hall Boulevard, Tigard, OR ............................................................ 8
Figure 2.8: Inductive Loops for Bicycles, 99W and SW Hall Boulevard NE Bound ....................... 9
Figure 2.9: Inductive Loops for Bicycles, 99W and Hall Boulevard, Southbound ........................ 9
Figure 2.10: OR-99W and SW Greenburg Road, Tigard, OR ...................................................... 10
Figure 2.11: Inductive Loops at OR-99W and SW Greenburg Road ........................................... 11
Figure 3.1: Camera setup at pilot study site .................................................................................. 14
Figure 3.2: Example screenshot of video recorded at pilot study intersection ............................. 14
Figure 4.1: Aerial photo of pilot study intersection with annotation ............................................. 18
Figure 4.2: Total pedestrian volumes (for all crosswalks) ........................................................... 19
Figure 4.3: Pedestrian group size by crosswalk .......................................................................... 20
Figure 4.4: Pedestrian group size proportions by crosswalk ....................................................... 20
Figure 4.5: Scatter plots of pedestrian volumes vs. pedestrian phases granted (hourly basis) ....... 22
Figure 4.6: 99W and SW Hall Boulevard 2012 Average Daily Pedestrian Phases Volumes per Month ..................................................................................................................................... 23
Figure 4.7: Average Hourly Pedestrian Phases at 99W and SW Hall Boulevard ........................ 23
Figure 4.8: Average DOW Pedestrian Phases at 99W and SW Hall Boulevard .......................... 24
Figure 5.1: SW 99W and Hall Boulevard Intersection Plan (Inductive Loops Circled in Red) ....... 31
Figure 5.2: Actual Bicycle Volumes for Intersection from Video Analysis Period (8/29 – 8/30) ... 31
Figure 5.3: Bike Volumes as reported by 2070 on August 23rd, 2013 ........................................ 32
Figure 5.4: Bicycle lane volume distributions compared between loop and actual counts (8/29-8/30) ........................................................................................................................................ 33
Figure 5.5: OR-99W Eastbound (see location of inductive loop relative to right turning vehicle) .............................................................................................................................. 34
Figure 5.6: Right lane vehicles vs. bike lane volume reported by 2070 at eastbound approach (towards Portland) .......................................................................................................... 36
1.0 INTRODUCTION

In accordance with the Research Project Work Plan document, Task 5 includes the development of a data collection pilot study and data collection guidelines. To facilitate the presentation of results Task 5 is broken down into two reports. This report with the label “Task 5” contains pilot data collection result; another report labeled “Task 6” contains data collection guidelines.

This report details the pilot study from site selection to lessons learned. The pilot study demonstrates how to use existing ODOT bicycle and pedestrian data and equipment to conduct sampling, site selection, and factoring methods.

A conference call between the ODOT TAC members and the PSU research team was held on July 11, 2013 to discuss the implementation of the pilot study. During the conference call next steps and implementation tasks were defined. The TAC and PSU team agreed on focusing the pilot data collection study on intersections with 2070 controllers; this type of technology has many potential cost-efficiency advantages as stated in the Task 2 report. The tasks included developing a list of potential sites for the pilot study and a schedule to implement the pilot study. Successful completion of the pilot study required support and coordination with ODOT’s Traffic Monitoring Unit.

The intersection of OR-99W and Hall Boulevard in Tigard was chosen for the pilot study. This intersection was chosen due to a number of advantageous characteristics:

- Presence of 2070 signal controller technology for data recording,
- Intersection operated by ODOT Region 1 and with the support of Tiffany Slauter (Region 1 Signal Manager),
- Inductive loops in the bike lanes of each approach (connected to 2070 controller),
- Pedestrian push button phase actuation at all crossings (phases recorded by the 2070 controller), and
- Adequate bicycle and pedestrian traffic.
- The site allowed a feasible deployment of tube counters (TimeMark Gamma tubes) to count bicycle on the approaches with highest bicycle traffic
- The presence of poles that allowed for a safe and effective deployment of video recording equipment

Details of site selection are discussed in Section 6.1. Pilot study results and lessons learned are reported in this report.
2.0 SITE SELECTION

2.1 SITE SELECTION CRITERIA

Several criteria were considered when selecting an appropriate site for conducting the pilot data collection study. The criteria considered were:

- Does the site represent a typical ODOT facility utilized by bicycles and pedestrians?
- Is there enough pedestrian and bicycle traffic to test counting methods?
- Do data collection systems already exist on-site?
- Is there an operating 2070 signal controller?
- Is there support from the Signal Manager responsible for the intersection to inspect equipment and collect data?
- Are there inductive loops in the bike lanes of each approach (connected to 2070 controller)?
- Are there pedestrian push button at all crossings (phases recorded by the 2070 controller)?
- Is it possible to deploy tube counters in the intersection approaches?
- Is it possible to find poles or locations to successfully install video cameras to record traffic (motorized, bicycles, and pedestrians) at all intersection approaches, crosswalks, and loop detectors?

2.2 POTENTIAL DATA COLLECTION SITES

2.2.1 SE Powell Boulevard (Hwy 26) and 26th Avenue, Portland, OR

SE Powell Boulevard (Hwy 26) and SE 26th Avenue, see Figure 2.1, in Portland was considered as a potential pilot site. This intersection uses a 2070 controller and is integrated with the Sydney Coordinated Adaptive Traffic System (SCATS) on Powell Boulevard. This signalized intersection is managed by Portland Bureau of Transportation (PBOT).

26th Avenue has inductive loops in the bike lanes and green bicycle boxes have recently been added. The bicycle boxes on the north approach are shown in Figure 2.2. Bicycle volumes on 26th Avenue are relatively high. There are no bicycle facilities on Powell Boulevard. Pedestrian push button actuation is also used at this site as shown in Figure 2.3.
One of the interesting aspects of this intersection, in terms of managing this site, is that there are no bicycle facilities directly on an ODOT Right of Way (ROW) at this intersection, but there are bicycle facilities intersecting ODOT facilities. In addition, SE Powell and 26th has both bicycle inductive loops and pedestrian push button actuation.

Figure 2.1: SE Powell Boulevard and 26th Avenue
Figure 2.2: Bicycle Facilities 26th Avenue at Powell Boulevard

Figure 2.3: Pedestrian Facilities at Powell Boulevard and 26th Avenue
2.2.2 NE Couch Street and NE Grand Avenue (OR-99E)

NE Couch Street is a westbound one-way street. It was recently converted to a one way couplet with E Burnside Street. Bicycle facilities were added to both Couch and Burnside including bike lanes and inductive loops as shown in Figure 2.5 and Figure 2.6. Grand Avenue, or OR-99E is a North bound, major arterial couplet with Martin Luther King Street. Street car tracks have been added to Grand Avenue in the last year. There are no bicycle facilities on OR-99E, but there are on NE Couch Street (Figure 2.4). In addition, the intersection has no push button actuation and pedestrian signal timing is in recall, therefore there is no pedestrian phase actuation data.

There are no bicycle facilities on the ODOT ROW (Grand Avenue) at this intersection, but there are bicycle facilities on the intersecting street (NE Couch Street). This intersection is managed by the Portland Bureau of Transportation (PBOT). Another benefit of this intersection is that it will require coordination with another jurisdiction, which is an important exercise in collecting and maintaining non-motorized counts.

Figure 2.4: NE Couch Street and Grand Avenue (OR-99E)
Figure 2.5: Inductive Loops on NE Couch Street

Figure 2.6: Bicycle Facilities on NE Couch Street at Grand Avenue (OR-99E)
2.2.3 99W and Hall Boulevard, Tigard OR

The PSU team met with Tiffany Slauter, Signal Manager for ODOT Region 1, on July 19, 2013 in preparation for considering potential sites for the data collection pilot. Slauter’s recommendation for the pilot study was the intersection of OR-99W and SW Hall Boulevard in Tigard, OR. The general location and an aerial photo off this site are shown in Figure 2.7.

Figure 2.7: 99W and Hall Boulevard, Tigard, OR

Benefits of this site include equipment and facilities that are less than three years old and owned by ODOT. This intersection includes inductive loop detection on all approaches for bicycles and pedestrian push button actuated signals. In addition, a 2070 controller with the most recent version of the Voyage control is used at this site in order to collect data. Based on preliminary data and experience, there was also evidence that there are adequate bicycle and pedestrian volumes to develop AADT estimation factors.

An initial exploration of the data collected by the traffic signal controller at this site was presented in the Task 3 Interim Report. The initial study of 99W and SW Hall Boulevard data identified improvements necessary in order to have a more accurate evaluation of the bicycle and pedestrian data. These include a separate short-term data collection at the site in order to evaluate the accuracy of the bicycle loop detectors and pedestrian volume estimation.

Figure 2.8 and Figure 2.9 illustrate the eastbound inductive bicycle loops at the intersection of 99W and Hall Boulevard. Figure 2.8 and Figure 2.9 also illustrate the possibility of a motor vehicle being counted with the inductive loop in the bicycle lane if a car merges to the right turn lane. The loops were placed at these locations with the objective of identifying bicycles for
signal actuation when motor vehicles are not present; not with a focus on counting accurate bicycle volumes.

Figure 2.8: Inductive Loops for Bicycles, 99W and SW Hall Boulevard NE Bound

Figure 2.9: Inductive Loops for Bicycles, 99W and Hall Boulevard, Southbound
2.2.4 Possible Short Term Counting Site: 99W and SW Greenburg Road, Tigard, OR

Another intersection that was recommended for the pilot study by Tiffany Slauter was OR-99W and SW Greenburg Road, located one street southwest of OR-99W and SW Hall Boulevard. This intersection has also been upgraded recently and uses 2070 controllers. The intersection of OR-99W and SW Greenburg Road also has inductive loops for bicycle detection and pedestrian actuated signals. Main Street, on the south side of the intersection, does not have bicycle facilities as shown in Figure 2.10. Hence, there are less bicycle loop detectors at this intersection when compared to Hall Boulevard and the angle of some approaches may hinder video recording and analysis.

![Figure 2.10: OR-99W and SW Greenburg Road, Tigard, OR](image)

Figure 2.10 illustrates the dual inductive bicycle loops on the Greenburg Road approach. 99W also has bicycle inductive loops on both legs of the intersection.
2.3 FINAL SITE SELECTION

After consulting with the TAC and discussing the pros and cons of the four candidate sites, summarized in Table 2.1, the intersection of 99W and Hall Boulevard was chosen because it met all the criteria originally listed. The enthusiastic and prompt support of Tiffany Slauter to inspect the controller, test equipment (loops/push buttons), and collect the 2070 data was also a decisive factor to choose 99W and Hall boulevard.
<table>
<thead>
<tr>
<th>Location</th>
<th>Mode</th>
<th>Controller/Technology/Jurisdiction</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR-99W and Hall Boulevard, Tigard</td>
<td>Bicycle &amp; Pedestrian</td>
<td>2070 Controller ODOT</td>
<td>• Long term count data for both bicycles and pedestrian actuation</td>
<td>• Loop data must be verified to determine if motorized vehicles are being counted as bicycles.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Bicycle loops and lanes on both Hall Boulevard and OR-99W</td>
<td>• Some loops maybe wired in series and double count. This can be corrected</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Pedestrian actuation on all approaches</td>
<td>• Unknown bicycle and pedestrian data accuracies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Recommended by Tiffany Slauter</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Reasonable number of bicycles and Pedestrians</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• The intersection one block away at Greenburg Road could be used to</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>demonstrate short-term counting site that is similar to OR-99W and Hall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Boulevard</td>
<td></td>
</tr>
<tr>
<td>NE Couch Street and Grand Avenue (OR-99E),</td>
<td>Bicycle Only</td>
<td>2070 Controller PBOT</td>
<td>• Some data is already reported on a website (PORTAL)</td>
<td>• Unknown bicycle data collection technology capabilities and accuracies</td>
</tr>
<tr>
<td>Portland</td>
<td></td>
<td></td>
<td>• Bicycle Loops and Lanes on NE Couch</td>
<td>• One way traffic on both legs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Significant number of bicycles and Pedestrians</td>
<td>• No pedestrian actuation (phases on recall)</td>
</tr>
<tr>
<td>SE Powell (Hwy 26) and 26th Avenue, Portland</td>
<td>Bicycle &amp; Pedestrian</td>
<td>2070 Controller PBOT</td>
<td>• Bicycle loops and lanes on SE 26th</td>
<td>• Unknown SCATS impacts on bicycle and pedestrian data collection technology capabilities and accuracies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Significant number of bicycles and Pedestrians</td>
<td>• May have difficulties with SCATS system and loops system</td>
</tr>
</tbody>
</table>
3.0 PRE-PILOT STUDY SITE VISIT

Before the actual pilot data collection took place there was a preliminary visit to the data collection site. This pre-data collection visit was necessary in order to:

- Inspect the 2070 controller
  - Verify whether pedestrian phases were being detected
  - Verify that bicycles were being detected
- Inspect intersection and detect any issue that may impact the flow or presence of bicycles or pedestrians (e.g. repairs or obstructions).
- Mark suitable locations for tube counters
- Mark poles and suitable locations to successfully install/secure video cameras
- Check video recording quality and coverage of the area under study

This section describes some of these pre-pilot data activities. Although some of the steps seem obvious they may save valuable crew and resources the day of the actual data collection or when the data is analyzed.

3.1 VIDEO SETUP

Video recordings were utilized to evaluate the accuracy bicycle and pedestrian data collection methods used in this pilot study. Video was recorded from three cameras mounted on a traffic signal mast arm pole at the northwest corner of the intersection. The video recording unit was hidden from view and locked to the pole for safety as shown in Figure 3.1.

Each camera was aimed toward a different portion of the intersection to maximize the field of view. A screenshot example of the recorded video is presented in Figure 3.2.
Figure 3.1: Camera setup at pilot study site

Figure 3.2: Example screenshot of video recorded at pilot study intersection
3.2 VALIDATION OF PEDESTRIAN PHASES

During the pre-pilot visit it was important to conduct a quality assurance/quality control (QA/QC) method for the pedestrian phases. This was implemented by:

- Opening the 2070 controller cabinet.
- Sending a crew member to each crosswalk push button and make sure that a pedestrian phase is called after pushing the pedestrian button.
- Verifying that the appropriate light/indicator turns on at the 2070 controller cabinet.
- Recording the number of pedestrian phases during a 15 minute interval (or 1 hour interval).
- After the site visit, the 2070 phase data was exported and verified that all pedestrian phases were being recorded (compared the number of phases in each of the crosswalks during the 15 minute interval (or 1 hour interval).
- If the recorded data did not match the observed field data it is necessary to go back to the site and correct whatever equipment issue before conducting the 24-hour video data collection.

3.3 VALIDATION OF BICYCLE LOOP DETECTORS

A similar QA/QC was conducted, including:

- Opening the 2070 controller cabinet.
- Sending a crew member with a regular bicycle to each bicycle loop detector and make sure that the bicycle is detected. If the bicycle is not detected lower the sensitivity until the bicycle is successfully detected.
- Verifying that the appropriate light/indicator turns on at the 2070 controller cabinet.
- Recording the number of bicycles passing over the detectors over a 15 minute interval (or 1 hour interval).
- After the site visit, the 2070 bicycle detection data was downloaded and verified the numbers (compare the number of bicycles passing over the loops during the 15 minute interval (or 1 hour interval).
- If the recorded data does not match the observed field data go back to the site and/or fix whatever equipment issue before conduction the 24-hour video data collection.

3.4 PRE-SITE VISIT DURATION

It is recommended to schedule several hours for the pre-site visit, inspection, and equipment validation. More time is necessary as the number of crosswalks/push buttons, loop detectors, and signal phases/cycle duration increases.
4.0 PEDESTRIAN COUNTS

4.1 DATA COLLECTION

As previously mentioned, the TAC and PSU team agreed on focusing the pilot data collection study on intersections with 2070 controllers; this type of technology has many potential cost-efficiency advantages as stated in the Task 2 report. For pedestrian counts, 2070 signal controllers are very appealing since they require small to no hardware/equipment costs to record pedestrian phases.

There are two main types of pedestrian phasing configurations:

1. Pedestrian phase in recall. Some intersections with pedestrian recall have push buttons and regardless of whether a pedestrian pushes the button a pedestrian phase is granted (usually at the minor approach). A pedestrian push button at an intersection with pedestrian recall is provided so that pedestrians understand that there is a pedestrian phase and that they have to wait for the pedestrian signal.

2. Actuated pedestrian crossings enable the pedestrian phase to be granted only when the pedestrian button is pushed.

It is possible to estimate pedestrian volumes based on pedestrian actuations at intersections where pedestrian phases are only granted by the pushing of actuation buttons. These volumes can be estimated by counting the number of pedestrian phases given by traffic signals and the estimation of an adjustment factor.

The 2070 controller records the number of pedestrian phases granted at each crosswalk in fifteen minute increments. Multiple button pushes of the same button do not affect the data collection as only the number of phases granted is recorded. However, there are some potential biases associated with the use of pedestrian phases to estimate pedestrian counts. Some of the potential biases contained in the pedestrian phase data to estimate pedestrian flows include:

- When a pedestrian pushes two different buttons for two directions (two different crosswalks) at the same corner. The 2070 controller grant and record two phases (one in each direction); if only one pedestrian utilizes the intersection then the number of phases is overestimating the number of pedestrians.

- The data may be biased if there are groups. A 2070 controller grants and records one phase regardless of the number of pedestrians crossing during a phase. Every time a group of pedestrians utilizes a crosswalk the number of phases is underestimating the number of pedestrians.

- In some instances, bicyclists push the pedestrian buttons which can also introduce bias into the data (overestimation of pedestrians).
In order to estimate pedestrian volumes utilizing phase actuation counts from the 2070 controller, it is necessary to estimate the accuracy of the counts and the value of the adjustment factor that is necessary to convert number of phases into pedestrian volumes.

In order to validate this method of pedestrian volume estimation, video was recorded at the intersection of OR-99W and Hall Boulevard in Tigard, OR from 9:00 AM on Thursday, August 29\textsuperscript{th}, 2013 to 9:00 AM on Friday, August 30\textsuperscript{th}, 2013. Before beginning the evaluation of pedestrian traffic at the intersection, a site visit was conducted with Region 1 Signal Manager, Tiffany Slauter, and the PSU research team. A validation of pedestrian counts was performed by pushing each of the push buttons and observing the pedestrian count detection in the 2070 controller. When a pedestrian button was pushed, a light on the pedestrian counting input card was triggered. All push buttons were functioning properly.

An aerial photo is shown in Figure 4.1 denoting the crosswalks which are herein referred to as North, South, East, and West.

![Aerial photo of pilot study intersection with annotation](image)

**Figure 4.1: Aerial photo of pilot study intersection with annotation**

### 4.2 VIDEO RESULTS

Pedestrian crossings were counted manually from the 24-hours video recording; these counts denoted as “video counts” herein were compared to the phase counts reported by the 2070 signal controller during the same time period. Hourly video counts volumes are presented in Figure 4.2. The peak hours of pedestrian traffic occurred between 12:00 PM and 6:00 PM; these six hours account for 43% of the total pedestrian daily volume of 596 pedestrians. Each pedestrian
represents a single pedestrian movement, i.e. one person crossing in a single direction. If a single person crosses two crosswalks at the intersection, this counts as two pedestrian movements.

Figure 4.2: Total pedestrian volumes (for all crosswalks)

The group size of pedestrian crossings was also documented from the video analysis. Group size refers to the number of pedestrians crossing in a single direction during a pedestrian phase. This information is incorporated into the adjustment factor. Figure 4.3 presents information about pedestrian group sizes observed over the 24-hour video data collection period.

Single pedestrians were the most common group sized observed, but groups of two were observed 57 times. Other group sizes were observed less often, as illustrated in Figure 4.3 and Figure 4.4. In total, there were 440 groups of pedestrians observed and a total of 596 pedestrians over the 24 hour study period which indicates that the average group size is equal to 1.35 pedestrians per group.
Figure 4.3: Pedestrian group size by crosswalk

Figure 4.4: Pedestrian group size proportions by crosswalk
4.3 DATA VALIDATION

Table 4.12 presents a summary of the pedestrian video counts and pedestrian phases from the 2070 controller logs. Note that the volumes are sorted by the location of the crosswalk with respect to the intersection as denoted in Figure 4.1. Directionality of pedestrians cannot be inferred from the 2070 actuations alone because only granted pedestrian phases are recorded. The northern, southern, and western crosswalks had more pedestrian volume than pedestrian phases granted, which is the result of more than one pedestrian crossing within a phase (as shown in Figure 4.3). The eastern crosswalk had fewer pedestrians than phases granted, likely due a combination of pedestrians pushing the actuation buttons for two directions at one time and cyclists pushing the eastern actuation button.

Table 4.1: Video Counts vs. 2070 Pedestrian Phase Counts Summary

<table>
<thead>
<tr>
<th>Crosswalk</th>
<th>North</th>
<th>South</th>
<th>East</th>
<th>West</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian (video data)</td>
<td>109</td>
<td>131</td>
<td>84</td>
<td>273</td>
<td>596</td>
</tr>
<tr>
<td>Pedestrian phases (2070 data)</td>
<td>91</td>
<td>109</td>
<td>100</td>
<td>182</td>
<td>482</td>
</tr>
<tr>
<td>Ratio (Pedestrians/Phases)</td>
<td>1.20</td>
<td>1.20</td>
<td>0.84</td>
<td>1.50</td>
<td>1.24</td>
</tr>
</tbody>
</table>

The ratios given in the bottom row of Table 4.1 can be used to develop adjustment factors for estimating pedestrian volumes from the counts of phases granted reported by the 2070 controller. To explore the variation of these factors throughout the day, scatter plots in Figure 4.5 depict the relationship between pedestrian phases granted and the actual pedestrian volumes per each hour of the 24 hour study period (24 dots per graph). There is a clear linear relationship with a relatively high $R^2$. While it appears from this analysis that a reasonable estimate of pedestrian volumes could be made from pedestrian actuations at the pilot intersection using the adjustment factors shown in Table 2.1, further research is necessary to generalize this finding to other days or locations.
4.4 ESTIMATION OF 99W AND SW HALL BOULEVARD 2012 PEDESTRIAN AADT

The results of the data collection at OR-99W and Hall Boulevard suggest that pedestrian phases can be used to estimate average pedestrian volumes and annual AADT with a reasonable accuracy (further research and data collection is necessary to estimate this level of accuracy). The steps to estimate pedestrian AADT are described below utilizing 2012 pedestrian phase counts at OR-99W and Hall Boulevard.
The monthly variation in the number of pedestrian phases is shown in Figure 4.6. The numbers are somewhat consistent with at least 400 phases on average per day per month.

Hourly average pedestrian phases at this intersection are also fairly consistent throughout the year as illustrated in Figure 4.7. Most phases take place around mid-day and decrease gradually during the afternoon. There are no other peak hours. This pattern reflects a non-commute pattern.
Figure 4.8 displays the average DOW (day of the week) pedestrian phases. Numbers are fairly consistent throughout the week.

![Figure 4.8: Average DOW Pedestrian Phases at 99W and SW Hall Boulevard](image)

In this case, because we are actually counting phases instead of pedestrians, before estimating pedestrian AADT it is necessary to estimate average annual daily (pedestrian) phases or AADP. The 2012 AADP number is 529 which is on average almost 22 actuations per hour – for all four crosswalks, see Table 4.2. To obtain AADP we follow the same procedure already shown in Task 3 for bicycle or pedestrian AADT.

Each day of the week is the average of each day of the week in the month. For example, all Mondays in January are averaged to compute the daily Monday average for January. For more details on computing average daily values see Task 3. Table 4.3 and Table 4.4 show weekday and weekend actuations, respectively. Weekend AADP (476) is approximately 12% less than weekday AADP (550) which indicates that there may be slightly more utilitarian trips/activity at this particular intersection.
### Table 4.2: OR-99W and Hall Boulevard 2012 day-of-week (DOW) & monthly pedestrian AADP

<table>
<thead>
<tr>
<th>DOW Averages</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>DOW Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>417</td>
<td>507</td>
<td>483</td>
<td>349</td>
<td>398</td>
<td>665</td>
<td>448</td>
<td>731</td>
<td>442</td>
<td>366</td>
<td>318</td>
<td>319</td>
<td>453</td>
</tr>
<tr>
<td>Mon</td>
<td>582</td>
<td>704</td>
<td>656</td>
<td>461</td>
<td>454</td>
<td>710</td>
<td>506</td>
<td>852</td>
<td>480</td>
<td>475</td>
<td>435</td>
<td>428</td>
<td>562</td>
</tr>
<tr>
<td>Tue</td>
<td>528</td>
<td>701</td>
<td>527</td>
<td>427</td>
<td>458</td>
<td>768</td>
<td>480</td>
<td>686</td>
<td>517</td>
<td>460</td>
<td>450</td>
<td>360</td>
<td>530</td>
</tr>
<tr>
<td>Wed</td>
<td>637</td>
<td>754</td>
<td>536</td>
<td>423</td>
<td>460</td>
<td>754</td>
<td>467</td>
<td>709</td>
<td>475</td>
<td>458</td>
<td>451</td>
<td>472</td>
<td>549</td>
</tr>
<tr>
<td>Thu</td>
<td>700</td>
<td>775</td>
<td>480</td>
<td>408</td>
<td>458</td>
<td>653</td>
<td>502</td>
<td>668</td>
<td>503</td>
<td>454</td>
<td>427</td>
<td>430</td>
<td>538</td>
</tr>
<tr>
<td>Fri</td>
<td>634</td>
<td>675</td>
<td>650</td>
<td>461</td>
<td>479</td>
<td>667</td>
<td>520</td>
<td>847</td>
<td>512</td>
<td>471</td>
<td>447</td>
<td>471</td>
<td>569</td>
</tr>
<tr>
<td>Sat</td>
<td>558</td>
<td>581</td>
<td>582</td>
<td>448</td>
<td>431</td>
<td>581</td>
<td>435</td>
<td>708</td>
<td>449</td>
<td>414</td>
<td>391</td>
<td>398</td>
<td>498</td>
</tr>
<tr>
<td>Monthly Average</td>
<td>579</td>
<td>671</td>
<td>559</td>
<td>425</td>
<td>448</td>
<td>685</td>
<td>480</td>
<td>743</td>
<td>483</td>
<td>443</td>
<td>417</td>
<td>411</td>
<td>529 AADP</td>
</tr>
</tbody>
</table>

### Table 4.3: OR-99W and Hall Boulevard 2012 weekday DOW & DOM pedestrian AADP

<table>
<thead>
<tr>
<th>DOW Averages</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>DOW Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>582</td>
<td>704</td>
<td>656</td>
<td>461</td>
<td>454</td>
<td>710</td>
<td>506</td>
<td>852</td>
<td>480</td>
<td>475</td>
<td>435</td>
<td>428</td>
<td>562</td>
</tr>
<tr>
<td>Tue</td>
<td>528</td>
<td>701</td>
<td>527</td>
<td>427</td>
<td>458</td>
<td>768</td>
<td>480</td>
<td>686</td>
<td>517</td>
<td>460</td>
<td>450</td>
<td>360</td>
<td>530</td>
</tr>
<tr>
<td>Wed</td>
<td>637</td>
<td>754</td>
<td>536</td>
<td>423</td>
<td>460</td>
<td>754</td>
<td>467</td>
<td>709</td>
<td>475</td>
<td>458</td>
<td>451</td>
<td>472</td>
<td>549</td>
</tr>
<tr>
<td>Thu</td>
<td>700</td>
<td>775</td>
<td>480</td>
<td>408</td>
<td>458</td>
<td>653</td>
<td>502</td>
<td>668</td>
<td>503</td>
<td>454</td>
<td>427</td>
<td>430</td>
<td>538</td>
</tr>
<tr>
<td>Fri</td>
<td>634</td>
<td>675</td>
<td>650</td>
<td>461</td>
<td>479</td>
<td>667</td>
<td>520</td>
<td>847</td>
<td>512</td>
<td>471</td>
<td>447</td>
<td>471</td>
<td>569</td>
</tr>
<tr>
<td>Sat</td>
<td>558</td>
<td>581</td>
<td>582</td>
<td>448</td>
<td>431</td>
<td>581</td>
<td>435</td>
<td>708</td>
<td>449</td>
<td>414</td>
<td>391</td>
<td>398</td>
<td>498</td>
</tr>
<tr>
<td>DOM Average</td>
<td>616</td>
<td>722</td>
<td>570</td>
<td>436</td>
<td>462</td>
<td>710</td>
<td>495</td>
<td>752</td>
<td>498</td>
<td>464</td>
<td>442</td>
<td>432</td>
<td>550 AAWDP</td>
</tr>
</tbody>
</table>
Table 4.4: OR-99W and Hall Boulevard 2012 weekend DOW & DOM pedestrian AADP

<table>
<thead>
<tr>
<th>Weekend Averages</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>DOW Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>417</td>
<td>507</td>
<td>483</td>
<td>349</td>
<td>398</td>
<td>665</td>
<td>448</td>
<td>731</td>
<td>442</td>
<td>366</td>
<td>318</td>
<td>319</td>
<td>453</td>
</tr>
<tr>
<td>Sat</td>
<td>558</td>
<td>581</td>
<td>582</td>
<td>448</td>
<td>431</td>
<td>581</td>
<td>435</td>
<td>708</td>
<td>449</td>
<td>414</td>
<td>391</td>
<td>398</td>
<td>498</td>
</tr>
</tbody>
</table>

Pedestrian phase factors have been obtained by dividing each entry in the table by the AADP displayed in the bottom right corner of the table (See Table 4.5). These could be used to estimate AADP for that intersection if the pedestrian actuation count on a particular day at that intersection is known. The days that best represent AADP are Tuesdays and Thursdays; the month that best represent AADP is March, July and September (when the factors that are close to one).

Table 4.5: OR-99W and Hall Boulevard 2012 Pedestrian Actuation AADP Factors

<table>
<thead>
<tr>
<th>DOW Factors</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>DOW Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>1.27</td>
<td>1.04</td>
<td>1.09</td>
<td>1.52</td>
<td>1.33</td>
<td>0.80</td>
<td>1.18</td>
<td>0.72</td>
<td>1.20</td>
<td>1.44</td>
<td>1.66</td>
<td>1.66</td>
<td>1.17</td>
</tr>
<tr>
<td>Mon</td>
<td>0.91</td>
<td>0.75</td>
<td>0.81</td>
<td>1.15</td>
<td>1.16</td>
<td>0.74</td>
<td>1.05</td>
<td>0.62</td>
<td>1.10</td>
<td>1.11</td>
<td>1.21</td>
<td>1.24</td>
<td>0.94</td>
</tr>
<tr>
<td>Tue</td>
<td>1.00</td>
<td>0.75</td>
<td>1.00</td>
<td>1.24</td>
<td>1.15</td>
<td>0.69</td>
<td>1.10</td>
<td>0.77</td>
<td>1.02</td>
<td>1.15</td>
<td>1.18</td>
<td>1.47</td>
<td>1.00</td>
</tr>
<tr>
<td>Wed</td>
<td>0.83</td>
<td>0.70</td>
<td>0.99</td>
<td>1.25</td>
<td>1.15</td>
<td>0.70</td>
<td>1.13</td>
<td>0.75</td>
<td>1.11</td>
<td>1.15</td>
<td>1.17</td>
<td>1.12</td>
<td>0.96</td>
</tr>
<tr>
<td>Thu</td>
<td>0.75</td>
<td>0.68</td>
<td>1.10</td>
<td>1.30</td>
<td>1.16</td>
<td>0.81</td>
<td>1.05</td>
<td>0.79</td>
<td>1.05</td>
<td>1.16</td>
<td>1.24</td>
<td>1.23</td>
<td>0.98</td>
</tr>
<tr>
<td>Fri</td>
<td>0.83</td>
<td>0.78</td>
<td>0.81</td>
<td>1.15</td>
<td>1.10</td>
<td>0.79</td>
<td>1.02</td>
<td>0.62</td>
<td>1.03</td>
<td>1.12</td>
<td>1.18</td>
<td>1.12</td>
<td>0.93</td>
</tr>
<tr>
<td>Sat</td>
<td>0.95</td>
<td>0.91</td>
<td>0.91</td>
<td>1.18</td>
<td>1.23</td>
<td>0.91</td>
<td>1.22</td>
<td>0.75</td>
<td>1.18</td>
<td>1.28</td>
<td>1.35</td>
<td>1.33</td>
<td>1.06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DOM Factors</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>DOW Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>0.91</td>
<td>0.79</td>
<td>0.95</td>
<td>1.24</td>
<td>1.18</td>
<td>0.77</td>
<td>1.10</td>
<td>0.71</td>
<td>1.10</td>
<td>1.19</td>
<td>1.27</td>
<td>1.29</td>
<td>1.00</td>
</tr>
</tbody>
</table>
4.5 CONVERTING AADP TO AADT

To account for the fact that phase actuations are being counted, not actual pedestrians, an additional adjustment factor can be used. As calculated in

this adjustment factor is the ratio of the actual pedestrian volume to the number of pedestrian phases recorded by the 2070 controller. For the 24-hour study, the average ratio of pedestrians to actuations for all crosswalks was 1.24; to estimate pedestrian AADT we can proceed as follows (utilizing a factor for Thursday in August that is 0.79):

Pedestrian AADT = 0.79 * 482 * 1.24 = 472

Applying these factors to pedestrian phase counts at other intersections may require two important assumptions:

1. That the pedestrian travel patterns by day of week and month of year match that of the other intersection (if Table 4.5 factors are applied), and
2. That the adjustment factor to convert from pedestrian phases to actual pedestrians is generalizable to other 2070 intersections (if the 1.24 factor is applied).

Further research and data analysis are necessary to test the validity of these assumptions. Because these questions cannot yet be answered, we offer these factors and calculations as a simple example of what could be the procedure to calculate pedestrian AADTs based on 2070 controller pedestrian phase counts.

Two special cases are possible:

4.5.1 AADT calculations at other 2070 intersections

In this case AADP factors (similar to Table 4.5 but specific to the new intersection) can be calculated utilizing the 2070 data. A pedestrian/phase ratio factor is needed (this ratio is 1.24 in the previous example). Before utilizing a pedestrian/phase ratio, there are some important factors to consider:

- The surrounding land use and demographics will in general dictate the pedestrian activity levels, particularly group size. When converting the actuations to pedestrians, group size will affect pedestrian volume estimations from pedestrian actuation counts. In order for this method to applied, these land-use / group size / actuation factors would need to be developed.
- Site geometry or preferred pedestrian paths could results in more than one pedestrian cross (i.e. the utilization of two crosswalks) which may increase the adjustment factor for the pedestrian/phase ratio.
- Counts can be biased by pedestrians pushing buttons for multiple directions at the same corner. In addition, bicyclists may also be using pedestrian push buttons.
4.5.2 AADT calculations at other nearby intersections without 2070 controllers

In this case it is necessary to perform a pedestrian count (24-hours ideally) and then apply an AADT estimation factor (this factor is obtained from Table 4.5 in the previous example).

The surrounding land use and demographics will in general dictate the pedestrian activity levels by day of the week and month of the year (typical pedestrian trips are less than 1 mile). The presence of transit stops may also affect the utilization of crosswalks and the hourly distribution of pedestrians.
5.0 BICYCLE COUNTS

The objective of this portion of the study was to validate two bicycle counting technologies: (1) inductive loops connected to 2070 controllers and (2) pneumatic tubes. The results for each technology are described in the following subsections.

5.1 INDUCTIVE LOOPS

5.1.1 Data Collection

The intersection of OR-99W and SW Hall Boulevard uses inductive loops to detect both motor vehicles and cyclists at each approach of the intersection. There are separate inductive loops for motor vehicles and bicycles. Bicycle inductive loops are located in each bicycle lane, at the stop bar and approximately 50 feet away from the intersection as shown in Figure 5.1.

The bicycle inductive loops ensure that cyclists are detected in the bike lanes regardless whether a motor vehicle is present at the approach. This is also true for bicycle inductive loops on 99W, although their presence is less critical due to the high motor vehicle volumes. In addition to detecting bicycles for signal actuation, the 2070 controller at this intersection can be configured in the Voyage control software to record bicycle induction loop detections. One of the goals of this pilot study was to test the accuracy of the bicycle inductive loops to count bicycles.

Like in the case of pedestrians, the same video recorded at the intersection of OR-99W and Hall Boulevard was utilized to count the number of bicycles per approach. There was a pre-pilot site visit by Region 1 Signal Manager, Tiffany Slauter and the PSU research team. A bicycle was brought to the site and a team member rode over each of the bicycle inductive loops while the bicycle counter input cards for each loop was observed. Each time the bicycle was detected by the loop, a light would flash on the card. The bicycle loop detector input card also has a sensitivity adjustment. Initially, the bicycle was not being detected by the loops. The sensitivity was adjusted until the bicycles were recorded. For most of the loops, the sensitivity was adjusted to the highest level. Because the sensitivity of the loops had a major effect on the results, two video data collections were carried out. Video was recorded for the following periods of time:

- From 12:00 PM on Wednesday, August 28th, 2013 to 11:00 AM on Friday, August 30th, 2013 (At High Loop Sensitivity)

- From 9:00 AM on Thursday, October 24th, 2013 to 9:00 AM on Friday, October 25th, 2013 (At Medium Loop Sensitivity)

Video was recorded using a camera mounted on a signal mast arm pole at the northwest corner of the intersection (see Figure 3.1 and Figure 3.2). The video was analyzed by manually watching video and recording bicycle movements by time, location, direction, and any distinct behavioral details that may be useful in the analysis. There were some minor limitations to the amount of detail that could be observed from the video due to the camera angle, the distance, or because of obstructions in the viewing area. The bicycle traffic volumes collected from this
video data are considered to be the actual volumes. The video traffic volumes were compared to the data collected by the 2070 controllers and inductive loops.

5.1.2 Video Results

The video counts were used to characterize the bicycle traffic patterns at the intersection studied. Figure 5.2 presents the bicycle volumes during the first video analysis period. It was discovered that bicycle lane volumes represented only 51 percent of the total bicycle volume observed. The other 49 percent of cyclists were traveling on the sidewalk. This suggests that almost half of the cyclists utilizing the intersection may feel that sidewalks are safer or more convenient for travel than the on-street bike lanes. This is especially important to note if factors are to be developed for estimating actual bicycle volumes from loop detections, as all the bicyclists using the sidewalk are not detected by the inductive loops. For example, using the actual video data Figure 4.4 shows that the peak rider volume for total bicyclists is 4 to 5pm, while for bike lane riders it
is one hour later. This indicates that sidewalk riders may have different travel patterns than those using the bike lane.

![Bar chart showing bicycle volumes and bike lane only volume](image)

**Figure 5.2: Actual Bicycle Volumes for Intersection from Video Analysis Period (8/29 – 8/30)**

### 5.1.3 The impacts of Loop Sensitivity and Location

It was already mentioned that in the pre-pilot visit, members of the PSU research team and Region 1 Signal Manager, Tiffany Slauter, tested the detectability of bicycles at each inductive loop on August 23rd, 2013. While riding or placing a bicycle over each inductive loop at the intersection, the inductive loop input card detection light in the 2070 controller was observed, indicating detection.

Upon testing the detectability of a bicycle at each inductive loop, it was clear that the sensitivity levels of the loops were too low to consistently detect bicycles. Consequently, the sensitivity levels were raised. However, it later became apparent during the first video analysis that these new sensitivity levels were also detecting nearby motorized vehicles since the inductive loops were over-counting bicycles. At around 11:00 AM on August 23rd, 2013, the sensitivity levels were raised and the impact of this action is illustrated in Figure 5.3. Unfortunately, the sensitivity change significantly increased over-counting and this was not discovered until the results for the first video analysis were compared to the inductive loop counts.
The initial video analysis covered the period of 9:00 AM on Thursday, August 29th, 2013 to 9:00 AM on Friday, August 30th, 2013. The video analysis was compared to the 2070 recorded bicycle volumes. Upon analyzing the bicycle volumes collected from the video analysis, it became clear that the bicycle counts as reported by the 2070 were far too high. See Table 5.1 below. Percent error was calculated using Equation 5-1.

\[
\% \text{ Error} = \frac{2070 \text{ Loop Count} - \text{Video Count}}{\text{Video Count}}
\]

Equation 5-1: Percent error of inductive loop counts

<table>
<thead>
<tr>
<th>Direction of Travel</th>
<th>NB Hall Blvd to Beaverton (2 Loops)</th>
<th>SB Hall Blvd to Tigard Library (2 Loops)</th>
<th>EB OR 99W to Portland</th>
<th>WB OR 99W to Sherwood</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicycle Counts (from Video)</td>
<td>19</td>
<td>35</td>
<td>15</td>
<td>28</td>
<td>97</td>
</tr>
<tr>
<td>Bike Lane Volume (from 2070)</td>
<td>299</td>
<td>444</td>
<td>827</td>
<td>642</td>
<td>2212</td>
</tr>
<tr>
<td>% Error</td>
<td>1474%</td>
<td>1169%</td>
<td>5413%</td>
<td>2193%</td>
<td>2180%</td>
</tr>
</tbody>
</table>

The disparity in counts due to the inaccuracy of the loops is also clearly visible when comparing the actual and loop bike lane counts for the same analysis period in Figure 5.4. This graph depicts the actual and detected hourly bicycle volumes as a proportion of the 24 hour volume. The distributions of volumes are significantly different.
The degree to which the inductive loops over-counted was significantly greater on the eastbound (OR-99W) approach. It is likely that this high error is due to the location of the inductive loop on the roadway, close the right turn pocket and hence it is capturing a high number of right turning vehicles. The Eastbound loop (towards Portland) is depicted below (Figure 5.5) with a pick-up truck driving within close proximity of the loop as it makes a right turning movement.
In order to lend validity to the hypothesis that vehicles are being detected by the bicycle inductive loop on the eastbound 99W approach at the right turn pocket, a scatter plot (Figure 5.6) comparing the bike volumes reported by the 2070 and the rightmost lane vehicle volumes was constructed. A linear regression model was estimated using right lane and right turn volumes as the independent variables; the regression model had a high R² value of 0.73 which suggests a clear relationship between the amount of vehicles and the loop detections.
As a default, the sensitivity of most loop detectors may be too low as explained below:

The sensitivity of the loop system is critical. Loop system sensitivity is defined as the smallest change of inductance at the electronics unit terminals that will cause the controller to activate. Many states specify that the electronics unit must respond to a 0.02 percent change in inductance, and typically many departments of transportation (DOTs) set the sensitivity setting at 4 or even lower by observing the flow of traffic and turning the sensitivity down until they stop getting detections and then turning it up a notch. (Note: On digital detectors with alphanumeric readouts, the scale typically goes from 1 to 10.) If no bicycles or motorcycles have gone by, inadvertently they might set the sensitivity too low. (Gibson 2008)

Bicycles have a significantly smaller mass of ferrous metal with which to trigger the inductive loop and thus it is difficult to determine a sensitivity setting that will be sensitive enough to detect all types of bicycles without being too sensitive so that nearby vehicles are inadvertently detected.
Since the volumes reported by the 2070 were highly inaccurate, another session of video was recorded after adjusting the inductive loops to a lower sensitivity setting on October 23rd. The impact of this sensitivity change is illustrated in Figure 5.7. The second session of video was recorded from 9:00 AM on Thursday, October 24th, 2013 to 9:00 AM on Friday, October 25th, 2013. (Table 5.2) Instead of analyzing the entire 24 hour period, a selection of ten peak hours were analyzed to assess if the new sensitivity setting was enabling more accurate counts. The ten peak hours included:

- 9:00 AM to 11:00 AM on Thursday, October 24th
- 2:00 PM to 7:00 PM on Thursday, October 24th
- 6:00 AM to 9:00 AM on Friday, October 25th

Figure 5.7: Illustration of Change in Bicycle Detection because of 10/23 Sensitivity Change
Table 5.2: Video Counts vs. 2070 Counts Summary (10/24 – 10/25)

<table>
<thead>
<tr>
<th>Direction of Travel</th>
<th>Northbound - Beaverton (2 Loops)</th>
<th>Southbound - Tigard Library (2 Loops)</th>
<th>Eastbound to Portland</th>
<th>Westbound to Sherwood</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Bike Lane Volumes from Video</td>
<td>30</td>
<td>35</td>
<td>10</td>
<td>28</td>
<td>103</td>
</tr>
<tr>
<td>Volumes reported by 2070</td>
<td>32</td>
<td>66</td>
<td>253</td>
<td>45</td>
<td>396</td>
</tr>
<tr>
<td>% Error</td>
<td>7%</td>
<td>89%</td>
<td>2430%</td>
<td>61%</td>
<td>74%</td>
</tr>
</tbody>
</table>

Accuracy did improve with sensitivity adjustment; however, there was still a significant over-count from the eastbound loop detector. Despite the sensitivity being at a better level to avoid detecting too many vehicles passing within close proximity, it seems like loops were still counting both some bicycles and some cars. This suggests that loops used for counting bike volumes must be installed in locations that are not conducive to being passed over by vehicles in order to obtain accurate counts, no matter the sensitivity level. It is also crucial that loops are installed away from right (or left) turning vehicles.

The pilot study also revealed another issue with some of the inductive bicycle loops. Hall Boulevard bike lane approaches have two bicycle loops; one at the stop bar and the other approximately 50 feet behind the stop bar. Tiffany Slaeter indicated that the two loops were wired in series. Having both loops wired in series creates a counting problem since the counts from both loops are added together and are represented in one data bin. Under ideal conditions, a cyclist would ride over both loops and be counted twice. However, it was noted that sometimes these counts were odd numbered. There are many possible reasons for the odd numbers such as: a) one detector is more sensitive than the other, b) the bicycle path avoided one loop, c) motor vehicles may be driving over one of the loops when merging late into the right turn lane, and d) one of the many combinations resulting from mixing a) b) and c) cases.

While having two loops can increase the probability that a bicycle will be detected at all, data outputs must be separated in order to obtain more useful bicycle loop counts.

### 5.1.4 Inductive Loop Recommendations

The results of this study revealed several issues that need to be addressed if inductive loops are to be effectively utilized for counting bicycles at signalized intersections.

- The installation location of loops in relation to vehicle movements may significantly affect the accuracy of counts. In order to obtain accurate counts, the loops should be installed at locations where vehicles will not be as likely to be inadvertently detected. For example, at the studied intersection, the eastbound loop was installed too close to the merge area of the right turning pocket, as shown in Figure 5.5.

- There are several loop configurations such as quadrupole, diagonal quadrupole, chevrons, elongated diamond patterns, as well as rectangular. Quadrupole and parallelogram loop configurations have been found to correctly detect bicyclists. In
California, Type D\(^1\) inductive loops are recommended for bicycle detection \((Shladover, \textit{et al.} 2009)\) \((Styer and Keung 2013)\). Examples of existing inductive loops in Oregon are shown in Figure 5.8. The City of Portland has been installing rectangular inductive loops. No substantive literature has been written about Portland’s inductive loops, however authors of this report are also testing the accuracy of the City of Portland’s inductive loops and have found that the loops have less error than the loops used at 99W and Hall Boulevard, however the Portland bicycle loops tend to undercount cyclists. An example of an inductive loop is shown in Figure 5.8c. Inductive loops are further discussed in Task 2: Data Collection Technologies of this report.

\footnote{Inductive loop types for bicycle counting: \url{http://www.cyclelicio.us/files/DetectingBicyclesMotorVehiclesUsingSameLoopDetector.pdf}}
The sensitivity of each loop must be calibrated to the lowest possible sensitivity that will be enough to consistently detect bicycles. This should be determined for each loop using at least one test bicycle, and bicycle detectability should be checked periodically to ensure bicycle loop count accuracies. ODOT currently tests the loops by checking induction. ODOT does not use a bicycle to test the performance of the bike inductive loops. It is recommended that ODOT develops bicycle specific guidelines to test inductive loops that are used to count bicycles.
If inductive loops are to be utilized to obtain accurate bicycle volumes for intersections, the proportion of cyclists using the sidewalk should be estimated. These cyclists will never be detected by loops and may represent a significant portion of cyclists using the intersection. During the initial 24 hour video analysis, 49% of the observed cyclists used the sidewalk. This proportion will likely depend on the location of loops, land use, traffic volume, perceived safety of the bicycle facilities, and the experience or comfort level of the cyclists utilizing the intersection. In cases where physical improvements can be made to increase the actual and/or perceived safety of the intersection, this will result in more accurate counts. In cases where improvements cannot be made, the proportion of cyclists using the sidewalk should be accounted for in the bicycle volume estimation process. Alternatively, if a significant portion of cyclists use the sidewalk, ODOT may consider installing actuation loops in the sidewalk as well.

Signage, pavement marking, or other means to improve bicyclist comprehension are recommended; it was observed that bicyclists would occasionally push pedestrian actuation buttons during periods of low traffic. Cyclists should be able to understand where and how they are being detected. Examples are illustrated in Figure 5.11 from the NACTO Guide.

![Figure 5.9: Bicycle Inductive Loop Signage. Source: NACTO Guide](image)

Although expensive and time consuming, video validation, or QA/QC, should always be conducted when inductive loops are to be used for bicycle volume counts. Without video validation, it is impossible to assess how accurately the loops are counting.
bicycles. In addition, the behavior of cyclists can be only understood by evaluating video (e.g. sidewalk utilization).

5.2 PNEUMATIC TUBES

5.2.1 Data Collection

An additional task was added to the pilot study to evaluate if existing ODOT tube counting equipment could be used to estimate bicycle volumes. ODOT routinely utilizes TimeMark® Gammas² pneumatic tubes for short-term counts of motorized vehicles. The vendor claimed that the same pneumatic tubes could be used to count bicyclists.

Pneumatic tubes were placed on the north and south approaches to the intersection on Hall Boulevard, approximately 450 feet from the intersection. The tubes were installed across the bike lanes using the manufacturer recommended four-foot distance between consecutive tubes for bicycle detection. To also evaluate bicycle detection on sidewalks, different configurations of the tubes were tested as depicted in Figure 5.10. The sensitivity setting on the pneumatic tube data collector was set to “high”, as opposed to the other two settings (“medium” or “low”) that are commonly used for motorized vehicles. Figure 5.11 is a picture of one of the tube installations.

A camera was placed between the pneumatic tube counters and the intersection, approximately 300 feet from each tube setup. The video was used to validate the tube counters ability to record bicycle counts. The data collection was conducted from 9:00 AM on Thursday, August 29th, 2013 to 9:00 AM on Friday, August 30th, 2013. Both the pneumatic tubes and the video cameras were installed by ODOT technicians.

² Product info can be found here: http://www.timemarkinc.com/Hardware/GammaNT.aspx
Figure 5.10: Diagram of Tube Setups on Hall Boulevard (Not to Scale)

Figure 5.11: Pictures of pneumatic tube installation
5.2.2 Video Analysis Results

Ten hours of video were analyzed to determine the accuracy of the tubes for counting bicycles. The following time periods were studied:

- 9:00 AM to 11:00 AM on Thursday, August 29th
- 2:00 PM to 7:00 PM on Thursday, August 29th
- 6:00 AM to 9:00 AM on Friday, August 30th

The results of the validation study are summarized in Table 5.3: 27% of cyclists used the sidewalks compared to the 51% that had used the sidewalks for the 24 hour analysis.

Table 5.3: Results of video analysis for pneumatic tube counters

<table>
<thead>
<tr>
<th>Date</th>
<th>Start Time</th>
<th>North Side</th>
<th></th>
<th>South Side</th>
<th></th>
<th>North Side</th>
<th></th>
<th>South Side</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bike Lane</td>
<td>Sidewalk</td>
<td>Bike Lane</td>
<td>Sidewalk</td>
<td>Bike Lane</td>
<td>Sidewalk</td>
<td>Bike Lane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>North</td>
<td>South</td>
<td>North</td>
<td>South</td>
<td>North</td>
<td>South</td>
<td>North</td>
</tr>
<tr>
<td>8/29</td>
<td>9:00 AM</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10:00 AM</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2:00 PM</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3:00 PM</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4:00 PM</td>
<td>3</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5:00 PM</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6:00 PM</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>8/30</td>
<td>6:00 AM</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>7:00 AM</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>8:00 AM</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>21</td>
<td>28</td>
<td>15</td>
<td>11</td>
<td>26</td>
<td>30</td>
<td>4</td>
</tr>
</tbody>
</table>

Descriptive characteristics were also noted from the video analysis of the approaches. Visual cues were much easier to notice on the high definition video recorded at ground level for the tube counter validation, as opposed to the standard definition bird’s eye view video utilized for the inductive loop validation. It was noted that cyclists were more likely to use the bike lanes during peak commuting hours, and these cyclists were often outfitted like commuters. Some appearance characteristics of these commuter cyclists included reflective or form-fitting clothing, cargo racks, panniers, helmets, and bicycle lights. On the other hand, cyclists were more likely to use the sidewalks during off-peak hours and these cyclists were outfitted casually; often not wearing helmets.

5.2.3 Tube Data Validation

Although the video results presented above can be utilized to gain some insight into how the cycling facilities are used by riders at this intersection, the tube data itself was not useful since the magnitude of the errors is too high. Percent errors for the tube setups are presented Figure 5.12 and were calculated using Equation 5-2.
Clearly, these tubes did not accurately count bicycles. The tubes undercounted significantly; only counting 7 of the 143 bicycles that were observed crossing the tubes in the video. The tubes were installed following the manufacturer’s recommendations and by ODOT technicians whose expertise is motorized tube data collection equipment.

### 5.2.4 Pneumatic Tubes Recommendations

The results of this study revealed several issues that need to be addressed if tubes are to be effectively utilized for counting bicycles:

- **TimeMark® Gammas** in their current configuration should not be used to count bicycles, as they were shown in this study to perform poorly; even on the highest sensitivity setting.

- Other pneumatic tubes provided by the same vendor (e.g. TimeMark® Deltas) may be tested in future research endeavors and alternative layouts and tubes may be considered.

- Other pneumatic tubes provided by other vendors have been shown to reasonably count bicycles (*Hyde-Wright, Graham and Nordback, Counting Bicyclists with Pneumatic Tube Counters on Shared Roadways 2013*). It is possible that Deltas or Gammas could be used if minor modifications such as tube thickness or changes in classification schemes are made, however this would require additional research.
6.0 DISCUSSION

This pilot study served as a proof of concept for estimating pedestrian volumes from recorded counts of granted pedestrian phases. This method is potentially a cost-effective way of estimating pedestrian activity at many locations considering that: (a) no additional equipment is necessary, (b) 2070 controllers are used on many ODOT facilities across the state, and (c) in many 2070 locations in suburban areas and small/mid-size towns there are significant pedestrian volumes.

The results of the pilot study clearly indicate that pedestrian actuations can be potentially used as a proxy for pedestrian volumes. Bicycle loops and tubes were less accurate. More research is needed to understand under what conditions it is possible to utilize 2070 AADP factors to estimate pedestrian volumes. Similarly, more research and studies are necessary to understand under what conditions and with what kind of equipment bicycle loops and tubes may be more accurate.

Figure 6.1: ODOT Region 1 2070 map
In ODOT’s Region 1 alone, there are 114 existing 2070 signal controllers and another 105 intersection 2070 controller upgrades are planned; statewide there are 331 2070 controllers installed and 105 planned as shown Figure 6.1 and Figure 6.2. These controllers can become a major part of a statewide non-motorized data collection system.
7.0 REFERENCES


