APPENDICES

Appendix A: Public Engagement

This Regional Bikeways Plan was guided by public engagement throughout the process, including four steering committee meetings, ten focus group meetings, a public survey, several update presentations to the IMPO's Transportation Policy Committee, draft plan public reviews, and a final public hearing.

Steering Committee

The Regional Bikeways Plan's steering committee was comprised of a people representing state, county, and local government agencies, transit operators, and bike infrastructure advocates. Steering Committee meetings were held in March, June, and November 2019, and in October 2020. The steering committee provided feedback on key components of the plan including goals and objectives, survey content, public input strategy, prioritization maps and criteria, and the draft final plan.

The IMPO would like to thank the following individuals for serving on the Regional Bikeways Plan steering committee:

- Hilary Anderson, Resident
- Bob Bronson, Indiana Dept. of Natural Resources
- Brandon Burgoa, Indiana Dept. of Transportation
- Ryan Crum, Town of McCordsville
- Andre Denman, City of Indianapolis
- Pete Fritz, Indiana Dept. of Health
- Austin Gibble, IndyGo
- Jeff Hill, City of Fishers
- Tami Houston, City of Fishers
- Lance Lantz, Town of Zionsville
- David Littlejohn, City of Carmel
- Steve Maple, Town of Pittsboro
- John Marron, IndyGo
- Jamey McPherson, Freewheelin' Bikes
- Joe Murphy, City of Lawrence
- Carmen Parker, Johnson County Trails
- Alison Redenz, Marion County Public Health
- Damon Richards, Bike Indianapolis
- Connie Szabo Schmucker, Bike Garage Indy
- Scott Singleton, Town of Plainfield
- Savannah Solgere, Town of whitestown
- Health By Design Staff
- Brooke Thomas, IndyGo

Focus Groups

Focus group meetings were held around the region in June 2019 and in October 2020. Four meetings were held during each round, each meeting in a separate county within the region (Hamilton, Hancock, Marion, and Johnson counties). Community representatives were invited to these meetings from fields ranging from local government to community nonprofits to health and education entities. An additional focus group in each round was the Indianapolis Mayor's Bicycle Advisory Committee (IMBAC), which includes several regional bicycle advocacy businesses and organizations. Over the course of the plan, the groups were asked for their feedback on the draft vision and goals for the plan, their concerns or ideas regarding the bicycle facility types that the plan focuses on, the draft prioritization criteria, the preliminary public survey results, and the draft plan itself.

The IMPO would like to thank the individuals that served on the focus group meetings and provided important feedback needed to complete the plan.

May 2019 Public Engagement

The Indianapolis MPO conducted a MetroQuest survey for the Regional Bikeways Plan from May 1 – June 21, 2019. A Spanish version of the survey was open from May 31-June 21. Just under 1,500 people responded. (This survey ran concurrently with the MPO's Regional Pedestrian Plan survey.)

The survey was advertised via:

- teMPO weekly e-newsletter (five times)
- Facebook (~9k reach, 11 posts total)
    - Boosted a post regionally in mid-May
    - Boosted a post to underrepresented populations

(people with multi-cultural interests and at or less than high school graduate) in early June

- Added a post written in Spanish in early June

- Twitter (~6k reach, 3 posts total)
- Information shared with local news media
- Information shared with partner organizations, municipalities, and counties
- A video created by IMPO staff, describing the plan and encouraging people to take the survey

While the survey was open, MPO staff visited approximately nine sites during daytime hours (including government facilities, libraries, public events) with tablets to allow people to take the survey in real-time.

Approximately three weeks after the survey opened, MPO staff reviewed the demographic results. When compared to the actual demographic proportion of racial/ethnic and income groups within the Metropolitan Planning Area, the survey was skewing toward white, middle/high income people. To attempt to correct this, the survey was extended, translated into Spanish, and Engaging Solutions was tasked with sharing the survey with Black/African American and Latinx people, and to organizations representing the interests of Black/African American, Latinx, and low income populations.

Unfortunately, this additional survey promotion, including additional paid Facebook promotions focused on the underrepresented groups, did not result in a significant change in the demographic proportions of those taking the survey. The final survey is therefore somewhat biased toward the responses of a higher-income, white population. The survey is also somewhat biased toward survey takers who live in Marion County. These limitations were shared when discussing the survey results with the steering committee, focus groups, and IMPO Transportation Policy Committee, and taken into consideration when adjustments were made to the final scoring used to prioritize projects within this plan.

Survey Results

Below is a ranking of Categories that respondents said were the most important to them. Within those Categories are Subcategories that were also ranked in importance:

1. Connectivity
    - New Connections
    - Extensions
    - Reduce Barriers
    - Connect to Transit
2. Health
    - Exercise
    - Healthcare
    - Grocery Stores
3. Economic Development
    - People and Jobs
    - Schools
    - Arts, Parks, and Recreation
    - Shopping Centers
    - Libraries
4. Regionalism
    - Multijurisdictional
    - Purpose
5. Equity
    - Younger People
    - Zero Car Households
    - Low Income
    - People of Color
    - Older People

Survey respondents were also asked to complete a budgeting exercise where they distribute a total of 20 stars across eight different destination types. Here is how those destinations ranked, based on the total stars they received from all respondents:

1. Recreation and Community Centers (18.3% of stars)
2. Jobs (17.4%)
3. Schools (14.5%)
4. Grocery Stores (13.4%)
5. Transit Stops / Stations (11.8%)
6. Retail Shopping (9.6%)
7. Healthcare (7.5%)
8. Social and Government Services (7.4%)

October 2020 Public Engagement

A complete draft of the plan was available for public comment from November 2 through November 15, 2020. The draft was advertised via:

- teMPO weekly e-newsletter
- Facebook (XXX,XXX users reached)
- Boosted
- Twitter (XXX,XXX users reached)
- Information shared with partner organizations, municipalities, and counties
- A video created by IMPO staff, about the draft plan
- A Live Q&A with staff about the plan

Some of the comments received focused on ______. The changes made include ____.

Public Hearing

On December 2, 2020, the Regional Bikeways Plan was presented to the IMPO's Transportation Policy Committee for their review and approval. During this meeting, a public hearing was held to invite the public to speak on the plan. Comments included:

- (Name): (Comment)

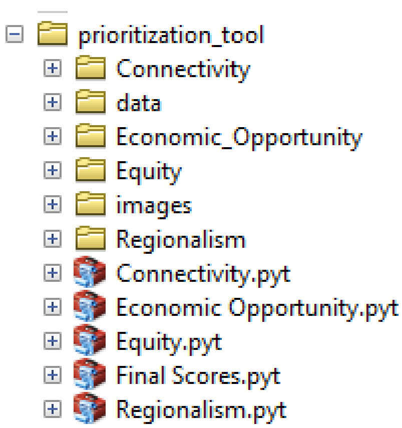
Appendix B: Prioritization Tool Documentation

The Indianapolis MPO Prioritization Tool is an ArcMap toolbox which allows for easy scoring of bike projects based on the methodology described in the 2015 Regional Bikeways Plan.

There are four categories for scoring:

- Connectivity
- Economic Opportunity
- Equity
- Regionalism

Each category has its own toolbox with tools corresponding to the various measures each category is composed of. In addition, each category has a tool for creating the output layer for that category, and a tool for scoring the measures.



Prioritization scores are produced by running through each category in succession, generating the values and scores for each topic, and then combining all categories together with the Final Scores tool.

There is also a data directory, which is intended to hold input and output datasets used in the tool.

Data Directory

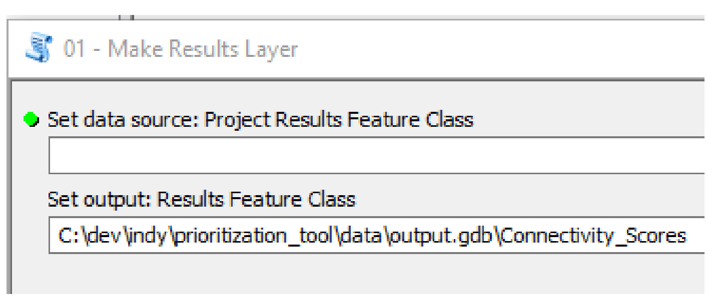
Input datasets are based on the datasets used in the 2015 plan and in some cases may be the exact same dataset. It is recommended that a user verify the input data to be sure the correct and most up-to-date data are being used in the analysis. Should newer data become available, a user can use it in the tool by simply pointing to the appropriate data on their computer or, if the user desires to update the default data used in the tool, they could simply delete the old data in the input.gdb and save the new data in input.gdb under the same name as the old data.

By default the outputs from the tools are saved in the output.gdb. A user is free to select an alternative location to save outputs, but the tools are designed to look in output.gdb to find output layers. If an alternative location is used for saving results a user will have to manually point to the output data for each tool, which may be a cumbersome process. If an alternative location for storing results is desired, it is recommended to complete the analysis using output.gdb and then copy results to the preferred location.

Categories

Creating a Results Layer

Each of the four categories has its own toolbox. The tools in each toolbox are numbered to indicate the appropriate order in which to run tools. The first tool in each toolbox, 01 - Make Results Layer, creates a layer in output.gdb for storing results.



This tool asks for an input layer representing the projects to be scored. A user may either select the layer from the layer catalog, or the layer can be selected from the current map's Table of Contents. Note that if a subset of projects are selected in the map document, only the selected projects will be copied into the results layer. This can be useful for running prioritization on a subset of all projects.

There is a layer in input.gdb named Proposed_Projects which is a current list of proposed projects. As with other inputs, this can be replaced with a more accurate layer at any time.

The tool pre-populates most of the parameters in each tool based on default datasets in input.gdb and standardized output layers in output.gdb.

The layer that is created by the 01 - Make Results Layer tool is a copy of the projects being scored. The project_uid attribute corresponds to the project's OID stored in the original project layer and can be used for joining results back to the original layer if desired.

OBJECTID *	Shape *	project_uid	Shape_Length
1	Polyline	1	5784.772023
2	Polyline	2	425.519042
3	Polyline	3	2539.09816
4	Polyline	4	4.685591
5	Polyline	5	882.848188
6	Polyline	6	4961.073588
7	Polyline	7	3937.482009
8	Polyline	8	46.710942
9	Polyline	9	658.287623
10	Polyline	10	5807.411553
11	Polyline	11	3103.985154

Scoring Each Measure

The tools for each measure do not calculate a score for that measure. They simply perform the measurement needed to calculate a score. For example, the Population tool does not assign scores for the population within 1 mile of a bikeway. It merely records the value of total population within 1 mile of each bikeway.

The scoring of each measure happens in the last tool of each toolbox, which is named Calculate Scores (see opposite page, top graphic).

This tool takes as an input the results layer created by the first tool in the toolbox. It also takes as input the scoring thresholds that determine how points are awarded. These thresholds have been pre-populated based on the 2015 plan, but the thresholds can be modified by deleting existing thresholds and typing new ones into the dropdown above each table.

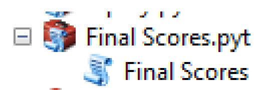
If a permanent change to thresholds is desired, these can be found within the code for each Calculate Scores toolbox near the top of the code (See opposite page, bottom graphic).

If a code change is made, it is recommended that a backup be kept in case the code change causes a breakage in the tool.

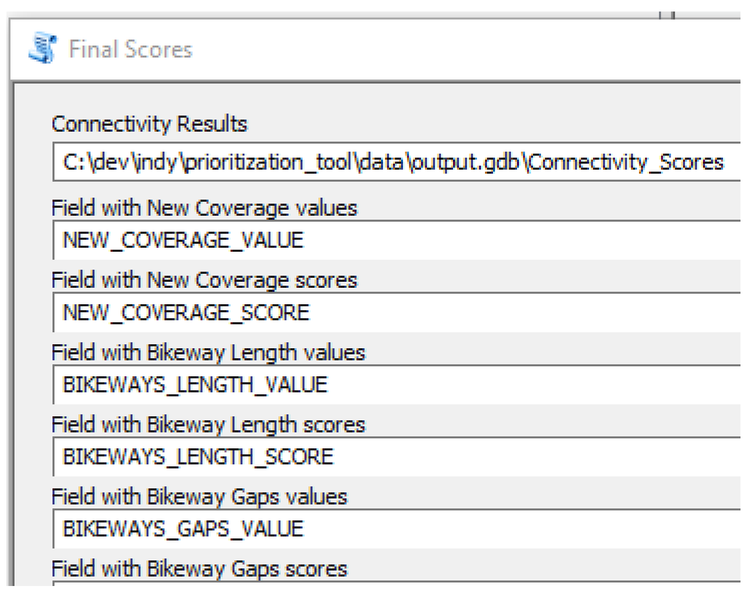
Final Scores

If a code change is made, it is recommended that a backup be kept in case the code change causes a breakage in the tool.

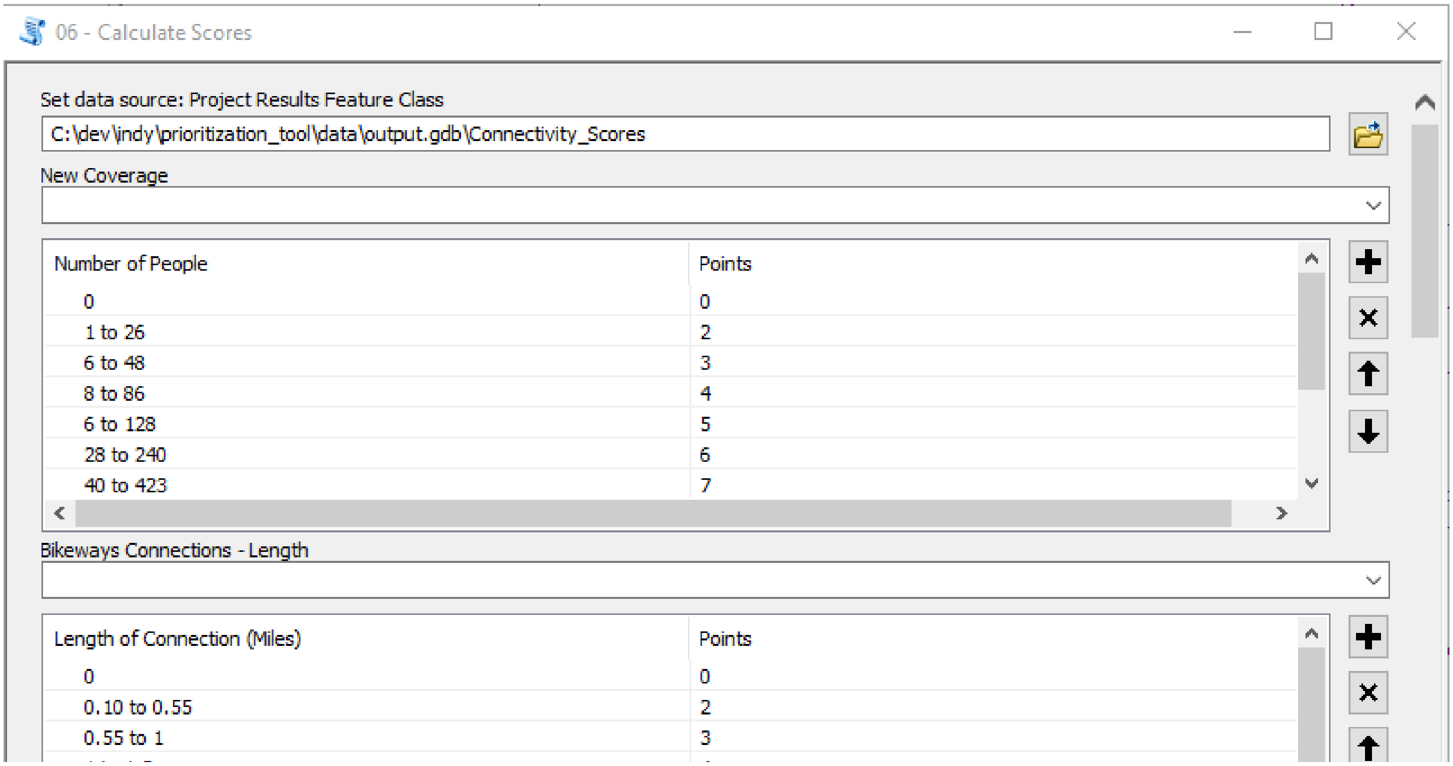
The Final Scores tool compiles an aggregate score for all categories in the prioritization methodology.



This tool takes many inputs. There is a parameter for each of the Results layers created by the toolboxes for each category. There are also parameters corresponding to each value and score combination for each category.



The tool aggregates the scores from each category and saves the results into a new output in the output.gdb. The output contains all the values and scores for each measure, as well as the aggregate prioritization score.




```
bikeways_length_list = zip(
    [
        '0',
        '0.10 to 0.55',
        '0.55 to 1',
        '1 to 1.5',
        '1.5 to 2.3',
        '2.3 to 3.3',
        '3.3 to 5.1',
        '5.1 to 8.2',
        '8.2 to 13.7',
        '13.7+'
    ],
    [0]+range(2,11)
)
bikeways_gaps_list = zip(['0', '1', '2', '3+'], [0,2,4,5])
existing_stops_list = zip(['0', '1', '2', '3', '4 to 5', '6+'], range(6))
proposed_stops_list = zip(['0 to 1', '2 to 4', '5 to 8', '8 to 13', '13+'], range(1,6
hard_barriers_list = zip(['0', '1', '2', '3 to 4', '5+'], [0]+range(1,6))
soft_barriers_list = zip(['0', '1', '2', '3 to 4', '5+'], range(5))
```

Bike Plan Scoring Criteria Methodology

In general, thresholds were assessed using quantile breaks in GIS, meaning each threshold has roughly the same number of values. This does not apply to the Regionalism criteria.

Regionalism (45 Points Max)

Arterial Bikeway System

Based on a hierarchy of the Arterial Bikeway System. Facilities and routes were designated by MPO staff assessing population and economic activity along both existing and proposed facilities, the length of the facility, and how it connects to other higher-level facilities. These routes only include existing routes and those proposed in community plans or the 2015 Regional Bikeways Plan. The source of this data is a custom shapefile created by MPO staff.

Level 1: 30 points

Example: Monon, Pennsy, Ronald Eagan Parkway, and US-31 facilities

Level 2: 20 points

Example: White Lick Creek, 146th Street, SR-135, and Pleasant Run facilities

Level 3: 10 points

Example: Gray Road Side Path, N CR 100E (Hendricks County), and Buck Creek facilities

Level 0: 0 Points

Other routes with insufficient length, activity, or connectivity

Multijurisdictional

Facility connects two or more municipal jurisdictions. The source of this data is the 2010 Census Places shapefile.

2+ Jurisdictions Connected: 15 points

Economic Opportunity (30 Points Max)

Population

Number of people within one mile of a facility, divided by project length. Based on 2016 American Community Survey Block Group data.

Values	Score
1 to 1401	1
1402 to 3221	2
3222 to 5620	3
5621 to 8663	4
8664 to 13199	5
13200 to 23677	6
23678+	7

Employment

Number of jobs within one mile of a facility, divided by project length. Based on 2018 InfoUSA Employment point data.

Values	Score
1 to 211	1
212 to 1041	2
1042 to 3362	3
3363 to 8232	4
8233+	5

Education

Number of primary through post-secondary schools, including trade schools, within one mile of a facility, divided by project length. The source of this data is based on 2018 InfoUSA point data.

Values	Score
0	0
1 to 3	1
4 to 7	2
8 to 17	3
18+	4

Arts, Culture, and Recreation

Number of parks, museums, and other recreational opportunities within one mile of a facility, divided by project length. The source of this data is based on 2018 InfoUSA point data.

Values	Score
0	0
1 to 4	1
5 to 8	2
9 to 13	3
14 to 27	4
28 to 52	5
53+	6

Restaurants and Shopping

Restaurants and Shopping: Number of restaurants and stores within one mile of a facility, divided by project length. The source of this data is based on 2018 InfoUSA point data.

Values	Score
0	0
1 to 5	1
6 to 17	2
18 to 43	3
44+	4

Libraries

Number of libraries within one mile of a facility, divided by project length. The source of this data is based on 2018 InfoUSA point data.

Values	Score
0	0
1	1
2	2
3 to 4	3
5+	4

Connectivity (48 Points Max)

Bikeway Network Extension

New length of connected network and number of new connections to existing bikeways. Based on the existing and proposed bike facility shapefiles.

Length of Connection (ft)

Values	Score
0 to 527 0	0
528 to 2640	1
2641 to 5808	2
95809 to 8659	3
8660 to 13200	4
13201 to 26083	5
26084 to 56918	6
56919+	7

Gaps Addressed

Values	Score
0	0
1	2
2	4
3	6
4+	8

New Coverage

New access to population that is not already served by existing bikeway infrastructure within one mile of the proposed facility, normalized by project length. This data is based on proposed and existing facilities and population from 2016 American Community Survey Block Group data.

Values	Score
0	0
1 to 11	1
12 to 32	2
33 to 52	3
53 to 72	4
73 to 93	5
94 to 113	6
114 to 144	7
145 to 210	8
211 to 321	9
322 to 565	10
566+	11

Transit Connections

Number of connections to existing and proposed fixed-route transit stops within one mile of the proposed facility, normalized by project length. This data is based on existing and proposed transit stops from the region's transit providers and does not include on-demand or paratransit.

Existing Transit Connections (existing stops)

Values	Score
0	0
1 to 3	2
4 to 8	3
9 to 14	4
15 to 26	5
27+	6

Proposed Transit Connections (proposed stops)

Values	Score
0 to 1	0
2	1
3	2
4	3
5+	4

Barriers

Number of hard barriers (rivers and interstates) and soft barriers (major arterials or collectors) crossed within one mile of the proposed facility, normalized by project length. This data is sourced from rivers, interstates, and INDOT functional class shapefiles.

Soft Barriers

Values	Score
0	0
1	1
2	2
3	3
4	4
5	5
6+	6

Hard Barriers

Values	Score
0	0
1	2
2	4
3	5
4+	6+

Equiy (27 Points Max)

Zero Car Households

Percentage of households without a car within one mile of proposed facility. This data is based on 2016 American Community Survey Block Group data.

Values	Score
0% to 0.01%	0
0.02% to 0.26%	1
0.27% to 0.68%	2
0.69% to 1%	3
1.01% to 1.6%	4
1.61%+	5

Households in Poverty

Percentage of households living in poverty within one mile of proposed facility. This data is based on 2016 American Community Survey Block Group data.

Values	Score
0% to 0.9%	0
1% to 3%	1
3.1% to 5.4%	2
5.5% to 8.6%	3
8.7% to 14.3%	4
14.4%+	5

Population Age 65 and Over

Population Age 65 and Over: Percentage of population age 65 and over within one mile of proposed facility. This data is based on 2016 American Community Survey Block Group data.

Values	Score
0% to 0.9%	0
1% to 11%	1
11.1%+	2

Population Age 18 and Under

Percentage of population age 18 and under within one mile of proposed facility. This data is based on 2016 American Community Survey Block Group data.

Values	Score
0% to 0.9%	0
1% to 26%	1
26.1%+	2

Minority Population

Percentage of non-white population within one mile of proposed facility. This data is based on 2016 American Community Survey Block Group data.

Values	Score
0% to 0.9%	0
1% to 5.6%	1
5.7% to 10.9%	2
11% to 18%	3
18.1%+	4

Access to Healthcare

Number of clinics, dentists, hospitals, etc. within one mile of proposed facility, normalized by project length. This data is based on 2018 InfoUSA point data.

Values	Score
0	0
1 to 8	1
9 to 29	2
30+	3

Food Access

Number of grocery and convenience stores within one mile of proposed facility, normalized by project length. This data is based on 2018 InfoUSA point data.

Values	Score
0	0
1	1
2	2
3 to 4	3
5 to 7	4
8 to 13	5
14+ to 6	6

Appendix C: Amendment Process

Upon adoption of the Prioritization Funding process by the Indianapolis Regional Transportation Council, there will be an amendment process every two years and regional bikeways plan update approximately every four years.

Two-Year Amendment

LPAs will be asked to provide updated information on previously proposed projects they have completed since the last regional bikeways plan and any new projects they want to complete in the future.

Regional Bikeways Plan Update

Will have the same provisions of the Two-Year Amendment in addition to a public input process to confirm or update the prioritization scoring criteria.

Appendix D: Future Count Program Memo / Documentation

BICYCLE COUNT PROGRAM GUIDANCE MANUAL

Bicycle Count Program Guidance Manual for the Indianapolis Metropolitan Planning Organization

February, 2020

CONTENTS

CHAPTER 1: INTRODUCTION

OVERVIEW

Bicycle location-count and volume data support resource prioritization, facility design decisions, safety analysis, and trend monitoring. At a system level, usage data also shed light on the overall quality of bicycle infrastructure and accommodations and whether investments are resulting in increased bicycling. The growing emphasis on performance-based planning and accountability further strengthens the case for better metrics related to bicycling, which require accurate and reliable underlying data.

The Bicycle Count Program Guidance Manual (the Manual) was developed as part of a broader effort to update the Indianapolis Metropolitan Planning Organization's (IMPO) Regional Bikeways Plan. As part of that project, the IMPO considered how it should use bicycle volume data to support bicycle facility planning and implementation in Central Indiana. Other key project activities included:

- Surveying agencies and reviewing adopted plans from across Central Indiana to understand the current collection and use of bicycle volume data
- Developing objectives for the regional bicycle count program
- Consolidating previously-collected data from across the region and uploading this data into a centralized data management platform
- Developing an implementation plan
- Installing pilot short-duration bicycle and pedestrian counters

The IMPO is developing its bicycle count program as the industry is quickly evolving. In particular, third-party data sources have emerged as a viable option for obtaining volume data at a large scale, potentially providing a comprehensive understanding of bicycle volumes that has not been possible in the past. As a result, conventional bicycle counts may shift from being the primary data source for estimating volume to being used for validating other data sources. This document lays out a framework for using count data to serve as either a primary data source or to validate third-party data.

HOW TO USE THE MANUAL

The Manual describes the recommended processes for the IMPO and its member jurisdictions and agencies to follow for bicycle volume data collection and management. It is intended to serve as a resource for IMPO staff and for other agencies across the region that may collect such data, including local agencies and private organizations. The primary purpose of this Manual is to ensure that bicycle volume data is collected in a consistent and coordinated fashion, which will produce more useful data. Recommended practices for IMPO partner agencies do not constitute a mandate for these agencies but are offered as guidance. Agencies that follow the recommendations will benefit from greater consistency with other jurisdictions and enhanced data management and analysis capabilities.

The Manual includes the following Chapters:

- **Chapter 1. Introduction**: a review of the Manual's key terms, the IMPO's count experience, and the bicycle count program's objectives.
- **Chapter 2. Bicycle Counting Fundamentals**: an overview of the two primary types of bicycle counts, data quality control approaches, application of factoring techniques, and generation of annualized bicycle volume estimates.
- **Chapter 3. Methods**: processes for using volume data to evaluate investments, validating third-party data sources, and developing bicycle crash rates.
- **Chapter 4. Implementation**: in-depth guidance for selecting count locations, counter technologies, data collection quality assurance; working with the MS2 Nonmotorized Database System (NMDS); and, developing factor groups and adjustment factors.
- **Chapter 5. Pilot Program Installation and Assessment:** recommendations for the pilot counters' locations, counter technology, and evaluation approaches.
- **Chapter 6. Appendix A:** a resource guide for counter technologies, and factoring, calibration, and validation approaches.
- **Chapter 7. Appendix B:** the Bicycle Count Program Objectives Memorandum.

GLOSSARY

ADJUSTMENT FACTORS: Calculations used to estimate annual volume from short-duration counts. Factors are derived from permanent (year-round) counter data.

ANNUAL AVERAGE DAILY BICYCLE TRAFFIC (AADBT): The daily total volume of bicycle traffic at a specific location averaged across a count year. [1]

BMT: Bicycle miles traveled

CALIBRATION: Adjusting the sensitivity of an automated counter (e.g., inductive loops or pneumatic tubes) to reduce under or over counting.

DAF: Daily adjustment factor

DIVERSION: Undercounting caused by bicyclists avoiding a detection zone.

FACTOR GROUP: A set of locations with similar hour-of-day, day-of-week, and seasonal bicycling activity patterns.

FACTOR GROUP REFERENCE SITE: Location with a permanent counter installed that establishes the adjustment factors for a factor group

HAF: Hourly adjustment factor

MADT: Monthly Average Daily Traffic

MAF: Monthly adjustment factor

MS2 NONMOTORIZED DATABASE SYSTEM (NMDS): MS2's platform for storing nonmotorized volume data. This platform serves as the IMPO's primary nonmotorized volume data warehouse.

MS2 TURNING MOVEMENT COUNT MODULE (TMC): MS2's platform for storing turning movement or intersection data, including pedestrian and bicycle volume data. This platform is used by the IMPO to store nonmotorized intersection volume data and data stored in the TMC can be accessed via the NMDS.

OCCLUSION: Undercounting caused by certain technologies' inability to sense when two people are bicycling side-by-side.

PERMANENT AUTOMATED COUNTERS: Counters installed at fixed locations that continuously monitor traffic, with the primary goal of understanding time-related activity patterns.

PMT: Pedestrian miles traveled

PROBE DATA: Data that is generated by monitoring the position of individual vehicles (i.e., probes) over space and time rather than measuring characteristics of vehicles or groups of vehicles at a specific place and time. [2]

SHORT-DURATION COUNT (SDC): Counts conducted over a limited duration, often between two hours and two weeks, with the primary goal of increasing the spatial coverage of the monitoring program.

TMAS: Federal Highway Administration's Travel Monitoring Analysis System

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1. Federal Highway Administration. "Traffic Monitoring Guide." 2016, https://www.fhwa.dot.gov/policyinformation/tmguide/.
2. https://ops.fhwa.dot.gov/wz/resources/publications/fhwahop13043/ch2.htm

THE IMPO'S COUNT EXPERIENCE

The IMPO previously collected bicycle and pedestrian volume data and managed bicycle and pedestrian counters for use across the region. Unfortunately, the IMPO's bicycle and pedestrian counters were stolen, which, along with competing demands for staff time, led to the end of its bicycle and pedestrian count program. While the IMPO does not currently monitor bicycle or pedestrian volumes on a routine basis, the IMPO is interested in partnering with local jurisdictions and partner agencies to collect, manage, and share bicycle volume data collected through counters, bikeshare systems, and GPS data sources.

The IMPO does collect and coordinate the collection of traffic counts across the region. The IMPO shares the traffic counts with the Indiana Department of Transportation (INDOT), who in turn makes the counts publicly available through the MS2 Traffic Count Database System (TCDS). The TCDS' online interface includes an interactive map and data search tools.[3]

In 2015, the IMPO participated in a Federal Highway Administration (FHWA) one-year pilot project intended to increase the capacity for Metropolitan Planning Organizations (MPOs) to collect and use nonmotorized data.[4] FHWA worked with 10 large MPOs, including the IMPO, to identify count locations, install counters, and collect and use the data. The MPOs were given seed funding to develop bicycle and pedestrian count programs and technical assistance to support their programs via a series of webinars and support on an email listserv. Each of the webinars were recorded and are available on the Pedestrian and Bicycle Information Center website.[5]

A final report was also published detailing the MPOs' experiences with collecting count data. The project resulted in a number of 'lessons learned' for MPOs in developing count programs, which are summarized below:

- Ensure sufficient staff time and resources are available for count programs
- Involve partners in all steps of establishing and running a count program
- Select count technology best suited to identified locations
- Validate automatic count data with manual spot checks

This document will build on the IMPO's counting experiences and the lessons learned in the 2015 pilot program.

BICYCLE COUNT PROGRAM OBJECTIVES

The bicycle count program's objectives will guide the implementation of counters, selection of new counters, data management approaches, and analysis. Additionally, the program objectives will have bearing on what outcomes can be measured, expected benefits to the IMPO's broader bicycle program, and how resources can be shared with local bicycle count programs. The IMPO bicycle count program's objectives are to:

» Develop performance measures to evaluate IRTIP investments
» Validate third-party data sources
» Develop facility-specific bicycle crash rates

The IMPO's bicycle count program's objectives were developed based on a review of related plans and policies; current bicycle data collection efforts within the Central Indiana region; and the IMPO's counting experience,

3. Indianapolis MPO. Traffic Counts. Retrieved March 20, 2019, from www.indympo.org/maps-resources/maps/traffic-counts.
4. Federal Highway Administration. "Bicycle-Pedestrian Count Technology Pilot Project: Summary Report." U.S. Department of Transportation, Washington, DC, December 2016.
5. Pedestrian and Bicycle Information Center. Counts Pilot Program. http://www.pedbikeinfo.org/planning/tools_counts_pilot_program.cfm

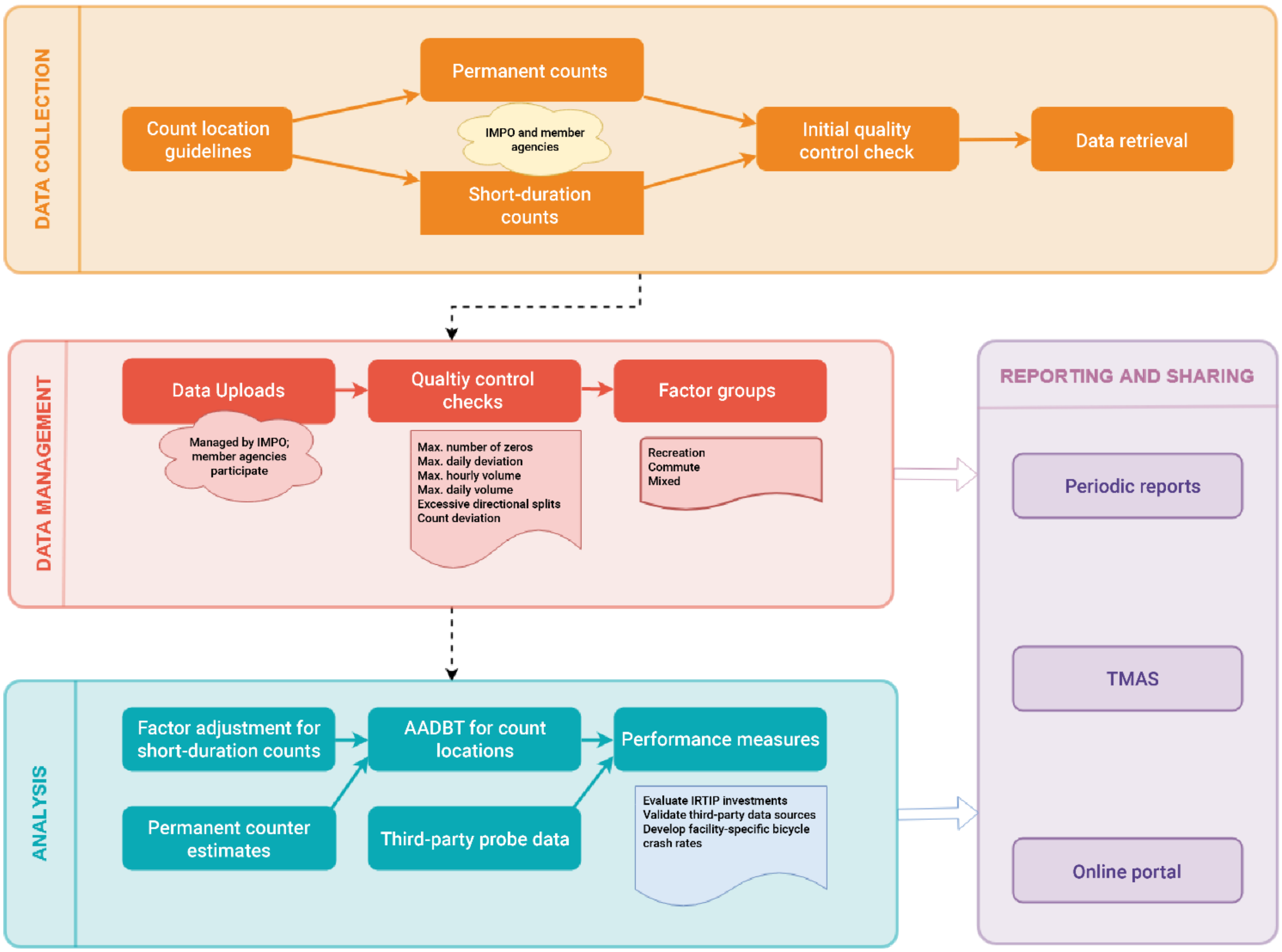
capabilities, staffing, and funding resources. Additionally, IMPO staff provided direction on their desired count program outcomes and local partnership opportunities. For more information on each objective's rationale, considerations, and data needs, see the ***Bicycle Count Program Objectives Memorandum*** in Appendix B.

CHAPTER 2: BICYCLE COUNTING FUNDAMENTALS

BICYCLE COUNTING FUNDAMENTALS

Bicycle count programs include a series of related processes, which are shown in ***Figure 1***. They include: 1) data collection, 2) data management, 3) analysis, and 4) reporting and sharing. Since the IMPO program is in the early stages of development and the field of bicycle volume data collection is evolving quickly, some aspects are further developed than others, and the structure may need to be updated over time.

Figure 1. The IMPO Bicycle Volume Program Structure



DATA COLLECTION

Bicycle count programs typically involve a combination of permanent automated counts and routine short-duration counts. Additional counts may be conducted on an as-needed basis. This section describes how each approach contributes to a comprehensive bicycle count program.

Permanent counts

Permanent automated counters are installed at fixed locations and continuously monitor bicycle traffic. Their primary function is to understand the temporal variations in bicycle activity at a given location. The continuous data provided by permanent counters can be used to understand how levels of bicycling are influenced by the season, day of the week, time of day, temperature, special events, or other factors. Such analyses can be conducted with continuous data from at least one year of counting. Moreover, the patterns identified from permanent counters serve as the basis for developing adjustment factors. Data from several permanent counters can be used in combination to identify trends over time.

Short-Duration Automated Counts

Short-duration counts (SDCs) are conducted for limited durations, typically between two hours and two weeks, and may be performed manually or with automated equipment. The primary function of SDCs is to expand the geographic coverage of a count program. Volume data provided by SDCs can be extrapolated to develop annual estimates using factors identified from permanent counters within the same factor group. Additional discussion on the use of factor groups is provided under ***Factoring*** below.

Many organizations begin monitoring bicycle traffic using SDCs exclusively, often collecting the data manually in an informal manner. Manual SDCs provide a low-cost way to begin counting bicyclists, and to collect behavioral and demographic data that is difficult or impossible to obtain through automated counting technologies. However, manual SDCs have significant limitations due to the extremely short counting interval, and they require significant staff or volunteer time to enter and manage data.

In recent years, many organizations have increased their use of automated SDCs. Automated SDCs often cover a longer period of time than manual counts, resulting in a richer dataset. Additionally, many automated count equipment vendors offer methods for downloading count data remotely and storing and analyzing the data online. Short-duration automated counts are most effective when they are implemented as part of a systematic program that involves rotating the counters across a set of locations over a given time interval, such as every three years. However, as-needed counts performed in response to stakeholder requests or planning needs (e.g., to observe patterns before or after new projects are implemented, or at high-crash locations) are an important element of a comprehensive bicycle count program. As-needed counts can be performed manually or using SDC automated counters.

DATA MANAGEMENT

Quality Control

Raw bicycle count data may need to be adjusted before they can be reliably used. Generally, there are two types of errors that occur when automated counters are used to collect data – corrupted data and systematic undercounting.

Corrupted Data

There are several causes of corrupted data, including equipment malfunctions due to a problem with the equipment itself, improper installations, or subsequent damage or vandalism to the equipment after installation. External events that cause the sensor to either count too few or too many people are another type of error. For instance, plowed snow may cover the sensor for an infrared counter.

Adjustments to the data, such as by substituting count data from a similar time period or from a counter within the same factor group, can address many of these problems, but should be clearly noted on any subsequent reports or analyses. Quality control checks or visual inspection of count data results can help identify where data should be adjusted. Possible QC rules include:

- » Check for a maximum consecutive number of 0 values in the data, such as 48 hours
- » Check for a maximum percentage deviation between sequentially recorded ADT values at a given site (note that this rule does not work well for low-volume sites and should be reserved for sites with an average of at least 100 users per day)
- » Check for a maximum hourly volume

- Check for a maximum ADT
- Check for excessive daily directional splits (i.e., difference between the two directions of traffic)
- Check for count value deviations from a specified "normal" range, such as a specified multiple of the interquartile range for the count period[6]

Some errors cannot be compensated for, such as if there are extended periods of corrupted or lost data. Routine data downloads are particularly important to minimize the risk of data loss under such circumstances.

Systematic Undercounting

Systematic undercounting occurs almost uniformly across all devices and is inherent in many automated counting technologies. Occlusion is the most common problem and is caused by the inability of certain technologies to sense when two people are walking or bicycling side-by-side. In this case, the device will register just one person. Another source of error is diversion, which occurs when bicyclists detour or deviate around a detection zone.

Routine calibration of counters will allow for adjustments to be made to correct for known systematic errors. The most basic form of calibration involves conducting a manual count when a counter is installed, comparing the manual count total with the total reported by the counter, and using the comparison to determine a calibration factor. Permanent count sites should be calibrated on a routine basis, such as when data is collected in the field, or counters are serviced for another purpose. More advanced calibration methods may attempt to account for calibration factors that vary according to observed volume, time of day, or other factors.

Factoring

Factor groups are sets of locations with similar activity patterns. Permanent count locations are grouped together to calculate adjustment factors, which in turn are applied to short-duration count locations that are thought to follow the same "peaking" patterns in terms of how traffic is distributed throughout the day, week, and year. While bicycle factor grouping is still an active area of research, patterns are typically presumed to be associated with surrounding land uses, climatic region, and facility types. For example, counters placed along bike lanes in Downtown Indianapolis and commuter bike routes in Fishers and Carmel may be placed within one factor group, while counters placed along recreational paths in parks around the region might belong to a different factor group. The use of recreational, commuting, and mixed factor groups is a common approach that is relatively easy to employ and accounts for many sites.

Factor Groups

Development of IMPO-specific factor groups and associated adjustment factors is an iterative process that will evolve over time as more data is collected and evaluated. As a starting point, the IMPO will categorize sites into three groups, according to their activity patterns. Activity patterns identified from collected data will indicate whether the site is characterized by recreation, commute, or mixed trip types. More specifically, the following metrics are used to determine the activity pattern of a given site.[7]

- **Hour-of-day**: *AM peak-to-midday index (AMI)*. The average hourly volume during weekday morning commute periods (7am to 9am) divided by the average midday volume (11am to 1pm).
- **Day-of-week**: *Weekend-to-weekday index (WWI)*. The average weekday volume divided by the average weekend volume.

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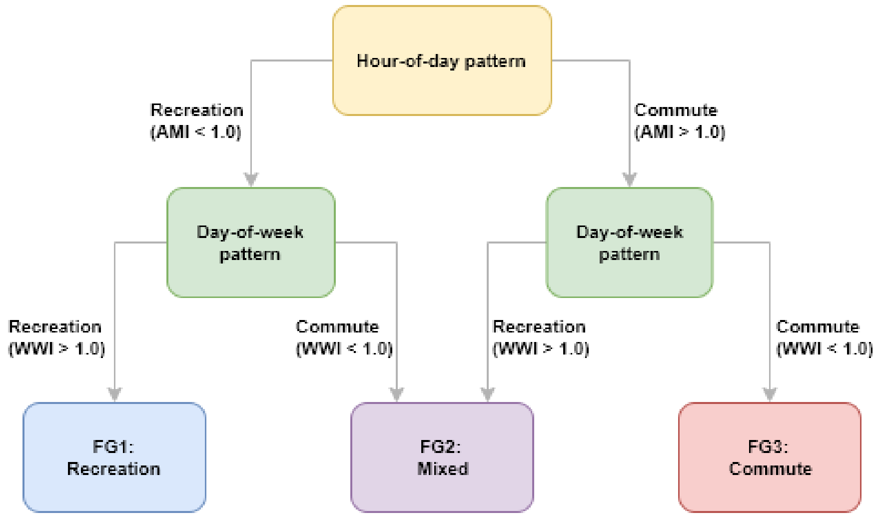
6. Turner, S., and Lasley, P. Quality Counts for Pedestrians and Bicyclists: Quality Assurance Procedures for Nonmotorized Traffic Count Data. Transportation Research Record, Vol. 2339 No. 1, 2013, pp. 57–67.
7. Miranda-Moreno, L.F., T. Nosal, R.J. Schneider, and F. Proulx. Classification of Bicycle Traffic Patterns in Five North American Cities. In Transportation Research Record: Journal of the Transportation Research Board, No. 2339. Transportation Research Board of the National Academies, Washington, D.C., 2013, pp. 68–79

The combination of hour-of-day and day-of-week metrics suggests an overall activity pattern for the site. The specific thresholds for 'commute' and 'recreation' activity patterns should be defined based on a review of data collected from several sites. Initial suggested thresholds are offered in Figure 2.

Figure 2. Factor Group Assignment Process



In addition to reviewing the hour-of-day and day-of-week patterns, the IMPO may wish to consider seasonal variation in its factor groups. For sites with a full year of data, a seasonal distribution metric may be calculated as follows:

» **Seasonal distribution:** *Warm Month Index*. The average daily count for the months of April through September divided by average daily count for the months of October through March for a given year.[8]

Including the seasonal distribution would introduce an additional layer to the factor group assignment process, resulting in a total of six factor groups (assuming two seasonal patterns are identified). Factor groups should be reevaluated annually. A detailed discussion on different methods to develop factor groups is provided in the ***Factoring Approaches*** section in Appendix A.

ANALYSIS

Adjustment Factors

The primary reason for establishing factor groups is to identify temporal patterns that can be used to develop estimates of Annual Average Daily Bicycle Traffic (AADBT) at locations where SDCs have been collected. The resulting adjustment factors are intended to account for differences in the underlying patterns at the count locations, or differences in when the counts were taken with respect to hour-of-day, day-of-week, and even seasonal changes. As factoring for nonmotorized traffic is an active area of research, the optimal method has not been determined. Two factoring approaches are provided in Appendix A, either of which would be appropriate for future use in the IMPO region. Ideally, the two methods should be compared to determine which one produces more reliable estimates and under what conditions.

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8. Nordback, K. (2019). Estimating Non-motorized Traffic Accurately: How Many Counters Do We Need? https://static1.squarespace.com/static/59480f9cc534a57e3a1b9f15/t/5b2aa0e42b6a28a0fc3cc763/1529520365914/Krista+Nordback_Estimating+Non-motorized+Traffic_How+Many+Counters+Do+We+Need.pdf

AADBT

The factoring process enables AADBT to be estimated based on a short-duration count. AADBT estimates represent the volume of bicycle traffic over an average 24-hour period at a specific location during a count year.[9] The IMPO can use AADBT estimates to monitor bicycling trends and patterns where short-duration or permanent counts have been conducted. AADBT is a desirable metric because it makes volumes observed at different locations consistent, even if they were taken at different times of year or if the underlying temporal patterns substantially differ.

AADBT estimates from individual locations can be used for a variety or reporting purposes. AADBT can be used to document changes in bicycling activity levels, identify high activity corridors and intersections, or calculate crash rates. AADBT estimates can also be used to develop Bicycle Miles Traveled (BMT) estimates. BMT estimates analyses require a significant amount of count data from carefully selected count locations.[10] The reliability of AADBT estimates derived from SDCs is closely tied to the length of the SDC period, the number of automated counters feeding into the factor groups, and the location of the counters.

REPORTING AND SHARING

Reporting and sharing data across the IMPO and with stakeholders, elected officials, and other decisionmakers is a key reason for developing and implementing a bicycle count program.

Reporting

Reporting refers to the process of communicating or transferring the results of the nonmotorized volume program to internal and external audiences. There are two main types of reports recommended: periodic reports and TMAS uploads.

Periodic reports

Periodic reports on an annual or biannual basis help organize the efforts of the count program and communicate the program's findings to the public. The reports should focus on the program performance measures and may also highlight programmatic activities such as counter acquisition and installation, software feature upgrades, or innovative uses of the data beyond the program itself. Developing a program report for the first time may require a significant effort, but should be considerably less time-intensive to update in subsequent years. Several MPOs in the Ohio-Kentucky-Indiana region regularly release such reports.The report should be targeted toward a general audience consisting of local agencies, bicycling and walking organizations, and IMPO committees and staff.

FHWA Travel Monitoring Analysis System

The Federal Highway Administration's (FHWA's) Travel Monitoring Analysis System (TMAS) provides a way for states and other counting agencies to submit data to FHWA through an online portal. TMAS recently began accepting uploads of bicycle count data, though few agencies have been successful in doing so. MS2's NMDS is expected to provide an option to export data in the TMAS format to facilitate uploading.

Data Sharing

There are a variety of ways the data might be shared, and the IMPO will need to consider how to best share bicycle data with a broad group of potential users, including local agencies, IMPO committees and staff, researchers, advocacy organizations, developers, and members of the public.

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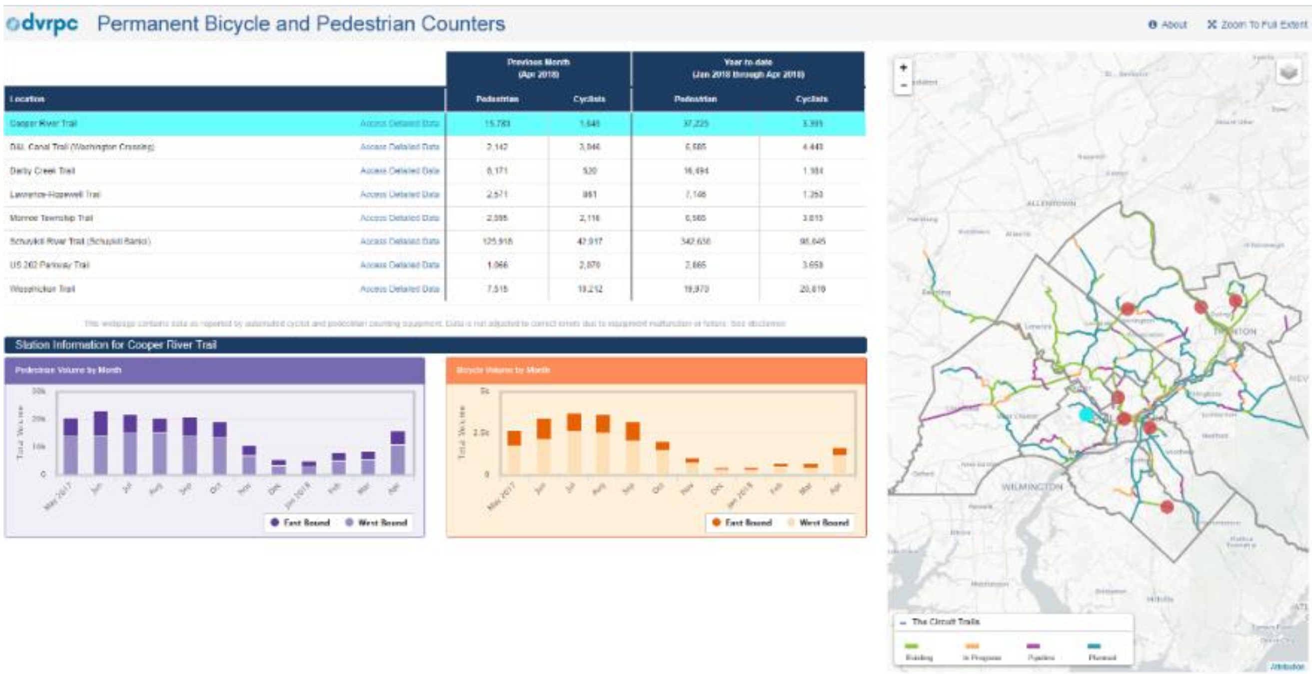
9. Federal Highway Administration. "Traffic Monitoring Guide." 2016, https://www.fhwa.dot.gov/policyinformation/tmguide/.
10. Washington State Department of Transportation, K. Nordback, and M. Sellinger. "Methods for Estimating Bicycling and Walking in Washington State." 2014.

From the perspective of a non-IMPO user, the most accessible method may be to post the data on a website. The Delaware Valley Regional Planning Commission's (DVRPC) pedestrian and bicycle count portal is an example of a very robust web portal for pedestrian and bicycle count data. The portal provides AADBT estimates for count locations throughout the DVRPC region as well as the underlying short duration count data, including counts by day and hour. Users can access the data through an interactive map or download it through a link to the DVRPC's ArcGIS server. In addition to sharing data with others, an online portal might also be used to store manual count data.[11]

Figure 3. DVRPC Travel Monitoring Pedestrian and Bicycle Counts



As the program grows and additional local agencies begin to collect count data, the IMPO may decide to use a third-party data management and sharing service, such as MS2. Use of an accessible data management platform for external users will benefit the IMPO in the long-term and will improve the ease of sharing AADBT among its member agencies.

Public-Facing Real Time Displays

The IMPO may also wish to consider partnering with local jurisdictions or park departments to install public-facing real time displays at automated count locations. Such displays can encourage bicycling by letting bicyclists know they count and by conveying to other roadway users that bicyclists are welcome and expected. Public-facing real time displays are most appropriate in high-profile locations that already have significant bicycle volumes.

The most common public facing real-time display is the Eco-DISPLAY Classic (formerly Eco-TOTEM). The Eco-Display can be set up to only count cyclists with loops, or it can be configured to count cyclists and pedestrians using loops and passive infrared. Eco Display is also fully customizable and can display counts, journey times, or safety messages.

11. Miami Valley Regional Planning Commission. "Miami Valley Bikeway Count program Summary." 2017, https://www.mvrpc.org/sites/default/files/bikeway_counting_program_summary.pdf

CHAPTER 3: METHODS

As discussed above in the ***Bicycle Count Program Objectives*** section, the three objectives of evaluating IRTIP investments, validating third-party data sources, and developing facility-specific bicycle crash rates will inform and be measured by the programs' performance measures. This section reviews possible data collection approaches and methods to monitor the IMPO's progress towards the objectives.

PERFORMANCE MEASURES TO EVALUATE IRTIP INVESTMENTS

Evaluating and tracking the impact of Indianapolis Regional Transportation Improvement Program (IRTIP) investments on bicycling behaviors in the IMPO region is a key motivator for the bicycle count program. As discussed in Appendix B, the IMPO determines how projects are selected and prioritized for several relevant funding sources, including Congestion Mitigation and Air Quality (CMAQ), Transportation Alternatives Program (TAP), and Surface Transportation Block Grant (STBG).

Understanding the impacts of the IMPO's infrastructure investments requires monitoring usage along CMAQ-, TAP-, and STBG-funded corridors. While the IMPO can expect to see different impacts from bicycle facility projects based on the facility type and local land use context, over time the IMPO can use the findings to compare the effectiveness of different investment decisions, and to evaluate the likely impact of future funding proposals.

The IMPO can take immediate steps by working with communities on IRTIP-awarded projects to collect "before" bicycle volume data on key upcoming bicycle facility projects, and "after" counts on high-profile, recently completed projects. After data from recently completed projects without before data is still useful for benchmarking purposes, and in some cases third-party data can be used to generate before data estimates. After data collection should be collected at regular intervals immediately following the project's opening, 6 months after, 1 year after, and 2 years after the project's completion. It is equally important to collect volume immediately after a project's opening, and in the following two years as it can take time for bicyclists to "find" updated facilities, and for behavior changes to take place.

In the long-term the IMPO can use a wide variety of before-and-after data to measure and track changes in bicycling ridership levels, vehicle speed, traffic volumes, traffic crashes, and economic activities at TIP project locations and along nearby key corridors. This level of analysis will require additional resources and encompasses a broader evaluation approach intended to track the wide-ranging impacts of IRTIP investments. By taking a broad approach, the IMPO can track the effects of IRTIP bicycle infrastructure investments on safety and economic activity.

AADBT BEFORE/AFTER INSTALLATION

Reliably demonstrating the impact of infrastructure investments on levels of bicycling can be more challenging and complex than it may initially seem. The IMPO will need to collect data over several years from permanent automated counters at high-profile project sites with substantial bicycle ridership to provide a baseline for comparison. Once the IMPO has established a baseline for comparison, it can then use data from short-duration automated counters to conduct before-and-after counts at project sites.

In the simplest case, bicycle volumes may be measured before and after a facility is constructed. Estimates should be converted to AADBT for comparison, according to the appropriate factoring method for the site, to account for seasonal variations in the volumes that could obscure the effects of the facility. This analysis will answer the question of how many people were attracted to the new facility, but does not necessarily indicate how many more people chose to bicycle or walk because of the new facility. Some of the observed "new" trips may in fact be rerouted trips that would have otherwise been made on different facilities. This does not reduce the benefits associated with the new facility but could lead to an overstatement of its impact on levels of bicycling or walking. To assess the impact of a new facility at a local network level an Advanced Approach is recommended.

Advanced Approach

To determine whether a new facility increased use, a more complex analysis is required. This would involve conducting counts on parallel facilities to control for potential rerouting in response to the new facility, or reviewing third-party data sources for a similar purpose. Counts from within a quarter-mile radius of the new facility corridor should be considered in this approach. When analyzing the impact of new facilities at a larger scale, such as for a high-profile project, a wider count shed would be appropriate for determining its impact on bicycling or walking activity levels across a community's network.

QUALITATIVE INTERCEPT SURVEYS

Count data cannot identify motivations behind changes in trips nor demographic information. To collect this data, the IMPO will need to use qualitative intercept surveys and other surveying approaches. Qualitative intercept surveys are conducted along facilities of interest and allow counting agencies an insight into users' identities and motivations. In particular, qualitative surveys can help counting agencies understand user motivations and profiles along new bicycle facilities. Asking users where they had traveled from to get to the new facility, and whether they would have otherwise made the trip along a different bicycle facility or by a different mode helps counting agencies answer difficult counting questions and set counting shed distances.

As with other surveying approaches, intercept surveys are limited to surveying biases and the willingness of bicyclists to participate in the survey. To increase the survey's success, the IMPO should limit the length (time to complete the survey), and complexity of the survey. Surveys should focus on only the most important questions. Additionally, pairing the survey with other programming – such as a Bike to Work Day or bike light giveaways – will encourage participation in the survey.

THIRD-PARTY PROBE DATA

Third-party probe data is quickly emerging as an important element of traffic monitoring approaches, including for bicycle volume monitoring. According to FHWA, "probe data is defined as data that is generated by monitoring the position of individual vehicles (i.e., probes) over space and time rather than measuring characteristics of vehicles or groups of vehicles at a specific place and time." Probe data can work in tandem with count data, providing a more comprehensive understanding of bicycle volume throughout the network, and as a reference source for rough volume estimates when before counts were not conducted (assuming no changes in conditions or bicycle volumes). Additionally, probe data can be used to generate volume estimates along well-counted roads as the collected count data can be used to validate and calibrate the probe data. Leveraging probe data in this way will allow the IMPO to expand its count database by "freeing up" counters for new un-counted locations.

Possible sources for bicycle probe data include volunteered GPS trace data from users of a specific mobile app such as Strava; GPS trace data associated with a particular mobility device such as a bikeshare bicycle; data from other location-based services; cellular phone traces, or Bluetooth readers. Probe data ultimately holds significant potential for helping the IMPO understand bicycling patterns and to calculate the above discussed performance measures.

VALIDATING THIRD-PARTY DATA SOURCES

As noted previously, third-party probe data sources are an important emerging source of volume data for all modes of transportation, including bicyclists and pedestrians. Eventually, calibration and validation of third-party probe datasets may become the primary function of the IMPO nonmotorized count program.

The data collection, management, and analysis processes associated with probe data vary greatly from conventional count data. Perhaps most importantly, probe data are not collected at a single point, and thus the data model for probe data vs. count data is fundamentally different. Additionally, probe data is more likely to be provided by vendors as a turnkey solution, where public agencies are data consumers, but are not directly involved in the data collection or management process (some types of count data operate similarly). A method for determining the accuracy of third-party data is needed. As such, this section outlines an approach for using count data to determine the accuracy of third-party data. As there are many third-party data providers and available datasets are rapidly evolving, the approach is intended to be vendor-neutral. Slight modifications may be needed depending on how the data is obtained and provided to the IMPO.

UNDERSTANDING THIRD-PARTY PROBE DATA SOURCES

Before discussing calibration and validation of third-party probe data sources, it is worth noting how these datasets are collected and processed. In general, probe data is obtained from smartphone users or from fleet vehicle systems (e.g., bikeshare systems). GPS traces, location-based services, and cellular network data may serve as the basis for third-party probe data. In some cases (e.g., Strava), users must “opt-in” by using a specific application, whereas in others (e.g., Streetlight, Streetlytics, Sidewalk Labs), location data is provided without the need for users to opt-in (other than generally enabling location-based services). The latter provide a much less biased dataset, though smartphone availability and use remain as sources of bias, even though opting-in is not required.

For opt-in datasets, classifying bike trips is relatively straightforward: app users indicate the beginning and ending of their bike trips directly in the app and GPS trace data is recorded. There is a potential for error in this case if users do not accurately indicate their trip ends. The extent of this type of error is unknown, including whether erroneous trips may be filtered out by the application provider.

For vendors that do not follow the opt-in model, classification of bicycle and pedestrian trips is considerably more complex. These trips must be identified based on characteristics such as facility type, acceleration, and other factors. Several of the vendors use a Machine Learning algorithm to identify which pings are most likely to be associated with a given mode, based on comparisons with pings where the mode is known. Once the mode is predicted, they assign a sequence of pings to a trip and to the corresponding mode.

Mode and trip classification algorithms have inaccuracies that may vary over time and space. Factors such as smartphone and app use, traffic conditions, signal interference, and facility type may have bearing on how well bicycle or pedestrian trips may be identified from probe data sources. Understanding and quantifying this error is important to determining the usefulness of this data.

CALIBRATION AND VALIDATION APPROACHES

Calibration and validation of third-party data sources are separate, but related processes that are essential to determining whether third-party data meets the IMPO’s business needs. There are few published examples of agencies calibrating and validating third-party bicycle and pedestrian probe data sources. However, travel demand model literature provides a useful reference for identifying appropriate calibration and validation processes. In this context, calibration and validation may be defined as follows:[12]

» **Calibration**: the adjustment of constants in estimated or asserted models to make the models replicate observed data for a base (calibration) year or otherwise produce more reasonable results. Model calibration is often incorrectly considered to be model validation.

» **Validation**: the application of the calibrated models and comparison of the results against observed data. Ideally, the observed data are not used for the model estimation or calibration but, practically, this is not always feasible.

Calibration

Calibration of third-party data sources is critical, as these data sources only represent a portion of the traveling public, and thus their activity estimates or scores are not intended to be representative of the entire public (unless the vendor has a process for calibrating their own estimates to match directly observed ground-truth data). Instead, they are expected to provide estimates that offer insight into relative volumes, such as between two segments in the same area. Third-party activity estimates need to be compared to ground-truth data to identify a calibration factor that scales the estimate so that it is consistent with verified use.

In general, the processes for model calibration defined here would produce equations based on observed counts and third-party estimates at a subset of locations (intersections/segments) that could in turn be used to estimate total volumes at all locations for which the third-party estimates are available, even if ground-truth counts are not available.

Calibration can be accomplished with varying degrees of complexity. Generally, more complex methods are expected to offer greater accuracy, but require more ground-truth data and are more resource-intensive to implement. Three possible approaches are presented in this Appendix A.

Validation

Whereas calibration is largely concerned with scaling third-party data sources to be comparable with ground-truth estimates, validation is needed to determine how reliable the data is and to identify potential problems with third-party data sources. For example, the calibration approaches above may result in volume estimates that are reasonable on a large scale (e.g., predicting regional miles traveled), but that are not reliable on an individual segment basis or for a short period of time. These questions must be explored through data validation. The goal of validation is not necessarily to accept or reject a particular data source (though that is a possibility). Instead, the main purpose is to understand how third-party data can be used and when it should not be relied upon.

As suggested in the definition offered above, ground-truth validation of third-party data should use separate data from that used for calibration. Practically, this implies that data provided to a third-party vendor to calibrate their own estimates should not be used by the IMPO to validate those estimates, if avoidable. Assuming the count data has not already been used to calibrate the third-party estimates, one option for making use of limited data availability is “cross-validation”, where models are iteratively calibrated on a subset of the data and validated against the remaining observations.[13]

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12. Federal Highway Administration. The Travel Model Improvement Program: Travel Model Validation and Reasonableness Checking Manual: Second Edition. https://www.fhwa.dot.gov/planning/tmip/publications/other_reports/validation_and_reasonableness_2010/fhwahep10042.pdf
13. Scikit-learn: Machine Learning in Python, Pedregosa et al., JMLR 12, pp. 2825-2830, 2011. 3.1. Cross-validation: evaluating estimator performance. https://scikit-learn.org/stable/modules/cross_validation.html

Selecting and Using Count Data for Calibration and Validation

The count data used to calibrate and validate third-party data sources should be of the highest quality. Generally, permanent count data that have followed recommended quality control procedures are suitable for use in calibration and validation activities. Importantly, these counts are expected to have been calibrated to minimize equipment errors, to track pedestrians and bicyclists separately, and to record directional information. Short-duration automated counts may also be used in validation if they contain this information. The use of factored counts for validation is not preferred, but may be acceptable if limited permanent count data is available for validation.

DEVELOP BICYCLE CRASH RATES

Reduction of bicycle crashes is a high priority for the IMPO. Calculating crash rates (crashes/volume) is a useful way of determining which locations should be prioritized. For instance, two locations may have a similar overall number of crashes involving bicyclists, but substantially different levels of bicycling activity. In this case, the location with fewer bicyclists but a high number of crashes may indicate a significant safety problem that could be reduced by installing physical countermeasures.

Intersection crash rates are typically calculated by dividing the number of crashes by the number of bicyclists entering the intersection. Similarly, midblock crash rates can be determined by dividing the number of crashes by the midblock crossing volume. For segments, crash rates are determined by normalizing the number of crashes by bicycle-mile traveled (segment volume x length).

Going beyond calculating crash rates, bicycle volume data can be used to develop safety performance functions (SPFs) for bicycle crashes. SPFs are statistical models that relate observed crashes at intersections or along segments to volumes at these locations and other risk factors. They can be used to identify locations with a higher than expected number of crashes, based on volume and other factors. Additionally, by applying the Empirical Bayes method highlighted in the Highway Safety Manual, some of the difficulties in studying locations with low frequencies of crashes can be avoided.[14] Volume estimates across the full network are necessary to apply this method.

Calculating changes in pre- and post-construction crash rates can be a useful tool in measuring a project's impact on safety. Tracking crash rates requires bicycle volume and crash data to be collected prior to a project's construction and for several years following the project's completion. The use of bicycle volume data and generated AABDT estimates are essential for determining a project's overall safety impact, as bicycle facility improvements may lead to higher bicycling volumes in addition to changes in crash numbers. Additional discussion on how the IMPO can use AADBT estimates for high-crash locations is provided in the ***Action 6-3: Calculate bicycle crash rates at high-crash locations*** section.

14. American Association of State Highway Transportation Officials (AASHSTO). 2014.Highway Safety Manual. http://www.highwaysafetymanual.org/Pages/default.aspx.

CHAPTER 4: IMPLEMENTATION

COUNTER IMPLEMENTATION RECOMMENDATIONS

This section provides general recommendations related to the IMPO's bicycle count program design, count technologies, and integration of third-party probe data. The program is designed to be implemented in two general phases, which can be accelerated or extended based on available staffing, capital funding, and maintenance resources. The two general phases are:

- Phase 1 - The first phase (***Phase 1***) can take place over an initial three-year period, and primarily uses the existing count technology from local partners and the IMPO's staff resources, and limited new count equipment.
- Phase 2 - The second phase (***Phase 2***) can be implemented over an additional four-year period and continuing on into the future, and requires additional investments in counting and program management resources.

TECHNOLOGY

Regardless of the phase, the IMPO should implement technology that is appropriate based on the context and duration of the count. Some technologies are not capable of distinguishing bicyclists in certain contexts. For example, passive infrared sensors placed on a shared-use path will capture a combined pedestrian and bicyclist count and require supplemental count technology to identify bicycle volumes. Table 1 presents preferred and alternative count technologies for various settings and for both short-duration and permanent installations.

Table 1. Recommended Count Technologies by Context and Duration

Context	**Permanent**	**Short-Duration Automated**
Bicycles in Bike Lane	» Induction Loops » Piezoelectric Strips » Automated Video**	» Pneumatic Tubes » Automated Video**
*Bicycles in Mixed Traffic**	» Piezoelectric Strips » Automated Video**	» Pneumatic Tubes » Automated Video**
Bicycles on Multi-Use Trail (separate counts from pedestrian traffic)	» Passive Infrared + Induction Loops » Passive Infrared + Piezoelectric Strips » Automated Video**	» Passive Infrared + Pneumatic Tubes » Automated Video**
Bicycles on Multi-Use Trail (combined counts with pedestrian traffic)	» Passive Infrared » Active Infrared	» Passive Infrared » Active Infrared

*Bicycle volume data collection in mixed traffic conditions should be limited to low-volume sites with 5,000 ADT or less.

** Due to the proprietary nature and need for third party processing, the full accuracy and effectiveness of automated video for bicycle counts is still being tested.

Permanent Counters

The key technology requirements for automated permanent counts are that pedestrians and bicyclists can be counted separately, and that directionality is recorded. A full discussion on different counter technologies is provided in the ***Data Collection Technologies*** section in Appendix A. The following technologies are recommended for permanent automated counts:

» Intersection: Automated video
» Shared use path: Automated video, inductive loop and infrared combination, piezoelectric strip and infrared combination
» Bicycle lane: Inductive loop, piezoelectric strip, automated video

Short-Duration Counters

Automated SDCs are afforded greater flexibility with respect to counter technology than automated permanent counts. In particular, mode separation and directionality are not required for short-duration automated counts. Nevertheless, mode separation is strongly recommended, as bicycles and pedestrians have distinguishable activity patterns and should be factored separately. Again, a full discussion on different counter technologies is provided in the ***Data Collection Technologies*** section in the Appendix. The following technologies are recommended for short-duration automated counts:

» Intersection: Automated video
» Shared use path: Automated video, infrared combination, pneumatic tube
» Bicycle lane: Pneumatic tube, infrared

LOCATION GUIDELINES

Permanent Counters

One of the prime objectives in locating permanent count sites is "representativeness" – the degree to which count sites collectively represent the temporal patterns of the IMPO region's bicycling activity. To be representative, permanent count sites should be located across a variety of contexts. The most common contexts are urban, suburban, and rural, but additional context categories based on the mix and density of uses may also be worth developing. For instance, downtown Indianapolis will have higher densities of use than a single-family residential neighborhood in Carmel, even though they are both within urban areas.

For factor development purposes, areas with higher bicycle activity typically yield more meaningful counts than areas of low activity. Downtowns, university campuses, school zones, commercial areas, major regional trails and bicycle corridors, and other popular recreation facilities are good candidates for permanent count sites, particularly if the counter can be installed at a pinch point. Pinch points are places in a corridor where bicyclists are channeled, such as bridges over major barriers or local streets channeling into a major street, which can support accurate and comprehensive data collection for factor group development.

The Traffic Monitoring Guide recommends for nonmotorized traffic that between three and five permanent counters be installed per factor group. Following the proposal in the ***Factoring*** section to establish three factor groups (recreational, commuting, and mixed factor groups), between nine and 15 permanent count sites are needed to develop robust factor groups. This proposal assumes that the three groups suggested below provide a thorough understanding of patterns. However, the number of factor groups could increase as a better understanding of patterns is achieved. A lower number of continuous counters could be adequate for certain factor groups if patterns appear to be consistent across locations.

Short-Duration Counters

Short-duration counts are focused on expanding the geographic coverage of the program. As with motor vehicle traffic monitoring, more count sites allow for greater understanding of travel patterns, additional analysis opportunities, and greater confidence in the data overall.

Short-duration automated counts are installed at locations with varying levels of expected bicycle volumes. To achieve a representative coverage of SDC sites, count sites should not be limited to high volume locations as this will bias traffic estimates inferred from the program. Selecting SDC locations as a network to best represent the different patterns, levels, and types of bicycling behaviors within a counting area allows counting agencies to generate AADBT that most accurately reflect current levels.

Research into nonmotorized monitoring programs has not determined an ideal number of short duration sites. Resource limitations are likely to be the determining factor in how many SDCs can be undertaken. To maximize extrapolation accuracy, SDCs should be installed for at least one day (24 hours), and ideally for one to two weeks to observe the full day-of-week patterns at the count site. Additionally, maximum accuracy can be achieved by installing SDCs during high volume periods, such as during the summer months. SDC sites should be recounted annually or at another interval, to monitor change over time.

The IMPO should conduct SDCs at locations that best represent the variety of facilities, densities, and conditions of the total counting area. Unlike permanent counters, SDC sites should not be limited to high volume locations. Counting only at high volume locations will likely result in bicycle traffic estimates that are biased. All SDC sites should be available for at least one week, to maximize extrapolation accuracy. Ideally, the SDC counts would be conducted for two weeks to observe the full day-of-week patterns at the count site and ensure an adequate number of observations. The IMPO can maximize the accuracy of its SDCs by counting during high volume periods, such as during the summer months and during seasonably mild, dry weather conditions.

While current research has not yet determined an ideal number of SDC locations, it is recommended that the IMPO identify SDC locations based on upcoming IRTIP-funded infrastructure projects, high-crash locations, and available staffing and resource levels for managing the counting technology and data. As SDCs will be moved between locations during the mild weather months and primarily in storage over the winter, it is recommended that the IMPO work with local partners to identify secure storage areas at local facilities to reduce the potential for theft or loss and travel time for staff rotating the counters.

DATA COLLECTION QUALITY ASSURANCE

High quality data originates from the data collection process. The IMPO should integrate the following quality assurance measures into both phases whenever bicycle count data is collected from automated permanent counters and SDCs:

- When working with automated counters, the counting agency should make sure that all vendor specifications for installation are followed. For instance, passive infrared sensors should be installed at approximately hip-height with a solid backdrop (e.g. building face) behind them.
- The counting agency should select site-level installation locations to mitigate bypass errors. This might include installing pneumatic tubes beyond the edge of the bike lane to capture bicyclists riding in the general travel lane or locating counters at "pinch points" such as bridges. However, vendor installation specifications should always be followed to ensure that the technology works as intended.
- Validation processes for permanent counters and SDCs:
  - Counting agencies should validate permanent counters with a two-hour manual count annually, except at low volume sites, where longer video counts (24 hours or more) may be needed to validate the counter. This type of validation consists of placing video cameras on one weekday and one weekend day for at least 12 hours per day per site with the camera and counter clocks synced.[15] Bicyclist counts from the video and counters should be compared by hour. If accuracy is lower than 80 percent, then the counting agency should contact the manufacturer to adjust settings or change location. After changes are made, the validation must be repeated. If accuracy is 80 percent or higher, then the

15. http://www.pedbikeinfo.org/pdf/PBIC_Infobrief_Counting.pdf.

counting agency can use the data to compute an equipment correction factor[16] to adjust for consistent under or overcounting (undercounting is common for properly adjusted bicycle counting equipment). If overcounting is due to counting motor vehicles, this data may be unusable for studying bicycle travel. Even slight overcounts due to counting motor vehicles as bicyclists can result in large errors and incorrect pattern identification at sites with high motor vehicle volume.
  - For short-duration automated count installations, counting agencies should obtain at least 25 field-validated count events.

» Counting agencies should document all count installations with a photo and accompanying site description.

IMPLEMENTATION STRATEGIES AND INVESTMENT REQUIREMENTS

This section outlines six primary strategies with supporting action items to implement the IMPO bicycle count program through Phase 1 and into Phase 2. For each action the responsible parties and recommended implementation phase is identified. These implementation mechanisms should be reviewed and updated throughout the program's development to reflect current lessons learned and available staff, equipment, and data management capacity. The six strategies are listed below and described in detail on the following pages.

Strategy 1: Build Bicycle Count Program capacity	**Strategy 2: Launch Phase 1 and Phase 2 of the Bicycle Count Program**	**Strategy 3: Develop and Apply Factor Groups**	**Strategy 4: Enhance Data Management and Analysis Processes**	**Strategy 5: Calibrate and Validate Third-Party Data**	**Strategy 6: Establish Performance Measures**

16. See NCHRP 797 Section 3.3.9 for details.

STRATEGY 1: BUILD BICYCLE COUNT PROGRAM CAPACITY

	Action	Responsible Party	Starting Phase
1-1	Develop materials for and deliver bicycle counting training for member agencies	IMPO	Phase 1
1-2	Establish staffing responsibilities for the bicycle count program	IMPO and member agencies	Phase 1
1-3	Establish guidance for when bicycle counts should be collected through the IRTIP project development and implementation process	IMPO	Phase 2
1-4	Develop and publish routine reports summarizing data collection activities and trends	IMPO	Phase 1
1-5	Convene bicycle count user group forum	IMPO and member agencies	Phase 2

Action 1-1: Develop materials for and deliver bicycle monitoring training

This Manal provides a comprehensive summary of the monitoring program purpose and structure. While the Manual is a key staff resource for the program, there is a need for training materials and resources targeted to different audiences and stakeholders, particularly to member agencies who will collect data and share it with IMPO staff in phases 1 and 2. Routine training (conducted annually or as otherwise needed) will be essential to ensure that data collected is reliable and useful. The training may be delivered as an in-person workshop or via webinar (which should be recorded to be conveniently accessible to additional audiences). The training should address the following elements:

» Overview of IMPO's program
» Bicycle counting basics

- Purpose and value of collecting bike travel data
- Data collection technologies including overcoming installation challenges
- Factoring
- Quality control/field validation
- Data management and sharing

Action 1-2: Establish staffing responsibilities for the nonmotorized monitoring program

Implementing the recommendations contained in this Manual will require dedicated staff time from the IMPO and member agencies. Many of the actions such as technical support and coordination with member agencies may already be closely related to current staff's work activities and could be integrated into staff job descriptions. Additional responsibilities related to program administration and data management may require additional staff resources. It is anticipated that these activities may account for 0.5 FTEs over the short-term, and up to 1 FTE as the program expands in complexity. Staff requirements related to data collection are subject to the level of investment and installation determined by the IMPO (see Actions 2-1 and 2-3 for more information). Potential job duties associated with this position include:

» Represent bicycle count program within the IMPO.
» Serve as liaison between the IMPO and bicycle count data collection partners and data users.
» Acquire data from partners and manage data in a centralized database.
» Assure bicycle count data meets quality control criteria.
» Conduct bicycle counting trainings.
» Develop counter installation schedules and work with data collection partners (including internal and external agency staff) to implement counters.

- Work with internal IT staff and data collection vendors to improve data management processes.
- Develop analysis methods and routines to monitor the program's objectives and performance measures.
- Integrate additional datasets with bicycle count data, including third-party probe data, and safety data.
- Summarize analysis findings and program activities in periodic reports.

Action 1-3: Establish guidance for when bicycle counts should be collected through the IRTIP project development and implementation process

In addition to collecting bicycle volume data through a systematic program, routine data collection through the IRTIP project development process will result in a more robust dataset. In particular, this data is needed to support reporting of before/after performance measures and to contribute to a greater understanding of how projects affect bicycle travel. Potential project development processes to be addressed include:

- Project scoping
- Project application processes
- Safety studies
- Environmental studies (NEPA, EIS, etc.)
- Existing routine traffic count programs

Action 1-4: Develop and publish routine reports summarizing data collection activities and trends

Developing and publishing routine reports will be essential to communicate the results of the IMPO's bicycle count program. The type and frequency of reports should be based on the capacity of staff and readiness of data to be shared. At a minimum an annual or biannual report should be developed by IMPO staff. The report should address the following topics:

- Program activities
  - Counter acquisition and installation
  - Trainings
  - Number of agencies submitting data to the IMPO
- Analysis (Note: Some of the analysis will be limited in Phase 1 and the first years of Phase 2 since trends will not yet be established)
  - Annual volume trends
  - Seasonal and daily patterns
  - Crash rates
  - Annual factor groups
- Policy implications of volume trends and patterns
- Innovative uses of the data at the IMPO or other agencies (if applicable)

Action 1-5: Convene bicycle counting user group forum

In addition to the recommended training, IMPO should convene bicycle counting stakeholders on a regular basis – especially during Phase 1 with participating member agencies. This could include quarterly user-group conference calls or webinars to allow IMPO staff and participating member agencies to share their experiences and findings, learn from each other, discuss data uses, and identify common challenges. Additionally, hosting an annual or biannual meeting or workshop can catalyze interest in the program, while showcasing the work of the IMPO and participating member agencies. To achieve greater participation, it may be beneficial to organize this around an existing or planned event.

STRATEGY 2: LAUNCH PHASE 1 AND PHASE 2 OF THE BICYCLE COUNT PROGRAM

	Action	Responsible Party	Starting Phase
2-1	Reactivate and monitor Phase 1 permanent counters	IMPO and member agencies	Phase 1
2-2	Work with member agencies to promote short-duration automated counts	IMPO and member agencies	Phase 1
2-3	Expand the permanent counter initiative	IMPO and member agencies	Phase 2
2-4	Expand the short-duration counter initiative	IMPO and member agencies	Phase 2

Action 2-1: Reactivate and monitor Phase 1 permanent counters

As the only communities so far in the Metropolitan Planning Area (MPA) with permanent counters installed, the IMPO should work with the cities of Indianapolis and Carmel to build out the region's permanent counter database. The primary goal for the permanent counter database in Phase 1 is to establish the three recommended factor groups (commute, recreation, and mixed) so that future SDCs can be extrapolated for AADBT-based metrics. Based on the recommended three factor groups, the IMPO should secure and support the operation of nine to 15 permanent counters (at least three per factor group) in Phase 1. The IMPO can achieve this goal with limited upfront operational costs by partnering with the cities of Indianapolis and Carmel, who already conduct permanent, automated counts, and have available equipment.

The City of Indianapolis installed 18 permanent, automated counters on bike lanes and multi-use trails around the City.[17] The permanent counters were funded by a grant in 2012, but the City is no longer able to maintain the counters due to lack of ongoing funding and some of the counters have experienced mechanical failures. The IMPO should partner with the City of Indianapolis to secure new batteries and cellular service for the functioning counters, along with staff time to allow the counters to become operational again.[18] During Phase 1, the IMPO should prioritize the operation of three to six of these counters that are placed along key commute and mixed bicycle facilities.

The IMPO should also work with the City of Indianapolis' Parks Department during Phase 1. The Parks Department's automated counter program has been ongoing for over 15 years and includes both trail and greenway locations. While the program's counters currently collect a combined volume count that does not differentiate between bicyclists and pedestrians, the IMPO should work with the Department to install supplemental count technology to generate separated count volumes. Assuming that the Department currently uses passive infrared counters, induction loops or piezoelectric strips can be added to the count location to identify and pull out bicycle volumes. During Phase 1, the IMPO should prioritize the modification of three to six of these counters along well-traveled trails and greenways.

The City of Carmel began collecting bicycle and pedestrian counts in 2018. The City currently has three automated counters installed along on-road bicycle facilities and trails. While two of the counters (the 96th Street Trailhead and the City Center locations) differentiate between bicyclists and pedestrians, the 106th Street Path

17. City of Indianapolis and Marion County. Indy Moves: Pedal Indy (2018, November). Retrieved April 3, 2019, from indymoves.org/wp-content/uploads/2018/09/Pedal-Indy-Draft-Plan_20181001.pdf.
18. The San Diego region uses a similar partnership approach to manage its bicycle count program. The region's MPO, SANDAG operates approximately 10 bicycle counters and the San Diego State University also operates an additional group of counters.

counter generates a combined user count. As with the City of Indianapolis Parks Department, the IMPO should partner with the City of Carmel to add either induction loops or piezoelectric strips to the 106th Street Path location to generate separate bicycle counts.

Table 2. Recommended Phase 1 Count Partnership Opportunities

Partner Agency	Facility Types	Factor Groups*	Phase 1 Counters
City of Indianapolis	» Bike Lanes » Multi-Use Trails	» Commute » Mixed	» 3 - 6
City of Indianapolis Parks Department	» Multi-Use Trails » Greenways	» Mixed » Recreation	» 3 - 6
City of Carmel	» Bike Lanes » Multi-Use Trails	» Commute » Mixed » Recreation	» 3

*Indicates expected factor group based on location and facility type.

Action 2-2: Work with member agencies to promote short-duration automated counts

The IMPO should expand its proposed partnerships with the cities of Indianapolis and Carmel to include automated SDCs. Additionally, the IMPO should partner with the City of Fishers in implementing automated SDCs. The City of Fishers conducted manual bicycle and pedestrian counts along trails in 2014 and 2016. Volunteers counted bicyclists and pedestrians separately at intersections and trail crossings, following the National Bicycle and Pedestrian Documentation Methodology. The City selected seven count sites in both 2014 and 2016. The sites were along both well-established trail networks in the western portion of the City, and on emerging trail systems in the eastern portion.[19] The IMPO should work with the City to identify candidate locations from the manual count program for automated SDCs. The locations should include both new and well-established trails from around the city.

During Phase 1 the IMPO should also partner with communities with upcoming IRTIP-awarded projects with bicycle facility improvements. Unlike the proposed partnerships with the cities of Indianapolis, Carmel, and Fishers, who have counting experience, the IMPO will need to take a stronger role in leading SDCs in other communities with upcoming IRTIP projects. These “before” IRTIP project counts are important to collect in Phase 1 and will build SDC knowledge and experience at the local level. The IMPO should evaluate the below IRTIP projects from the Draft 2020-2023 IRTIP with obligated funds for the state fiscal year 2018[20] for automated SDCs during Phase 1:

Table 3. Potential Phase 1 SDC Count Sites

Partner Agency	Project Name	Programmed Funds	Obligated Funds
Avon	» Bike/pedestrian facilities on White Lick Creek Trail » Pedestrian bridge across White Lick Creek north of CR 100 S.	» $1,440,532 » $634,009	» $440,000 » $622,000
Beech Grove	» Churchman Ave. from Emerson Ave. to Arlington Ave.	» $58,000	» $866,360
Fishers	» 113th St. from Olio Rd. to Florida Rd. » Nickel Plate Trail Extensions	» $263,118 » $1,194,400	» $263,118.22 » $1,114,400
Franklin	» Safety revisions at Mallory Parkway and US31	» $531,132	» $509,882.31

19. City of Fishers. Trail Counts 2016 Report.
20. Indianapolis Metropolitan Planning Organization. DRAFT 2020-2023 Indianapolis Regional Transportation Improvement Program. April 5, 2019. https://d16db69sqbolil.cloudfront.net/mpo-website/downloads/TIP/0-Draft-2020-2023-IRTIP_190405_113843.pdf.

Hamilton	» 146th St. River to Herriman Blvd. multi-use path » Noblesville/Hamilton Co. Riverwalk (east bank) White River SR32 and Logan St. Ph2A	» $36,307 » $120,680	» $36,306.98 » $120,680
Indianapolis	» Market St. reconstruction Pennsylvania	» $500,000	» $500,000
Lawrence	» E. 56th St. Trail from Boy Scout Rd. to Franklin Rd.	» $124,329	» $0
Nobelsville	» Midland Trace Trail from Gray Rd. to Willowview Rd.	» $637,512	» $637,512
Speedway	» B&O Trail from Main St. to east of Big Eagle Creek	» $661,251	» $661,251
Westfield	» Old Monon Trail 191st St. to 216th St., and over SR32	» $1,358,816	» $1,358,815.55

Action 2-3: Expand the permanent counter initiative

Building off the proposed partnerships with the Cities of Indianapolis and Carmel, the IMPO should expand the permanent counter initiatives from Phase 1 and finish bringing on and updating the available permanent count technology. Additionally, the IMPO should analyze how well the Phase 1 count data fits into the three factor groups and identify potential areas of underrepresentation. Addressing areas of underrepresentation early in the count program's implementation will assist the IMPO later in SCD extrapolation efforts.

Taking lessons learned in the field during Phase 1, the IMPO should work with local jurisdictions to purchase permanent counters. These permanent counters can be secured through a variety of methods which are outlined in the ***Partnership with Local Agencies*** section below. Partnering with additional communities around the region during Phase 2 is essential to the use of the counts to measure IRTIP investments, and to leverage future SDCs. Regardless of the community, the IMPO should prioritize locations with known or expected significant bicycle volumes (more than approximately 100 bicycles/day), high bicycle crash rates, or upcoming IRTIP-funded work.

Action 2-4: Expand the short-duration counter initiative

The IMPO should expand the SDC programs in the Phase 1 partner communities and monitor future IRTIP funding awards for counting opportunities with additional communities. In addition to IRTIP counting opportunities, the IMPO should identify locations with significant bicycle crash rates, from the State's consolidated crash dataset, that could serve as additional SDC locations. As with the permanent counters, the IMPO can take lessons learned in the field during Phase 1, to work with local jurisdictions to purchase SDCs. These SDCs can be secured through a variety of methods, which are outlined in the ***Partnership with Local Agencies*** section below.

STRATEGY 3: DEVELOP AND APPLY FACTOR GROUPS

	Action	Responsible Party	Starting Phase
3-1	Define factor group thresholds	IMPO	Phase 1
3-2	Assign Phase 1 and 2 Permanent counter factor groups	IMPO	Phase 2
3-3	Monitor and adjust factors annually based on analysis of Phase 1 and 2 data sets.	IMPO	Phase 2
3-4	Assign factor groups to short duration count locations based on matching patterns for established thresholds	IMPO	Phase 2
3-5	Explore innovative factoring methods	IMPO	Phase 2

Action 3-1: Define factor group thresholds

As discussed above in the ***Factoring*** section, this Manual provides a framework for defining factor groups based on hour-of-day and day-of-week activity patterns. As the IMPO and participating member agencies begin to collect count data from the Phase 1 permanent counters, the IMPO should begin to identify discrete factor groups using the methods outlined in the ***Factoring*** section and the ***Factoring Approaches*** section in Appendix A.

Action 3-2: Assign Phase 1 and 2 permanent count location factor groups

As Phase 2 permanent counters are installed, they should be assigned to a factor group. Factor group assignment will initially be based on the patterns identified in Phase 1. However, factor groups may change and should be refined based on observed patterns. Phase 1 count locations may be subject to reassignment as factor groups are better defined over time. Patterns should be evaluated annually at each location to ensure it is assigned to the correct factor group.

Action 3-3: Monitor and adjust factors annually based on analysis of Phase 1 and 2 data sets

The confidence and reliability of adjustment factors will be low in the initial years of the bicycle count program. As the quantity of sites and duration of data collected at Phase 1 and 2 permanent count sites increases, the confidence and understanding of factor groups and adjustment factors used to estimate AADBT for short-duration automated count sites will also increase. Each year, IMPO staff will need to analyze the existing data and update the adjustment factors.

Action 3-4: Assign factor groups to short-duration count locations based on matching patterns to established thresholds

The value and usability of data collected from short-duration automated counts relies on the identification of suitable factor groups to be compared with permanent count sites. IMPO staff will need to assign appropriate factor groups for each site based on observed patterns. As described in ***Action 3-3: Monitor and adjust factors annually based on analysis of Phase 1 and 2 data sets***, this is an iterative process: as the program matures and more is learned about common site patterns and characteristics the assignment thresholds and number of factor groups may change requiring staff to update the assignments and classifications for these sites.

Action 3-5: Explore innovative factoring methods

As the quantity and quality of bicycle count data improves over time, the IMPO may wish to explore different factoring methods. In particular, the 'day-of-year' factoring approach should be compared to conventional factoring methods. This approach has been found to produce more reliable estimates under some conditions, but may be difficult to apply statewide. To determine its usefulness and identify potential concerns, the prediction accuracy of the day-of-year method should be compared with the conventional factoring approach. Additionally, the use of a seasonal index should be explored to determine whether it results in improved accuracy. Finally, the potential use of third-party probe data for factoring could be evaluated. Probe data may provide a suitable basis for developing adjustment factors (substituting for permanent counts) or for applying existing factors (substituting for short-duration counts). It may be beneficial to conduct a research project to explore these questions.

STRATEGY 4: ENHANCE DATA MANAGEMENT AND ANALYSIS PROCESSES

	Action	Responsible Party	Starting Phase
4-1	Establish data sharing processes with member agencies	IMPO and member agencies	Phase 1
4-2	Automate data transfer using vendor APIs and custom scripting	IMPO and member agencies	Phase 2
4-3	Upload count data to TMAS	IMPO	Phase 2

Action 4-1: Establish data sharing processes with member agencies

Leveraging the count data collection efforts of member agencies represents a key approach to growing and improving the IMPO bicycle count program. The IMPO should work with member agencies to establish processes for sharing count data. One option may be to purchase a third-party data management and sharing service, such as MS2, that member agencies can directly upload their count data to.

Action 4-2: Automate data transfer using vendor APIs and custom scripting

Transferring files between data vendors and warehouses is a time-consuming task that will become more burdensome as additional data is collected. Some count data collection vendors offer Application Programming Interfaces (APIs) that may be used to help automate the data transfer process. The IMPO should work with vendors that do offer APIs for their counters, including Eco-Counter and Miovision offer APIs, to establish API and scripting processes to limit manual file uploads for both the IMPO and its member agencies.

Action 4-3: Upload count data to TMAS

The FHWA's Travel Monitoring Analysis System (TMAS) recently began to accept nonmotorized counts. The IMPO should coordinate with INDOT on the submittal of bicycle count data from the IMPO region. As the process for local agencies to upload their data involves several steps and has proven difficult for some local agencies with limited staff and data processing capabilities, the IMPO should serve as a regional conduit for collecting and reporting the data with INDOT.

STRATEGY 5: CALIBRATE AND VALIDATE THIRD-PARTY DATA

	Action	Responsible Party	Starting Phase
5-1	Obtain statewide third-party, segment-level pedestrian and bicycle volume estimates	IMPO	Phase 2
5-2	Collect count data for calibration and validation	IMPO	Phase 2
5-3	Conduct calibration and validation study	IMPO	Phase 2

Action 5-1: Obtain statewide third-party, segment-level bicycle volume estimates

Following the establishment of the permanent and SDC databases in Phase 2, the IMPO should evaluate the potential need and use for third-party probe data. Potential third-party data should only be acquired after the permanent and SDC databases have been established so that the third-party data can be calibrated based on the local counts.

Action 5-2: Collect count data for calibration and validations

Making use of the data obtained pursuant to Action 5-1 will require the IMPO to conduct a calibration and validation study. Local count data should be collected across a large number of sites with differing characteristics to support the third-party data's calibration and validation. A minimum of 100 local sites is recommended, though more sites would improve the analysis results. Once calibrated and validated, the third-party probe data could prove to be a useful tool in expanding the count program's scope, and in supporting the program's IRTIP-investment performance measures. In particular, third-party data would be helpful in generating "before" bicycle volume estimates for IRTIP projects that were not able to support or secure a local count.

Action 5-3: Conduct calibration and validation study

The recommended method for calibrating third-party data is based on log-linear regression, which is described in detail in the ***Third-Party Data source Calibration and Validation Approaches*** section in Appendix A. Potential validation methods or metrics include Percent Root Mean Square Error, Scatterplots, Model Comparison and evaluation of trip lengths and temporal distributions. These are also described further in the ***Third-Party Data source Calibration and Validation Approaches*** section in Appendix A

STRATEGY 6: ESTABLISH PERFORMANCE MEASURES

	Action	Responsible Party	Starting Phase
6-1	Develop AABDT estimates for Phase 1 permanent and short-duration automated count sites	IMPO	Phase 1
6-2	Conduct pre-/post-construction AADBT estimates in conjunction with bicycle IRTIP projects (short-duration automated counts or probe data)	IMPO and member agencies	Phase 1
6-3	Calculate bicycle crash rates at high-crash locations	IMPO	Phase 2

Action 6-1: Develop AADBT estimates for Phase 1 permanent and short-duration automated count sites

Building upon efforts from Strategy 3, development of reliable AADBT estimates for Phase 1 and short-duration count sites is the foundation for reporting results from the IMPO bicycle count program. While permanent count sites will provide high-quality AADBT estimates, short duration-count sites will be less reliable. As the number of permanent sites increases, the confidence in AADBT estimates from short-duration count sites will improve.

Action 6-2: Conduct pre-/post-construction AADBT estimates in conjunction with bicycle IRTIP projects (short-duration automated counts or probe data)

As discussed above in the ***Performance Measures to Evaluate IRTIP Investments*** section, strategic collection of short-duration automated counts can be a powerful tool for evaluating the before/after impact of IRTIP projects or other site-specific interventions (such as an enforcement or educational campaign). Where identified, short-duration counts should be conducted in advance of appropriate IRTIP projects or interventions and after project completion. Thorough evaluation of the impacts of such IRTIP projects includes collecting data after project completion and at regular intervals over time to account for initial spikes in use that may occur immediately following a new project. This action should be coordinated with strategy ***Action 1-3: Establish guidance for when bicycle counts should be collected through the IRTIP project development and implementation process***, as there is a need to develop policy that establishes agency protocol for when these counts should occur.

Action 6-3: Calculate bicycle crash rates at high-crash locations

Crash rates for bicycle crashes can be misleading due to the low number of crashes at any given location. As a result, development of crash rates should be focused high-crash locations. Ideally, multiple years of crash data (up to 5) would be used to calculate crash rates along with volume data from permanent or factored short-duration counts. If volume data is not available for the entire period, professional judgment should dictate whether bicycle activity levels were likely to have changed significantly during that time. If not, a single year may be used to develop the crash rate.

PARTNERSHIP WITH LOCAL AGENCIES

As discussed in the above ***Counter Implementation Recommendations*** section, there are several opportunities in Phases 1 and 2 for the IMPO to build the bicycle count program through partnerships with local agencies. In addition to the three IMPO partner agencies that currently conduct bicycle counts, Hancock County expressed interest in establishing an ongoing bicycling count program within the next four to seven years and identified five possible local counting partners[21] in their 2018 Trails Plan.[22] The IMPO should work with Hancock County and other interested counties and local jurisdiction to meet planning and staff resource needs to conduct local bicycle counts. The IMPO can support partner communities' purchase of count technology and installation services through the development of model purchase, installation, and management Request for Proposals (RFPs) and contracts; and, negotiating bulk purchase agreements. The IMPO should coordinate closely with interested member agencies on understanding how to best support their purchase and operation of bicycle count technology and data subscription services.

21. Hancock County identified the Town of Cumberland, the City of Greenfield, the Town of McCordsville, the Town of New Palestine, and Pennsy Trails of Hancock County as possible counting partners.
22. Hancock County. Hancock County Trails Plan: Final Report (2018, November). Retrieved March 19, 2019, from hancockcountytrailplan.com/wp-content/uploads/2018/11/Final-Plan-Report_12-4-18.pdf.

CAPITAL COSTS

Acquisition of permanent counters and vendor services for SDC installations is critical to the development of the IMPO's regional count program. It is anticipated that the majority of the new counters and vendor services will be purchased by the IMPO and by partner agencies with support from the IMPO in Phase 1; however, the IMPO should begin now to work with local agencies to integrate count technology and vendor services into IRTIP-funded projects for Phase 2 to leverage outside funding opportunities. As of August 2018, counting equipment for bicyclists can be purchased using federal funds through multiple programs, including:

- Federal Transit Administration Capital Funds (FTA)
- Associated Transit Improvement (ATI)
- Highway Safety Improvement Program (HSIP)[23]
- National Highway Performance Program (NHPP)
- Surface Transportation Block Grant Program (STBG)
- Transportation Alternatives Set-Aside (TA)
- Recreational Trails Program (RTP)
- Safe Routes to School Program (SRTS)
- Metropolitan Planning funds (PLAN)[24, 25]

For planning purposes, permanent off-street counters are assumed to cost $6,000 per counter and on-street bicycle counters are assumed to cost $8,000 per counter. Each on-street counter is assumed to require two data loggers and loop sets to cover both directions. Permanent sidewalk counters are assumed to cost $8,000 per counter. These costs do not account for maintenance or ongoing data subscription services.

For counters to be installed on INDOT facilities, the IMPO should lead or oversee the approval and installation process with INDOT, working with local partners as appropriate. For counters to be installed on locally-maintained facilities (including any purchased by the IMPO through grants or other mechanisms), local agencies should coordinate installation and be responsible for maintenance.[26]

INSTALLATION COSTS

Permanent counter installation costs may range from $2,000 to $5,000 or more depending on site-specific factors and selected technologies. In general, trail installations are less expensive than on-street installations. For planning purposes, $4,000 is recommended as an average installation cost, assuming contractors are used. Economies of scale may be realized with more ambitious installation scenarios. Data transmission costs of $50 per month per site should also be expected.

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23. HSIP projects must be consistent with the Indiana Department of Transportation's Strategic Highway Safety Plan.
24. Specific program restrictions apply on the use of PLAN funds for bicycling counting equipment.
25. Federal Highway Administration, Pedestrian and Bicycling Funding Opportunities. Accessed 05/22/2019. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/funding/funding_opportunities.cfm.
26. If counters are purchased by the IMPO for local use, the IMPO must be able to access the data. Ideally, this access will be via automated download and not require site visits.

CHAPTER 5: PILOT PROGRAM INSTALLATION AND ASSESSMENT

PILOT PROGRAM

The pilot program will build off the Phase 1 ***Counter Implementation Recommendations*** outlined in this document and focus on using the region's available counting technology. The pilot program will allow the IMPO to test the Manual's recommendations and make strategic adjustments through partnerships with local agencies. The pilot program includes a variety of options which the IMPO can select based on available partnerships and project opportunities in the summer of 2019. As part of this pilot, Toole Design will work with a subcontractor to install short-duration bicycle and pedestrian counters at the selected pilot locations.

Table 4. Pilot Program Options

Partner Agency	**Duration & Technology**	**Facility Types**	**Related Objectives**	**Notes**
City of Indianapolis	» Permanent » Data subscription	» Bike Lanes » Multi-Use Trails	» Validate third-party data sources** » Develop Bicycle Crash Rates	» Restart the permanent count program and prioritize locations with high bicycle crash rates. » This pilot initiative will assist the IMPO in gaining a better understanding of the costs and resources associated with supporting this program.
City of Indianapolis Parks Department	» SDC » Pneumatic tubes	» Multi-Use Trails » Greenways	» Validate third-party data sources** » Develop Bicycle Crash Rates	» Install supplemental SDC technology, such as pneumatic tubes, to test the process for converting the combined count locations into separated counts. » The IMPO should select a location with a known significant bicycle volume and high crash rate.
City of Carmel	» SDC » Pneumatic tubes	» Bike Lanes » Multi-Use Trails	» Validate third-party data sources ** » Develop Bicycle Crash Rates	» Install supplemental SDC technology, such as pneumatic tubes, at the 106th Street Path site to test the process for converting the combined count locations into separated counts.
City of Fishers	» SDC » Passive Infrared + Pneumatic Tubes*	» Multi-Use Trails	» Validate third-party data sources** » Develop Bicycle Crash Rates	» Install passive infrared and pneumatic tubes at a manual count location with known significant bicycle volumes and bicycle crash rates. » This will assist the IMPO in learning how to best partner with a community that has not yet conducted automated counts.
*IRTIP Project Agency**	» SDC	» Bike Lanes » Multi-Use Trails	» Develop performance measures to evaluate IRTIP investments	» Install passive infrared and pneumatic tubes at a project site with combined pedestrian and bicycle activity, or only pneumatic tubes at a project site with only bicycle activity. » This will highlight for the IMPO how to conduct pre-project bicycle counts, and potentially how to partner with a community that has not yet conducted automated counts.

*The IMPO should select a project based on the site's feasibility for a summer 2019 count.

**While the IMPO will not be able to validate third-party count data until after Phase 2, once the count database has been built out, automated count data collected during the pilot will assist the later validation efforts.

PILOT LOCATION SELECTION

When selecting count sites based on the list of pilot program options in ***Table 4,*** the IMPO should consider several factors when, described in detail below:

- » Ensuring each site's data will support the broader goals of the Regional Bikeways Plan Update.
- » Ensuring each site's data will support the count program's objectives.
- » Evaluating site feasibility to support a bicycle counter during the summer of 2019.

Plan goals

- » **Ridership:** Placing counters along corridors with high bicycle ridership will document existing bicycle activity in the region. Areas with known significant bicycle activity are preferred for data collection and validation purposes as well (see ***Site feasibility***).
- » **Safety:** Areas with documented high bicycle injury or fatality rates are preferred. Collecting counts in areas of concern can build a data-driven case for future safety improvements. This also supports the count program's objectives (see ***Program objectives***).
- » **Equity:** Areas within or connecting to Environmental Justice populations are preferred.
- » **Access:** Placing counters at access points to destinations will help the IMPO understand which destinations attract significant bicycle activity, and which ones may need facility or safety improvements to encourage more bicycle activity. Example locations include trails leading to recreational destinations or on-street facilities leading to commercial areas and downtowns.
- » **Connectivity:** counters could be place along low-stress neighborhood routes to determine if they are currently being used, and to build a case for enhancing these routes as alternatives to facilities on busier roads.

Program objectives

- » Corridors with programmed IRTIP-funded bicycle facilities in the next 1-2 years are preferred. Pilot data collected can be used as the "before" counts for a later "before-and-after" analysis.
- » Areas with known significant levels of third-party probe data, such as popular recreation and commuting trails, shared-use paths, and protected bike lanes are preferred. Pilot data can be used to generate initial comparisons and exploration of how third-party data can be used to supplement the count program in later phases.
- » Areas with known high bicycle crash rates are preferred. Pilot data can be used as a benchmark to compare changes over time. Locations with known high bicycle crash rates that also have programmed IRTIP-funded bicycle facilities to be installed in the next 1-2 years would provide the greatest opportunity for before-and-after bicycle crash rate comparisons.

Site feasibility

- » Areas with known significant bicycle activity are preferred for the pilot program. Selecting an area with known significant bicycle activity allows count program administrators to apply a null-value test with confidence. A null-value test allows count program administrators to quickly check if the counter is on and accurately recording bicycle activity by reviewing the number of zero values being recorded; if more zero values are recorded than expected, based on prior knowledge of bicycle activity at a certain site, the counter should be recalibrated. Areas such as downtowns, university campuses, school zones, commercial areas, major regional trails and bicycle corridors, and other popular recreation facilities are good candidates, as they typically are popular destinations for bicyclists.
- » Areas with no ongoing or planned construction activities along the corridor for the pilot period are preferred. Additionally, areas with no construction activities along adjacent corridors are preferred.

Construction activities on adjacent corridors may also impact bicycling levels across the counter and lead to over- or under-counting.

- The pilot locations should have sufficient space in the public right-of-way to install counting equipment and approval from nearby land and property owners. Counters should be installed without impacting nearby vegetation, utility poles, or other structural items.
- The pilot locations should have good drainage and a limited history of standing water in the area. During the summer season, when strong storms and rain events are more common in Central Indiana, it is recommended that the pilot locations be in areas with good drainage and away from rivers, creeks, drainage facilities, and flood zones. In addition to possibly impacting the counting equipment (dependent on the type of technology and post-storm water levels), standing water will impact bicycling behaviors and volumes in the area.
- The pilot locations should be close enough to the IMPO office so that visiting the site on a regular basis during the pilot is not burdensome. In addition to visiting the pilot locations during the counter installation, staff may also need to visit the sites for calibration and validation purposes. However, it is also important to attain good geographic coverage of the Central Indiana region during the pilot period. In this vein, the IMPO may decide to place a limited number of counters in “collar” counties surrounding Indianapolis. The IMPO should partner with local agencies to monitor counters placed in these locations.
- Approval from the hosting partner agency for the counter’s installation is essential. Depending on the hosting partner’s right-of-way activity approval processes, expedited approval from the hosting agency may be required to launch the pilot during the first part of the 2019 summer.
- The IMPO should develop an agreement with the hosting partner agency to secure access to count data collected from pilot counters. This is especially important if the IMPO decides to select an existing permanent counter for the pilot period that is owned and operated by a member agency. In addition to securing access to the counter’s data, the IMPO should also consider the ongoing operational and subscription costs that may be associated with the selected pilot counter.

PILOT PROGRAM ASSESSMENT

The pilot program included 22 locations across the MPA and took place from September 25, 2019 (Wednesday) to September 28, 2019 (Saturday) under good weather conditions. While bicyclists were counted at each of the count locations during the four-day period, the volume of bicyclists counted ranged greatly from less than 10 at Allisonville Rd 500 (south of E 116th St), to over 1,500 at Monon Trail (north of 161st St). A summary of the bicycle count totals for each of the 22 count locations is shown in Figure 4.

The count data was processed using an algorithm by ETALYC for a total of 91 hours (0500 to 2400 hours) at all the locations, except for Fall Creek Entrance to Fort Ben (south of Boy Scout Rd) in Lawrence and Monon Trail and 161st in Westfield. The bicycle counts for these two locations were processed for all 96 hours from (0000 to 2400 hours). The bicycle count data was grouped in 15-minute bins when processing the video data for all 4 days at each count location. The count data for all of the locations included both through and turning movements, when not at a mid-block location. Example images of how the movement counts were identified at the pilot count locations are included in Figure 5 and Figure 6.

Figure 4. Summary chart of the 22 pilot count locations and number of bicyclists counted

Location	Count
Allisonville Rd 500 South of E 116th St	6
Allisonville Bike Lanes 570 South of E 62nd St	22
Madison Ave Side Path Just North of Beech Park Dr	65
136th St Path Just West of Ironwood Dr	80
Fall Creek Trail North of School Dwy On Brooks School Rd	98
Ped Bike Trail On Eastview Dr	101
Midland Trace Trail NE of Waterhaven Dr	113
Craig Trail Just East of Monte Vista Ct	145
Speedway B O Trail 350 West of Main St	151
22nd St Just East of Delaware St	207
Main St Path Just West of Brookshire Pkwy	250
MUP btw N Lantern Rd Holland Park	265
Youngs Creek Greenway Trail West of Main St Intersection	297
Mulberry St Hal Sharpe Rd MUPs	336
BO 500 East of 800E	449
Pennsy Trail-Greenfield Just West of S State St	541
White Lick Creek Trail 100 North of Springcrest St	616
Fall creek Entrance to Fort Ben	637
N Sherman Dr 10th St	738
Vandalia Trail Just East of Vestal Rd	1165
Monon Trail North of 161st St	1546
Total	**7828**

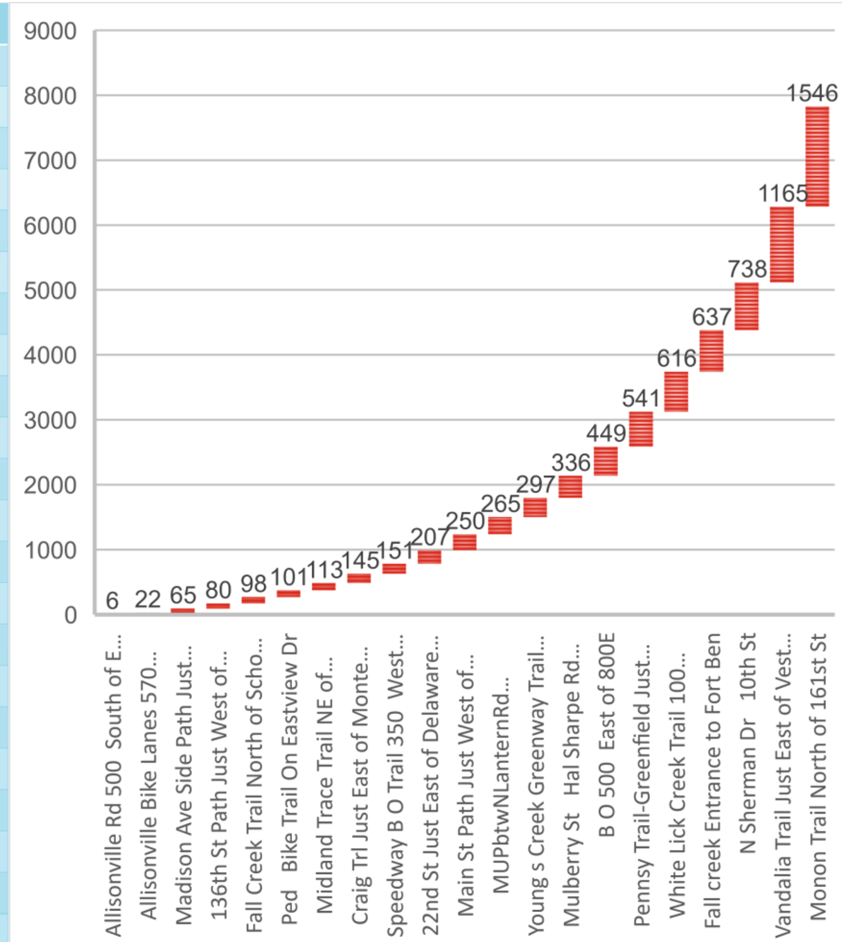


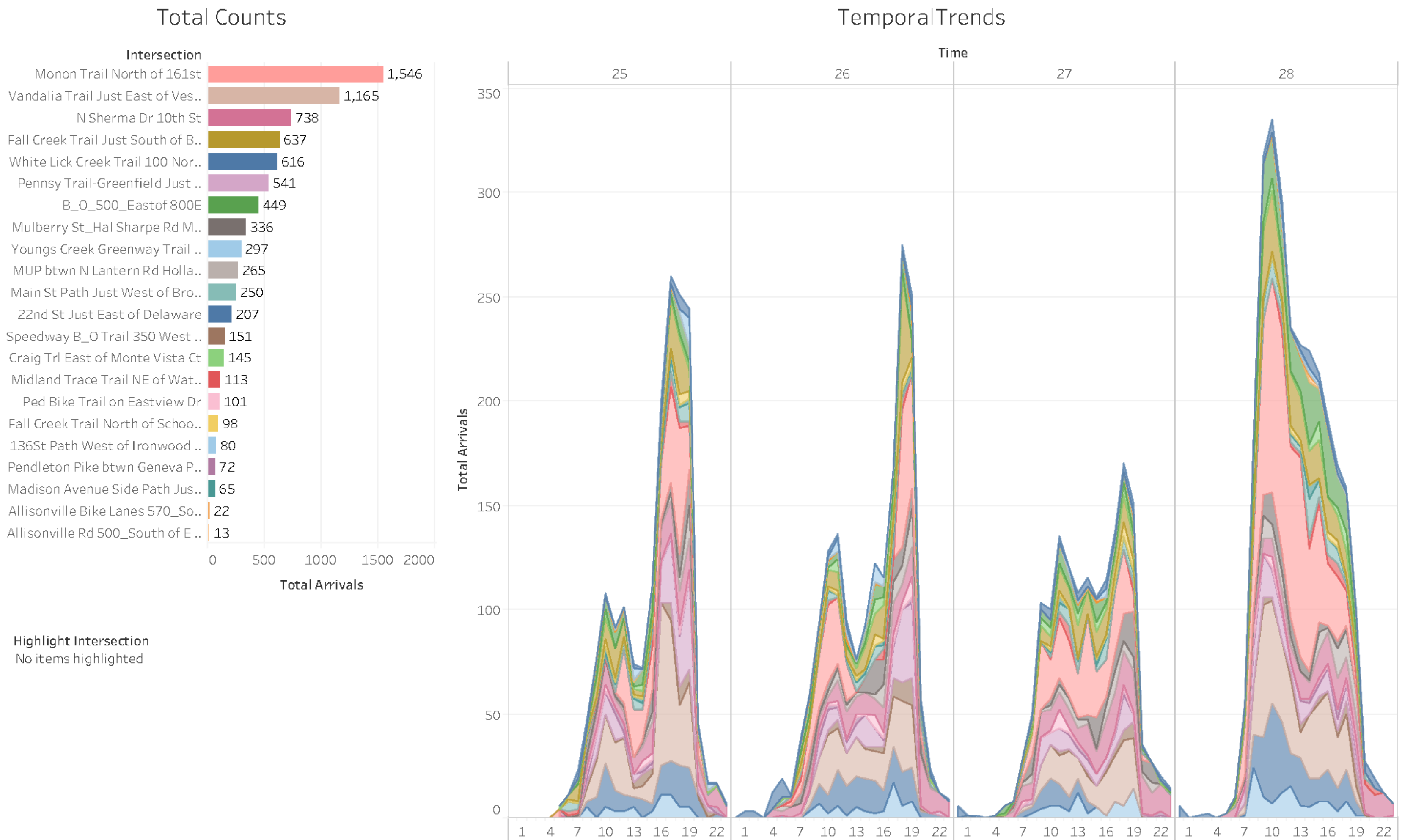
Figure 5. Midland Trace Trail NE of Waterhaven Dr pilot count location

Figure 6. N Sherman Dr at 10th St pilot count location

The observed bicycle activity data followed the expected trends of bi-peaks on Wednesday and Thursday, a flatter activity curve on Friday, and a late-morning peak on Saturday. These trends follow typical bicycle community behavior and suggest that the pilot observed overall normal bicycling trends over the four-day period. The pilot counts' temporal trends are graphically depicted in Figure 7.

Among trail pilot count locations, the observed counts displayed slightly varying behavior trends than the overall behavior trends with a spike in evening activity on trails. This may be due to recreational bicycle trips taken on trails in the evening for exercise purposes or for running errands; or, a willingness among bicycle commuters to take a potentially longer trip home in the evening on a trail that provides more separation from motor vehicles but may not be as direct as an on-road option. Future count programs that include trail locations should include evening observations, especially during fair weather conditions.

Figure 7. Bicycle Count Temporal Trends



CHAPTER 6: APPENDIX A

DATA COLLECTION TECHNOLOGIES

This section provides an overview of available count technologies, the recommended duration and context, pros and cons, and special considerations. For additional information on count technologies, see National Cooperative Highway Research Program Report 797 (NCHRP 797) and the accompanying NCHRP Web-Only Document 229, which includes revised results and additional technologies not tested in the original study.[27] Chapter 4 of the Federal Highway Administration (FHWA) Traffic Monitoring Guide (TMG) also provides a good starting point for understanding the available technologies.[28]

Automated Video

» ***Description:*** Video footage is taken in the field, and computer algorithms are used to identify individual pedestrians or bicyclists. In some cases, video may be reviewed by vendor staff to classify pedestrians or bicyclists.
» ***Recommended Duration:*** 24 hours to permanent
» ***Recommended Context:*** Shared use path, on-street bike lane, on-street mixed traffic, intersection
» ***Applicable Count Type***: Permanent, short-duration automated

Automated video (Source:

Pros	Cons
» Can be used to capture specific attributes, such as user movements or other characteristics » Video can be saved and referred to later for further observations » Wide detection width (up to 75’ depending on quality of images) » Portable » Easy to install	» Because of the proprietary nature and need for third party processing, the full accuracy and effectiveness of the technology is unknown » High cost

Special Considerations

» Mounts overhead at angle; can be used for screenline or intersection counting
» Lighting and weather conditions can affect video image
» Potential for privacy concerns
» Avoid:

- Locations with poor lighting conditions (glare, heavy shadowing, etc.)
- Locations where temporary obstructions may occlude data collection (delivery truck parking, etc.)

27. Ryus, P., A. Butsick, F.R. Proulx, R.J. Schneider, and T. Hull. “NCHRP Web-Only Document 229: Methods and Technologies for Pedestrian and Bicycle Volume Data Collection- Phase 2.” 2016. http://www.trb.org/Main/Blurbs/175860.aspx
28. Federal Highway Administration. “Traffic Monitoring Guide.” 2016, https://www.fhwa.dot.gov/policyinformation/tmguide/.

Infrared Detectors (Passive and Active)

- ***Description:*** There are two types of infrared detectors, active and passive. In the case of passive infrared detectors, people passing the sensor are identified and counted based on the heat profiles they emit. In the case of active infrared detectors, an infrared beam is established across the facility between a transmitter and receiver. When the beam is broken, a count is recorded.
- ***Recommended Duration:*** 2 weeks to permanent
- ***Recommended Context****:* Shared use path
- ***Applicable Count Type***: Permanent, short-duration automated

Passive infrared detector

Pros	Cons
» Relatively low cost » Portable » Easy to install	» Sensors unable to distinguish between bicyclists and pedestrians » Subject to undercounting due to occlusion (two or more bicyclists and pedestrians traveling side by side counted as one) » Counters may be subject to vandalism or theft

Special Considerations (Passive Detectors)	Special Considerations (Active Detectors)
» Sensitive to ambient background temperatures. » Sensor should be mounted at the edge of a path around 30 to 40 inches above ground (some overhead models are available). » Sensor should be directed perpendicular to the path of travel. » Avoid: ▪ Directing sensor at doors, windows, or metallic surfaces in direct sunlight ▪ Directing sensor at vegetation or objects prone to movement ▪ Locations where pedestrians are likely to linger (bus stops, entryways, kiosks, etc.) ▪ Locations where snow storage or debris may block sensor	» Mount sender and receiver perpendicular to path of travel. » Avoid: ▪ Locations where any motorized traffic can travel between the sender/receiver ▪ Locations where pedestrians are likely to linger (bus stops, entryways, kiosks, etc.) ▪ Locations where animals are likely to encounter the sensor ▪ Locations where snow storage or debris may block sensor

Pneumatic Tubes

» ***Description:*** A rubber tube or pair of tubes is nailed or taped to the road or trail surface. When the tubes are compressed, an air pulse in the tube triggers a count to be recorded. Bicyclists are identified based on the sequence of pulses recorded. Note that bicycle-specific pneumatic tubes count bicyclists more accurately than general traffic tubes.
» ***Recommended Duration****:* Several hours to a month
» ***Recommended Context:*** Shared use path, on-street bike lane, on-street mixed traffic
» ***Applicable Count Type***: Short-duration automated

Pneumatic tubes

Pros	Cons
» Relatively low cost » Portable » Easy to install	» Not appropriate for data collection in snowy conditions » Counts motor vehicles that drive over the tubes

Special Considerations

» Surface of detection area should be relatively flat and perpendicular to travel flow
» Specific procedures for shared roadways vs. bike lanes or shoulders
» Not appropriate for use in snowy conditions
» May be prone to vandalism or avoidance where tubes are installed conspicuously
» Additional installation equipment (tools) needed
» Avoid:

- Locations where stopping may occur (intersections, traffic control locations, etc.)
- Locations where vehicles park or trucks load/unload (parking areas, bus stops, loading zones, etc.)
- Installation in locations or in ways that may cause bicyclists to navigate around the tubes

Inductive Loop Detectors

» ***Description:*** Wire loops are installed on or under the road or trail surface with a current running through them. When the magnetic field produced by these loops is disturbed by a vehicle, including a bicycle, a count is recorded. This technology is very similar to the induction loops used for traffic signal actuation and vehicle counts, although bicycle-specific loops are designed to maximize counting accuracy.
» ***Recommended Duration:*** Permanent
» ***Recommended Context:*** Shared use path, on-street bike lane, on-street mixed traffic
» ***Applicable Count Type***: Permanent

Inductive loop detector

Pros	Cons
» Good for collecting bicycle only counts. » Durable, low-maintenance, and theft-proof. » Does not create a bump in the bikeway that bicyclists might seek to avoid	» Not reusable » Some bicycle types may not be registered due to their material composition » Repaving may impair function » High installation costs

Special Considerations

» Best in locations with predictable path of travel for bicycle traffic (bike lane, path, etc.)
» Presence of overhead or buried utilities may interfere with the inductive loop
» May require permitting and/or utility coordination
» Temporary or "surface Loops" are available to avoid cuts where needed (less permanent installation).
» Avoid:

- Locations with overhead or buried utilities
- Locations where bicyclists may ride outside of the loop detector

Piezoelectric Strips

- ***Description:*** Piezoelectric materials produce an electric current when they are compressed. This technology involves two strips of piezoelectric material installed in the surface of the road or trail. Counts are recorded when the piezoelectric strips are compressed. The strips' compression can detect bicycle volume, direction, and travel speeds.
- ***Recommended Duration:*** Permanent
- ***Recommended Context:*** Shared use path, on-street bike lane
- ***Applicable Count Type***: Permanent

Piezoelectric strips

Pros	Cons
» Good for collecting bicycle only counts » Durable, low-maintenance, and theft-proof » Does not create a bump in the bikeway that bicyclists might seek to avoid	» High installation cost

Special Considerations

- May require permitting and/or utility coordination
- Install perpendicular to bicyclist path of travel
- Avoid locations where motor vehicles may travel across sensors

Combination Inductive Loop/Infrared Detectors

- ***Description:*** An inductive loop sensor and a passive infrared sensor are installed at a single location to detect bicyclists and pedestrians and classify movements by mode. The passive infrared detector is used to obtain a combined count of pedestrians and bicyclists. The loop detector is used to obtain a bicycle-only count. Pedestrian counts can be derived by subtracting the bicycle-only number from the combined number.
- ***Recommended Duration:*** Permanent
- ***Recommended Context:*** Shared use path
- ***Applicable Count Type***: Permanent

Inductive loop and infrared detector on a post installation

Pros	Cons
» Detects bicyclists and pedestrians and can be used to generate bicycle-only and pedestrian-only counts	» High installation cost

Special Considerations

- Best in locations with predictable path of travel for mixed traffic (pinch points or bridge approaches best)
- Presence of overhead or buried utilities may interfere with the inductive loop
- May require permitting
- Avoid installing in locations with overhead or buried utilities and in locations where pedestrians and bicyclists may travel outside of the loop detector or sensor

Manual Field Data Collection

- ***Description:*** Data collectors manually record counts of pedestrians and/or bicyclists, either directly in the field or based on video footage.
- ***Recommended Duration:*** 2-4 hour intervals focused on peak travel hours
- ***Recommended Context****:* Any context
- ***Applicable Count Type***: Manual

Manual field data collection form

Pros	Cons
» Can be used to develop baseline user information (e.g., age, sex) and understand user behavior (e.g., helmet use, sidewalk riding) » Can be used to calibrate automated counts » Can be conducted by volunteers, if available	» Resource-intensive due to number of hours required for training, data collection, and data entry » Requires staff to manage and process data » Limited usefulness due to short data collection periods

Special Considerations

- The safety and comfort of data collectors should be considered before performing field counts
- Extrapolation of manual counts to annual estimates is subject to a high margin of error

FACTORING APPROACHES

CONVENTIONAL FACTORING APPROACH

The TMG outlines an approach for factoring short-duration counts based on motor vehicle traffic monitoring principles. It requires the application of three types of expansion factors: seasonal factors, day-of-week factors, and hour-of-day factors.

A seasonal adjustment factor is needed to account for the time of year a short duration count (SDC) was collected. Day-of-week and/or hour-of-day adjustment factors are needed to account for cases in which the SDC period was shorter than one week or one day, respectively. Estimated AADBT from counts less than a week in duration are subject to significant error, but a method for factoring can still be useful.

The steps involved in factoring SDCs vary depending on the duration of available SDC data. Example factoring scenarios are illustrated in Table 5.

Table 5. Short-duration Count Factoring Process

Short duration count period covered	**Steps**	**Example**
Two months or more (complete months)	1. Identify AADBT for factor group reference sites 2. Identify MADT for each month at factor group reference sites 3. Divide ADT by MADT to determine MAFs 4. Identify MADT for SDC site 5. Multiply MAF by SDC site's MADT to estimate AADBT at the SDC site; divide by number of months to estimate AADBT at the SDC site	1. $AADBT_{R(1)}$ = **1,000**; $AADBT_{R(2)}$ = **500**; $AADBT_{R(3)}$ = **1,250**; $AADBT_{R(1\text{-}3)}$ = **917** ([1,000+500+1,250] / 3) 2. $MADT_{R(January)}$ = **420**; $MADT_{R(February)}$ = **394**; 3. $MAF_{R(January)}$ = **2.18** (917/420); $MAF_{R(February)}$ = **2.33** (917/394) **4.** $MADT_{SDC(January)}$ = **1,700**; $MADT_{SDC(February)}$ = **1,350** **5.** $AADBT_{SDC}$ = **3,426** ([1,700 × 2.18]) + [1,350 × 2.33]) / 2
One month (complete month)	1. Identify AADBT for factor group reference sites 2. Identify MADT at factor group reference sites 3. Divide ADT by MADT to determine MAF 4. Identify MADT for SDC site 5. Multiply MAF by SDC site's MADT to estimate AADBT at the SDC site	1. $AADBT_{R(1\text{-}3)}$ = **917** 2. $MADT_{R(January)}$ = **420** 3. $MAF_{R(January)}$ = **2.18** 4. $MADT_{SDC(January)}$ = **1,700** 5. $AADBT_{SDC}$ = **3,706** (1,700 × 2.18)
One week (any 7 consecutive days within same month)	1. Identify AADBT for factor group reference sites 2. Identify MADT at factor group reference sites 3. Divide ADT by MADT to determine MAF 4. Identify WADT for SDC site 5. Multiply MAF by SDC site's WADT to estimate AADBT at the SDC site	1. $AADBT_{R(1\text{-}3)}$ = **917** 2. $MADT_{R(January)}$ = **420** 3. $MAF_{R(January)}$ = **2.18** **4.** $WADT_{SDC(January)}$ = **1,450** **5.** $AADBT_{SDC}$ = **3,161** (1,450 × 2.18)
Multiple days within same month	1. Identify AADBT for factor group reference sites 2. Identify ADT for each day of week at factor group reference sites 3. Divide reference site's AADBT by month/day ADT to determine DAF for each month/day combination 4. Identify daily counts for SDC site 5. Multiply DAF by SDC site's daily count; divide by number of days to estimate AADBT at the SDC site	1. $AADBT_{R(1\text{-}3)}$ = **917** 2. $ADT_{R(January,\ Monday)}$ = **265**; $ADT_{R(January,\ Tuesday)}$ = **215** 3. $DAF_{R(January,\ Monday)}$ = **3.46** (917/265); $DAF_{R(January,\ Tuesday)}$ = **4.26** (917/215) 4. $Count_{\ Monday\ 1/7/2019}$ = **850**; $Count_{\ Tuesday\ 1/8/2019}$ = **733** 5. $AADBT_{SDC}$ = **3,302** ([850 × 3.46] + (733 × 4.26]) / 2
One day, 12am to 12 pm	1. Identify AADBT for factor group reference sites 2. Identify ADT for day of week at factor group reference sites	1. $AADBT_{R(1\text{-}3)}$ = **917** 2. $ADT_{R(January,\ Monday)}$ = **265** 3. $DAF_{R(January,\ Monday)}$ = **3.46** 4. $Count_{\ Monday\ 1/7/2019}$ = **850**

	3. Divide reference site's AADBT by month/day ADT to determine DAF for month/day combination 4. Identify 24-hour count for SDC site 5. Multiply DAF by SDC site's daily count to estimate AADBT at the SDC site	5. AADBT$_{SDC}$ = **2,941** (850 × 3.46)
One or more hours (may cross days)	1. Identify AADBT for factor group reference sites 2. Identify AHT for each day of week and hour combination at factor group reference sites 3. Divide reference site's AADBT by AHT for month/day/hour combination to determine HAF for each month/day/hour combination 4. Identify hourly counts for SDC site 5. Multiply HAFs by SDC site's hourly counts and divide by the number of hours to estimate AADBT at the SDC site	1. AADBT$_{R(1\text{-}3)}$ **= 917** **2.** AHT$_{R(\text{January, Monday, 7am})}$ = **22;** AHT$_{R(\text{January, Monday, 8am})}$ = **25;** AHT$_{R(\text{January, Monday, 11am})}$ = **19;** AHT$_{R(\text{January, Monday, 12pm})}$ = **32;** AHT$_{R(\text{January, Monday, 4pm})}$ = **26;** AHT$_{R(\text{January, Monday, 5pm})}$ = **35** **3.** HAF$_{R(\text{January, Monday, 7am})}$ = **41.7** (917/22)**;** HAF$_{R(\text{January, Monday, 8am})}$ = **36.7** (917/25)**;** HAF$_{R(\text{January, Monday, 11am})}$ = **48.3** (917/19)**;** HAF$_{R(\text{January, Monday, 12pm})}$ = **28.7** (917/32)**;** HAF$_{R(\text{January, Monday, 4pm})}$ = **35.3** (917/26)**;** HAF$_{R(\text{January, Monday, 5pm})}$ = **26.2** (917/35) 4. Count $_{\text{Monday 1/7/2019, 7am}}$ = **78**; Count $_{\text{Monday 1/7/2019, 8am}}$ = **86**; Count $_{\text{Monday 1/7/2019, 11am}}$ = **72**; Count $_{\text{Monday 1/7/2019, 12pm}}$ = **102**; Count $_{\text{Monday 1/7/2019, 4pm}}$ = **80**; Count $_{\text{Monday 1/7/2019, 5pm}}$ = **112** 5. AADBT$_{SDC}$ = **3,096** ([78 × 41.7] + [86 × 36.7] + [72 × 48.3] + [102 × 28.7] + [80 × 35.3] + [112 × 26.2]) / 6

AADBT$_{R(x)}$: Annual Average Daily Traffic at reference site *x*;
AADBT$_{R(1\text{-}3)}$: Combined Annual Average Daily Traffic at reference sites 1-3;
AADBT$_{SDC}$: Estimated Annual Average Daily Traffic at short-duration count site;
ADT$_{R(m,\ d)}$: Observed Average Daily Traffic at reference sites for month *m*, day *d;*
AHT$_{R(m,\ d,\ h)}$: Observed Average Hourly Traffic at reference sites for month *m*, day *d*, hour *h;*
Count $_{date}$: Observed 24-hour count at short-duration count site on indicated *date;*
DAF$_{R(m,\ d)}$: Monthly/Daily Adjustment Factor for reference sites for month *m* and day *d*;
HAF$_{R(m,\ d,\ h)}$: Monthly/Daily/Hourly Adjustment Factor for reference sites for month *m*, day *d*, and hour *h;*
MADT$_{R(m)}$: Observed Monthly Average Daily Traffic at reference sites for month *m;*
MADT$_{SDC(m)}$: Observed Average Daily Traffic at short-duration count site for month *m;*
MAF$_{R(m)}$: Monthly Adjustment Factor for reference sites for month *m;*
WADT$_{SDC(m)}$: Observed Weekly Average Daily Traffic at short-duration count site during month *m*

DAY-OF-YEAR FACTORING METHOD

The day-of-year adjustment factor method is a relatively recent development in nonmotorized traffic monitoring.[29] In this approach, each day of the calendar year's daily traffic is evaluated against the Annual Average Daily Traffic (AADBT) for the site, providing an adjustment factor for each calendar day. Factors are recalculated every year so that contextual information such as the day of week and weather are implicitly captured in the factors. This approach replaces the seasonal and day-of-week factors in the conventional approach and has been shown to outperform that method when working with permanent counters in relatively close proximity to the SDC sites. However, it can still be used with data collected for periods less than 24 hour by first applying hour-of-day factors. It remains to be seen whether the day-of-year factoring approach translates well to the state level.

29. Hankey, S., Lindsey, G., & Marshall, J. (2014). Day-of-year scaling factors and design considerations for nonmotorized traffic monitoring programs. Transportation Research Record: Journal of the Transportation Research Board, (2468), 64-73.; Nosal, T., Miranda-Moreno, L., & Krstulic, Z. (2014). Incorporating Weather: Comparative Analysis of Annual Average Daily Bicyclist Traffic Estimation Methods. Transportation Research Record: Journal of the Transportation Research Board, (2468), 100-110.

The steps to estimating AADBT for a short-duration count site using the day-of-year factoring method are as follows (example values from Table 5 are shown in parentheses):

1. Identify Combined AADBT at reference sites (2,750)
2. Identify the short-duration count period study dates (1/1/2019-1/7/2019 and 7/1/2019-7/6/2019)
3. Summarize count totals from reference site during study period (48,883)
4. Determine the study period AADBT for reference sites (3,760)
5. Calculate the ratio of AADBT to study period AADBT for reference sites (0.73)
6. Identify study period AADBT for short-duration count site (4,131)
7. Multiply results from steps 5 and 6 to estimate AADBT for short-duration site (3,015)

THIRD-PARTY DATA SOURCE CALIBRATION AND VALIDATION APPROACHES

CALIBRATION APPROACHES

Naïve Approach

At the simplest level, a relationship between ground-truth data and third-party estimates can be represented by a "Naïve approach," as follows:

$$Y_i = \alpha + \beta X_i + \epsilon_i,$$

where

Y_i = estimated volume at location *i*, α = 0, β = estimated coefficient, X_i = third-party activity estimate at location *i*, ϵ_i = random error term at location *i*

In this scenario, the regression coefficient (β) is estimated from observed count volumes and corresponding third-party data. Note that this is simply estimating a linear regression model with the intercept forced to be 0, which can be accomplished using standard tools in Excel. This method is easy to compute and to explain, but may result in unacceptable errors under some circumstances. This approach effectively re-scales the third-party estimates based on the degree to which they under or over-estimate true volumes, averaged across all locations. The pros, cons, and considerations for this, and other calibration approaches are listed in Table 6.

Stratified Approach

A similar, but slightly more complex method compared to the Naïve approach is to estimate different regression models for different scenarios or location types. Separate calibration factors would be calculated for each of the defined scenarios to adjust for the degree to which the third-party estimates over or under-count within each of those location types. Under this approach, the scenarios would be defined based on expected or documented similarities with respect to the relationship between third-party data and observed data. For example, it may be that third-party data accounts for a smaller portion of volume in rural or low-income areas, and a separate calibration factor is needed to account for this difference. This approach is represented as follows:

$$Y_i = \alpha_1 + \beta_1 X_i + \epsilon_i$$

$$Y_j = \alpha_2 + \beta_2 X_j + \epsilon_j$$

$$\ldots$$

$$Y_q = \alpha_n + \beta_n X_q + \epsilon_q$$

where

i, j,…, q= locations in location type groups 1, 2,…, n, $Y_i, Y_j, \ldots, Y_q$ = estimated volume at locations *I, J,.., Q*, which correspond to location types 1 through n, $\alpha_1 \ldots \alpha_n = 0$, $\beta_1 \ldots \beta_n$ = coefficients at location types 1 through n,
$X_i, X_j, \ldots, X_q$ third-party activity estimates at locations *I, J,.., Q*, which correspond to location types 1 through n, $\epsilon_i, \epsilon_j, \ldots, \epsilon_q$ =random error associated with locations i, j,..,q

Under this approach, location types could be established based on factors such as:

- Facility type – trail, bike lane, sidewalk, shared lane
- Context – Downtown, general urban, suburban, rural, university
- Sociodemographic data – population density, income

The key question when considering whether a combination of factors should be part of a separate location type is whether the regression coefficient differs significantly from other established models. As such, this approach is iterative and requires some exploratory data analysis. Once the location types have been defined, applying the method to third-party data is straightforward. Each segment is assigned to a location type, and the corresponding equation is applied.

Advanced Approach (Recommended)

A more complex approach that would likely result in more accurate volume estimates under a greater range of scenarios involves estimating a model with third-party probe data as one of several explanatory variables. The other variables would be determined based on their predictive strength, but could include contextual variables similar to those listed under the stratified approach (e.g., facility type, context, socio-demographics). This approach is best handled using log-linear regression, which can be represented as follows:

$$\ln(Y') = \alpha + \beta_1 \ln(X_1) + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon$$

Where

Y' = estimated volume; α = intercept; β_1 = coefficient for third-party data; X_1 = third-party activity estimate; β_n = coefficients for contextual variable *k*; X_n = data values for contextual variable *k*; ϵ = random error

This equation can be rearranged as:

$$Y' = X_1^{\beta_1} e^{\alpha_0 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon}$$

The result of calibrating in this way has multiple desirable characteristics. First, by using log-linear regression, the estimated volumes are proportional to the third-party estimate, rather than simply adding or subtracting values to this number. Similarly, the effects of the contextual variables can be interpreted as multipliers on the third-party estimate. For example, one such variable might be a binary indicator for "proximate to parks," which might yield that, e.g., locations proximate to parks have 30% higher volumes, for a given third-party estimate level, than locations not proximate to parks. This can be seen as a way to remove potential biases from these estimates. Finally, a model specified in this way will not yield negative estimated volumes, which could happen if multiple variables were included like this in a standard Ordinary Least Squares linear regression. However, after the model is developed, applying it to third-party data to develop volume estimates could be simpler than applying the set of calibration equations outline in the recommended approach.

Table 6. Calibration Approaches for Third-Party Probe Data Sources

Approach	**Pros**	**Cons**	**Considerations**
Naïve	» Simple to implement and easy to explain » Fewer ground-truth data points required compared to other approaches	» Overall low accuracy » Accuracy varies across locations	» Level of variation across locations should be documented before pursuing this method to determine if it is an acceptable approach.
Stratified	» Accounts for inconsistent relationships between third-party and observed activity estimates across location types	» Cumbersome data requirements for identifying and applying location types » Requires exploratory data analysis and/or ongoing review of results to	» Thresholds for differentiating location types would be needed

	» Location types may align with factor grouping methodology » Method can be implemented incrementally, such as by starting with 2 to 4 location types and expanding over time	determine appropriateness of location types » Requires a larger number of ground-truth data points	
Advanced	» Likely to provide most accurate segment estimates » Approach accounts for different contexts » Data requirements may be lower than stratified approach outlined above, after scaling factors are developed	» Cumbersome data requirements for initial model development » Significant statistical modeling expertise required to develop model » Difficult to explain	» Suggested model functional form is log-link

VALIDATION APPROACHES

Root Mean Square Error and Percent Root Mean Square Error

Root Mean Square Error (RMSE) and percent RMSE (%RMSE) are often used to characterize how well predicted and observed values align. RMSE is defined as follows:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y_i - X_{1i})^2}$$

Y_i = Observed count on link *i*; X_{1i} = Volume assigned to link i in third-party dataset; n = Number of Links.

Since RMSE is dependent on the scale of the data and therefore can be difficult to compare across groups, %RMSE is recommended and is defined as:

$$\%RMSE = \frac{RMSE}{mean\ count}\ x\ \ 100$$

Some agencies, including the IMPO, have established maximum allowable %RMSE thresholds for validating traffic forecasts. In general, acceptable %RMSE levels decline as volume increases, suggesting relatively high thresholds should be expected and accepted for pedestrian and bicycle volumes. Percent RMSE should be calculated on a directional basis and can be summarized by groups (e.g., similar facility types), or by geography (e.g., by county or urban vs. rural). RMSE is not particularly meaningful as a measure of third-party data at an aggregate level, such as statewide, as error ranges across groups are masked. Experimentation may be needed to determine a reasonable threshold for acceptable %RMSE, with 15 to 20 percent suggested as a starting point.

Scatterplots

Scatterplots offer a visual check of third-party data compared to observed volumes. They reveal whether the two datasets are correlated, and the extent of variance in the datasets. They also shed light on whether the variance is random or exhibits a pattern (such as higher levels of variance at low-volume sites). Scatterplots alone are not likely to determine the usefulness of third-party data, but may point to additional issues to investigate. Similarly, they may assist with identifying outliers that require further exploration.

Model Comparison

The 'stratified' and 'advanced' calibration approaches outlined in the previous section may provide useful information for validation purposes. Using the stratified calibration approach, differences in model coefficients across location types may point to underlying inconsistencies or biases within the third-party data source. The variables included in the advanced model may be interpreted similarly.

In addition to different models within the study area having different coefficients, third-party data sources may eventually be validated by agencies across the country, with different results. Calibration models developed in other areas should be compared to those developed in Central Indiana to identify inconsistencies or similarities.

Trip Length and Temporal Distributions

Comparing trip length distributions from third-party data sources to prior research or available travel surveys may shed light on the reasonableness of the third-party data. In its validation report, Streetlight Data compares trip length distributions from its dataset with those of the National Household Travel Survey (NHTS), finding that its data includes a somewhat higher proportion of short-distance trips. They attribute this difference to underreporting of short trips in the NHTS. Conversely, datasets that are more geared toward long-distance recreational bicyclists may show longer than average trip distances.

Time-of-day or day-of-week distributions are another reasonableness check that can help identify data anomalies. The distribution of trips by time-of-day and day-of-week should roughly match that of installed counters. Differences in temporal patterns between these two data sources may indicate bias toward particular user groups.

CHAPTER 7: APPENDIX B

BICYCLE COUNT PROGRAM OBJECTIVES MEMORANDUM

The Indianapolis Metropolitan Planning Organization (IMPO) is undertaking a project to update its Regional Bikeways Plan. As part of that effort, it is considering whether and how it should use bicycle volume data to support bicycle facility planning and implementation in Central Indiana. This memorandum establishes objectives for the IMPO Bicycle Count Program that will guide the IMPO's involvement in future data collection or management efforts. The findings and recommendations will be used to structure the Bicycle Count Program Guidance Manual and pilot counter installation effort.

BACKGROUND

In recent years, cities and states throughout the United States have increased the amount of data they collect on their transportation system, with particularly large growth in bicycle and pedestrian data collection systems. This growth can be attributed to a combination of factors, including the development of automated data collection technologies, greater data management and processing capabilities, a broad interest in data-driven policymaking, greater interest in bicycling and walking generally, and the explicit inclusion and coverage of bicycle and pedestrian traffic volume data collection in the 2013 edition of the Federal Highway Administration's (FHWA) Traffic Monitoring Guide (TMG) and subsequent revisions.[30, 31]

In 2015, the Federal Highway Administration (FHWA) began a one-year pilot project intended to increase the capacity for Metropolitan Planning Organizations (MPOs) to collect and use nonmotorized data.[32] FHWA worked with 10 large MPOs, including the IMPO to identify count locations, install counters, and collect and use the data. The MPOs were given seed funding to develop bicycle and pedestrian count programs and technical assistance to support their programs via a series of webinars and support on an email listserv.[33] A final report was also published detailing the MPOs' experiences with collecting count data. The project resulted in a number of 'lessons learned' for MPOs in developing count programs, which are summarized below:

- Ensure sufficient staff time and resources are available for count programs
- Involve partners in all steps of establishing and running a count program
- Select count technology best suited to identified locations
- Validate automatic count data with manual spot checks.

In addition to the FHWA's pilot project, other national efforts have developed useful guidance for institutionalizing bicycle and pedestrian traffic monitoring programs, methods to collect volume data, and approaches to analyzing the resulting data. While practices for monitoring motorized traffic are very well established, bicycle and

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30. Federal Highway Administration. 2016.Traffic Monitoring Guide. https://www.fhwa.dot.gov/policyinformation/tmguide/
31. The TMG provides guidance to State Departments of Transportation (DOTs) on how to monitor traffic on their road networks, including coverage of speed, volume, and weigh-in-motion. Traffic data collected by State DOTs and their local agency partners following the standards outlined in the TMG is submitted to FHWA for inclusion in their Travel Monitoring Analysis System (TMAS), which was recently updated to accommodate bicycle and pedestrian traffic count data. While FHWA mandates that motorized traffic volume measurements be taken on a regular basis, there is not currently a similar mandate for bicycle or pedestrian traffic monitoring.
32. Federal Highway Administration. "Bicycle-Pedestrian Count Technology Pilot Project: Summary Report." U.S. Department of Transportation, Washington, DC, December 2016.
33. Pedestrian and Bicycle Information Center. Counts Pilot Program. http://www.pedbikeinfo.org/planning/tools_counts_pilot_program.cfm

pedestrian traffic have some important distinctions from motorized traffic that require special consideration in developing a volume program. These include:

- Bicyclists and pedestrians are more difficult to accurately and consistently monitor than motor vehicles because they do not follow constrained paths, may obstruct one another from the sensors, and are more difficult to reliably detect.
- Bicycle and pedestrian traffic variability is more complicated than motorized traffic, and these patterns are not thoroughly understood.[34]
- Bicycle and pedestrian traffic count technologies are often different from those used for motorized traffic, and therefore may require additional staff training, maintenance, and data management.

Bicycle Volume Data Users

Bicycle volume data is used by local municipalities, regional planning organizations, State Departments of Transportation (DOTs), advocacy organizations, and research institutions to monitor bicycling behavior, evaluate design treatments, and to measure progress towards safety and ridership goals. Policy makers, transportation planners, and engineers can use bicycle volume data in a variety of applications, including:

- Tracking levels of walking and bicycling over time
- Controlling for exposure in traffic safety studies
- Understanding the determinants of bicycle travel
- Prioritizing infrastructure projects
- Optimizing signal timing for all modes
- Informing studies of economic and health impacts of nonmotorized travel, and
- Calibrating travel demand models

In addition to these applications, some communities use count data as part of their open data portfolio to encourage citizen engagement and to support community data transparency efforts. A survey of some of the leading examples from regional organizations across the country is provided in Appendix A of this memo.

DEVELOPMENT OF OBJECTIVES

To identify goals for the IMPO's bicycle count program, the Toole Design team reviewed related plans and policies; current bicycle data collection efforts within Central Indiana; and the IMPO's counting experience, capabilities, staffing, and funding resources. Additionally, IMPO staff provided direction on their desired count program outcomes and local partnership opportunities.

Related Plans and Policies

The Toole Design Team reviewed 10 plans from around the region (**Table 7**). The review includes the 2015 Regional Bikeways Plan, six plans developed following the 2015 Regional Bikeway Plan's publication, and the most recent bicycle plans from the three communities where bicycle counts are currently being conducted in the region: Indianapolis, Carmel, and Fishers.

34. For example, it is well established that bicycle trips are less likely during precipitation, but the extent to which this varies by geography, trip purpose, and time of day is less well studied. Practically, this means that factoring methods might need to be different from established practices for motorized traffic

Table 7. Plans Reviewed

	Jurisdiction	*Type*	*Title*	*Date*
Regional Plans	Indianapolis MPO	Bike Plan	2015 Central Indiana Regional Bikeways Plan	2015
County Plans	Hancock County	Trails Plan	Hancock County Trails Plan	2018
	Boone County	Thoroughfare Plan	Boone County Thoroughfare Plan	2017
City Plans	City of Indianapolis and Marion County	Transportation Plan	Indy Moves	2018
	City of Carmel	Comprehensive Plan	Carmel Clay Comprehensive Plan	2009
	City of Fishers	Bike and Pedestrian Plan	Fishers Bicycle and Pedestrian Master Plan	2014
	City of Lawrence	Bike and Pedestrian Plan	Bicycle and Pedestrian Master Plan	2018
	City of Greenfield	Comprehensive Plan	Greenfield Comprehensive Plan	2015
Town Plans	Whitestown	Bike and Pedestrian Plan	Whitestown Bicycle + Pedestrian Master Plan	2018
	McCordsville	Recreation Plan	McCordsville Parks and Recreation Master Plan 2017-2021	2017

Of the 10 plans reviewed, three of the plans either mentioned the community's existing count program or the desire to start a count program: Hancock County, the City of Indianapolis, and the City of Fishers.

In addition to reviewing the plans for bicycle counting elements, the Team also considered how Environmental Justice was discussed, as understanding bicycle facility usage among underserved communities was of interest to the IMPO. While none of the reviewed plans specifically mentioned Environmental Justice, several of the plans discussed an interest in understanding how bicycle facilities can be programmed to better serve or include underserved populations.

2015 Regional Bikeways Plan

The 2015 Regional Bikeways Plan was written to accompany the 2035 Long Range Plan. The Regional Bikeways Plan's vision to increase options for cycling and to create a safe bikeway network are supported by the two primary goals of:

- Increasing the use of bicycling in the region for all trip purposes, and
- Improving the safety of cyclists throughout the region.

The Regional Bikeways Plan included surveys of biking tendencies and drew upon planned routes from existing plans throughout the region to create a regional network map. The overall vision recommends the completion of 746 miles of bikeways by 2035, and an overall vision for 2,800 miles, with 629 completed at the time of publication.

The planning process prioritized proposed projects throughout the region that created a fiscally constrained plan for 2035. Projects were scored with points in the categories of regionalism, economic opportunity, connectivity, equity. It also identifies an "arterial system" based on prioritization by the steering committee aimed at linking all the communities in the region, with three prioritization tiers.

Hancock County

In their 2018 Trails Plan, Hancock County included an evaluation strategy to establish an ongoing bicycle and pedestrian count program. The 2018 Trails Plan listed the count program as a medium-level priority, indicating it as important to the County but requiring planning and staff resources. The County established a timeline of four to seven years to establish the count program, but the Plan also estimated the program's cost as being outside of the County's readily available funding levels. The Plan outlined the number and location of count sites as possible program metrics, and identified the below agencies as possible program partners:

- Town of Cumberland
- Town of Fortville
- City of Greenfield
- Town of McCordsville
- Town of New Palestine
- Town of Shirly
- Town of Wilkinson
- Pennsy Trails of Hancock County, Inc.[35]

City of Indianapolis

The City of Indianapolis, in its 2018 Transportation Plan, recommended supplementing its automated count program by partnering with volunteers to conduct manual counts. The Plan identified the Mayor's Bicycle Advisory Council and local community groups as possible partners for recruiting volunteers. The City cited the automated counters' high cost and limited geographic coverage as barriers for expanding its automated count program.[36]

The City originally recommended launching a bicycle count program in its 2012 Bike Plan with the goal of assessing the bicycle network's effectiveness. The City identified three ways to use count data: documenting crash data and traffic violations, measuring behavior changes before and after public awareness campaigns, and tracking participation levels in bicycling events. The Plan outlined two count-focused metrics for tracking the City's progress towards achieving this goal:

- Installing at least one permanent counter on each major roadway with a bike lane and supplementing them with portable counters throughout the City's bicycle system.
- Conducting manual counts twice a year on bicycle facilities along key routes.

The 2012 Plan also highlighted the benefit of count data for tracking changes in bicycle ridership, and for prioritizing roadway projects.[37]

City of Fishers

The City of Fishers in their 2014 Bike and Pedestrian Plan encouraged continuing their annual manual bicycle and walking counts as an evaluation tactic. In the 2014 Plan, the City recommended collecting bicycle and pedestrian counts before and after infrastructure projects to determine the project's impact. In addition to manual

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35. Hancock County. Hancock County Trails Plan: Final Report (2018, November). Retrieved March 19, 2019, from hancockcountytrailplan.com/wp-content/uploads/2018/11/Final-Plan-Report_12-4-18.pdf.
36. City of Indianapolis and Marion County. Indy Moves: Pedal Indy (2018, November). Retrieved April 3, 2019, from indymoves.org/wp-content/uploads/2018/09/Pedal-Indy-Draft-Plan_20181001.pdf.
37. City of Indianapolis. Indianapolis Bicycle Master Plan (2012, June). Retrieved March 19, 2019, from Citybase-cms-prod.s3.amazonaws.com/f528a48064a94b178162d936a193c20e.pdf.

counts, the 2014 Plan also considered the use of automated counters and volume-based GPS data, including Strava.[38]

Key takeaways from plans and policies review

- In addition to where bicycle and pedestrian counts are currently taking place, there is interest in Hancock County to develop a bicycle and pedestrian count program with the support of local jurisdictions and agencies.
- Bicycle Count Program metrics should address the size of the program and the location of where data is collected.
- There is an interest in using bicycle count data to document crash data and traffic violations, measure behavior changes before and after public awareness campaigns, track participation levels in bicycling events, track general changes in bicycle ridership, and prioritize bikeway projects.
- Further guidance is needed for communities to include Environmental Justice communities and areas in bicycle project planning and prioritization.

Current Counting Efforts within Central Indiana

City of Indianapolis

The City of Indianapolis has 18 permanent, automated counters installed on bike lanes around the City.[39] The bike lane counters were funded by a grant in 2012, but the City is no longer able to maintain the counters due to lack of ongoing funding. Funding to secure new batteries and cellular service, along with staff time would be needed to allow the counters to become operational again.

The City's Parks Department maintains automated counters along trails and greenways. The trail and greenway counter program has been ongoing for over 15 years. The program's counters generate a general user total that does not differentiate between bicyclists and pedestrians.

The City also collects pedestrian count data. Pedestrian frequency and volume levels are used by the City as part of their technical assessment to determine transportation project selection.[40]

City of Carmel

The City of Carmel began collecting bicycle and pedestrian counts in 2018. The City currently has three automated counters installed along both trail and on-road bicycle facilities. The 96th Street Trailhead was the first location installed in January 2018. The remaining two counters were installed in June 2018 near the City Center and along the 106th Street Path. While both the 96th Street Trailhead and the City Center counters differentiate between bicyclists and pedestrians, the 106th Street Path counter generates a combined user count.

City of Fishers

The City of Fishers conducted manual bicycle and pedestrian counts along trails in 2014 and 2016. Volunteers counted bicyclists and pedestrians separately at intersections and trail crossings, following the National Bicycle and Pedestrian Documentation Methodology. The City selected seven count sites in both 2014 and 2016. The sites were along both well-established trail networks in the western portion of the City, and on emerging trail

38. City of Fishers. Fishers Bicycle and Pedestrian Master Plan (2014, July). Retrieved March 19, 2019, from http://playfishers.com/DocumentCenter/View/172/Bicycle-and-Pedestrian-Draft-Plan-PDF?bidId=.
39. City of Indianapolis and Marion County. Indy Moves: Pedal Indy (2018, November). Retrieved April 3, 2019, from indymoves.org/wp-content/uploads/2018/09/Pedal-Indy-Draft-Plan_20181001.pdf.
40. City of Indianapolis. Transportation Project Selection process. Retrieved March 20, 2019, from www.indy.gov/activity/transportation-project-selection-process.

systems in the eastern portion. The City used the trail count data to identify and determine trail additions and maintenance priorities, and to support grant applications and budget development.[41]

Key takeaways from current data collection efforts

» There is interest among local jurisdictions to count bicyclists in Central Indiana; however, there have been some challenges to date, and a coordinated approach is lacking.
» The utility of data collected by local jurisdictions may be less than what it could be under a more coordinated effort and with greater consistency in implementation.
» Ongoing funding is essential to the success of any count program.

IMPO's Counting Experience, Capabilities, and Resources

The IMPO previously collected bicycle and pedestrian volume data and managed bicycle and pedestrian counters for use across the region. Unfortunately, the IMPO's bicycle and pedestrian counters were stolen, which, along with competing demands for staff time, led to the end of its bicycle and pedestrian count program. The IMPO does not currently monitor bicycle or pedestrian volumes on a routine basis.

IMPO does collect and coordinate the collection of traffic counts across the region. The IMPO shares the traffic counts with the Indiana Department of Transportation (INDOT), who in turn makes the counts publicly available through the MS2 Traffic Count Database System (TCDS). The TCDS' online interface includes an interactive map and data search tools.[42]

The IMPO is interested in partnering with local jurisdictions and partner agencies to collect, manage, and share bicycle volume data collected through counters, bikeshare systems, and GPS data sources.

Key takeaways from IMPO's counting experience, capabilities, and resources

» There is interest among IMPO staff to use bicycle volume data; however, past challenges in collecting bicycle and pedestrian volume data and managing counters pose barriers to operating a regional Bicycle Count Program.

BICYCLE PROGRAM OBJECTIVES

IMPO Bicycle Program Needs

Based on the information reviewed in the preceding section, the proposed objectives for the IMPO bicycle count program are to:

» Develop performance measures to evaluate TIP investments
» Validate third-party data sources
» Develop Bicycle Crash Rates

The bicycle count program's objectives will guide the implementation of counters, selection of new counters, data management approaches, and analysis to be conducted. Additionally, the program goals will have bearing on what outcomes can be measured, expected benefits to the IMPO's broader bicycle program, and how resources can be shared with local bicycle count programs.

In this section, the objectives are presented, including the rationale, considerations, and data needs. Greater detail on how to achieve these objectives will be provided in subsequent project deliverables.

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41. City of Fishers. Trail Counts 2016 Report.
42. Indianapolis MPO. Traffic Counts. Retrieved March 20, 2019, from www.indympo.org/maps-resources/maps/traffic-counts.

Objective #1: Develop Performance Measures to Evaluate TIP investments

Rationale:

Understanding the impact of investment decisions will equip the IMPO to make informed infrastructure investment decisions based on anticipated changes in bicycle use.

Considerations:

While the IMPO does not control or manage bicycle facilities in the region, it does direct funding for local projects. The IMPO determines how projects are selected and prioritized for several relevant funding sources: Congestion Mitigation and Air Quality (CMAQ), Transportation Alternatives Program (TAP), and Surface Transportation Block Grant (STBG).

Understanding the impacts of infrastructure investments will require the IMPO to track bicycle volumes along a variety of corridors where bicycle facilities have been implemented. This could entail monitoring usage along CMAQ-, TAP-, or STBG-funded corridors. The IMPO can expect to see different impacts from bicycle facility projects based on the facility type, proximity to activity generators, significance within a broader network, and other contextual considerations. Depending on the consistency of the results, the IMPO may be able to use the findings to evaluate the likely impact of future funding proposals.

The long-term objective is to measure and track changes in bicycling ridership levels at the investment location and along nearby key corridors. This long-term objective will require additional resources and encompasses a broader evaluation approach intended to track the wide-ranging impacts of the infrastructure investment. By taking a broad approach, the IMPO can track the effects of IRTIP investments attributable to changes in the local infrastructure.

Data Needs:

Informing IRTIP project decisions would require the following types of count data:

- » Permanent automated counters at high profile project sites with substantial bicycle ridership to provide a baseline for comparison.
- » Short-duration automated counters to be implemented as part of before-and-after counts at investment sites.

Objective #2: Validating Third-Party Data Sources

Rationale:

Third-party data sources have recently emerged as a critical element of the overall traffic monitoring approach for all modes, including bicycles. Leveraging third-party data sources will expand the IMPO's count dataset with limited local technology investments.

Considerations:

The increasing availability of user-generated location data collected by GPS- or cellular network- enabled devices may have significant implications for the IMPO's Bicycle Count Program. User-generated data is already in use for motor vehicle planning and operations and has some significant advantages over count data. For example, this data covers a wider geographic area and data management and processing are typically provided by the company that collects the data.

As of early 2019, Strava is the primary provider of crowdsourced bicycle user data. Strava collects GPS trace data from bicyclists (and runners) who use its app to track their performance. Since Strava's user base consists largely of recreational or competitive bicyclists, it does not represent the full spectrum of bicyclist types throughout Central Indiana. In particular, as bicycling infrastructure is implemented in hopes of attracting new bicyclists onto the region's streets, Strava data may not reflect an uptick in ridership. Nevertheless, Strava data can be a useful data source for observing the relative use of routes by experienced bicyclists. Paired with count data for validation, Strava could serve as the basis for crude bicycle volume estimates. If used for this purpose, it would be most appropriate to demonstrate relative use rather than absolute volumes.

Streetlight Data and Streetlytics are emerging providers of bicycle volume data that use proprietary algorithms to detect bicycle trips from mobile device data. Unlike Strava, Streetlight Data and Streetlytics use navigation-GPS data and Location-Based Services (LBS) data from a broad user group. Importantly, their data is not limited to bicyclists and runners who opt-in to a specific application. As of July 2018, Streetlight data's reach included 65 million devices, which equals just shy of one-quarter of the U.S. and Canadian adult populations.[43] These wider user bases represent a less-biased segment of the population than what Strava currently uses. Nevertheless, all smartphone-based data sources incur some bias.

Validation of third-party data sources is needed to assess their accuracy. There is no established guidance for how many validation locations are needed. For example, the Colorado Department of Transportation recently released a report that found Strava trips represent anywhere from 3 to 30 percent of total bicycle use, depending on the location.[44] With such variability, using Strava to predict overall levels of bicycling at an individual location is not recommended. We are unaware of any similar validation studies being conducted on Streetlight or Streetylitics. In general, validating at more locations will improve the ability to use the data to estimate systemwide bicycling activity. Staff time and resource limitations for conducting counts are likely to be the most significant challenges for validating Strava data.

Data Needs:

Validating third-party data sources would require the following types of count data:

» Permanent and short-duration automated counters to establish broad trends and patterns, and to use as the basis for factoring short-duration counts from third-party sources.

» Third-party data from Strava, Streetlight Data, Streetlytics, or another vendor.

Objective #3: Develop Bicycle Crash Rates

Rationale:

Evaluating bicycle crash rates will equip the IMPO to track its progress toward its 2015 Bikeways Plan's goal of improving safety for cyclists,[45] measure the impact of traffic safety programs and projects, and focus resources toward safety priority corridors.

Considerations:

While the 2015 Bikeways Plan did not establish a crash reduction target, the development of a bicycle crash rate performance measure will assist the IMPO in tracking its progress towards its general goal of improving safety for cyclists. Developing bicycle crash rates will require accurate and consistent measurement and reporting of bicycle volume and traffic crash data.

In the short-term, the IMPO should focus on accurately measuring the bicycle crash rate along key safety corridors. Understanding the bicycle crash rate along corridors with a high level of reported bicycle crashes will be

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43. "Streetlight Metrics: Our Methodology and Data Sources." Streetlight Data. October, 2018. https://3yemud1nnmpw4b6m8m3py1iy-wpengine.netdna-ssl.com/wp-content/uploads/2018/10/StreetLight-Data_Methodology-and-Data-Sources_181008.pdf.

44. Colorado Department of Transportation. Strava Metro Data Analysis Summary. June 2018. https://www.codot.gov/programs/bikeped/documents/strava-analysis-summary_06-25-18.pdf

45. The IMPO is currently reviewing the 2015 Bikeways Plan goals and developed revised goals for the Updated Bikeways Plan Goals.

an important first step to developing a regionwide method for estimating bicycle crash rate. The IMPO may eventually expand this objective to measuring and tracking changes in the bicycle crash rate across the region.

Data Needs:

Measuring the bicycle crash rate will require accurate bicycle volume and traffic crash data available on a consistent basis. While crash data is provided by ARIES (Automated Reporting and Information Exchange System), developing reliable bicycle volume estimates requires a committed data collection and analysis effort consisting of permanent and short-duration counts.

Measuring the bicycle crash rate would require the follow types of count data:

- » Permanent and short-duration automated counters along high-crash bicycle corridors and intersection.

Additional Ideas for IMPO's Involvement in Bicycle Data Collection and Management:

In addition to the objectives discussed above, the IMPO Bicycle Program could support and encourage bicycle data collection across the region through a few additional efforts, including:

- » Serving as a resource for MPO member agencies and establishing best data collection practices for the region
- » Developing a count equipment loaner library
- » Managing bicycle count data on a regional level and serving as a data clearinghouse
    - ▪ Examples of regional bicycle and pedestrian count data-sharing platforms are included in Appendix B.1.
- » Potentially installing permanent counters to understand seasonal patterns

NEXT STEPS

The Toole Design Team looks forward to feedback from the IMPO on the bicycle count program goals outlined in this memorandum. The bicycle count program's goals will influence the development of the Bicycle Count Program Guidance Manual for the IMPO.

The user-friendly Guidance Manual will assist staff in the development of the count program, should resources become available for future implementation. The Guidance Manual's recommendations will consider resource needs and availability, including staff time, when outlining program elements such as maintenance and data management. Depending on future discussions between the IMPO staff and the project team during the Bikeways Plan Update, the Guidance Manual may also consider opportunities for establishing common contracting vehicles for single-vendor agreements among the IMPO and its member jurisdictions.

Following the Guidance Manual's development, the project team in partnership with IMPO staff will undertake a limited data collection effort. The project team and IMPO staff will leverage ongoing planning efforts from other Regional Bikeways Plan Update initiatives when identifying potential locations for data collection.

APPENDIX B.1. EXAMPLES OF REGIONAL COUNT DATA-SHARING PLATFORMS

Pima Association of Governments (Tucson, AZ)

The Pima Association of Governments organizes an annual bicycle and pedestrian count in the Tucson region. These manual counts are conducted at over 80 intersections every October by volunteers and staff who have attended a brief training session. Counts are conducted in the morning and afternoon peak periods for two hours each, aggregated by 15-minute increments. In addition to the number of overall pedestrians and bicyclists, information such as gender, age range, helmet use, sidewalk riding, and wrong-way riding is collected.[46] The results are posted on an interactive web map.[47]

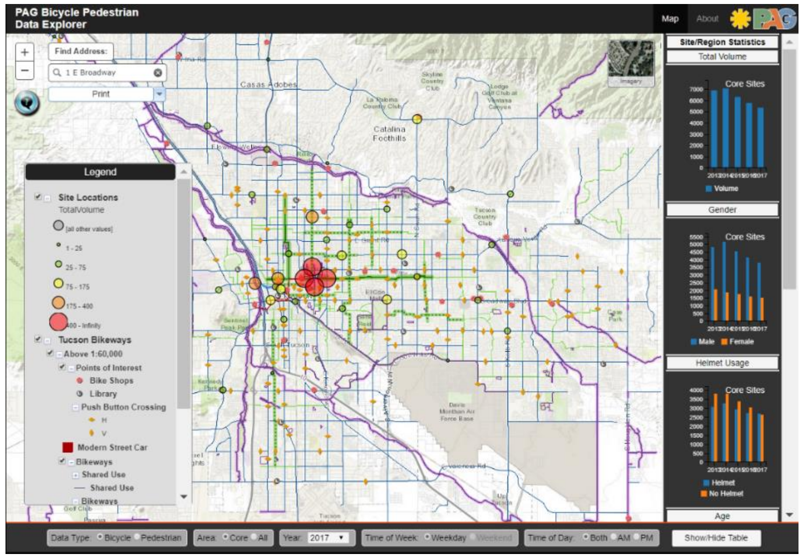

Figure 8: Pima Association of Governments Bike Ped Data Explorer

San Diego Association of Governments (San Diego, CA)

In 2010, the County of San Diego Health and Human Services Agency was awarded a $16 M grant to promote physical activity and healthy eating. As part of this grant, the health agency teamed with the San Diego State University and San Diego Association of Governments (SANDAG) to implement an active transportation monitoring program. Through this partnership, SANDAG installed Eco-Counter devices (Zelt, Pyro and Eco-Multi) at 26 sites on the regional bike network. Using GPS data combined with daily bicycle volumes, the partners were able to attribute 34,800 minutes of daily cycling to the active transportation network.[48]

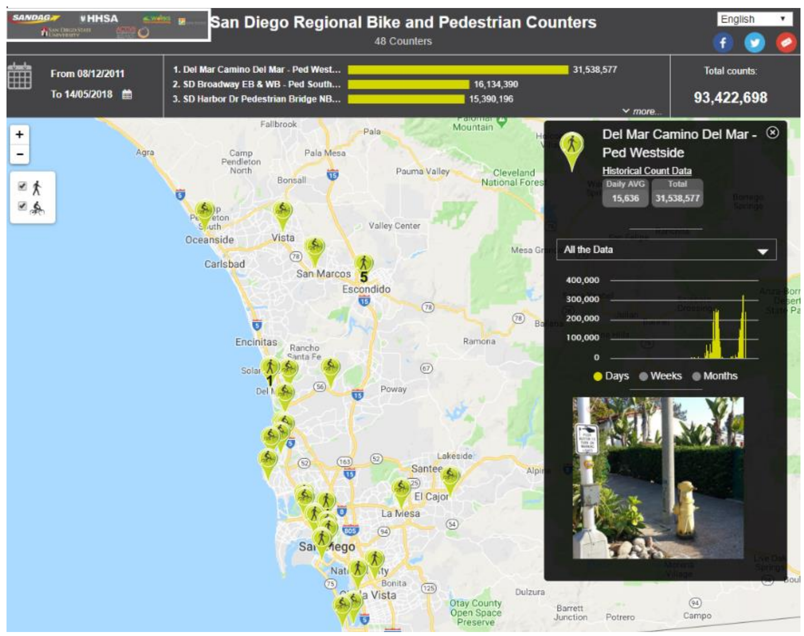

Figure 9: SANDAG Regional Bike and Pedestrian Counters Network

46. Pima Association of Governments. "2016 Bicycle and Pedestrian Count." *N.d.,* Accessed December 26, 2017. https://www.pagregion.com/Default.aspx?tabid=1269..
47. Pima Association of Governments. "Bicycle and Pedestrian Data Explorer" N.d., Accessed February 2, 2018. http://gismaps.pagnet.org/BikePedDataExplorer/Map.aspx
48. Sherry Ryan et al. "Designing and Implementing a Regional Active Transportation Monitoring Program Through a County-MPO-University Collaboration." 2013. https://activelivingresearch.org/sites/default/files/2013_Methods_Ryan.pdf..

Southern California Association of Governments (Los Angeles, CA)

One of the best examples of a regional nonmotorized count database is the Southern California Association of Governments' (SCAG) Bike Count Data Clearinghouse. Jurisdictions in the region upload their count datasets to the site and the data are presented in an interactive web map. Public users can view the map and download the raw datasets. However, the count data does not have standardized variables, making it challenging for users to compare data across jurisdictions. Currently, the web map has data for over 1,000 count locations.[49]

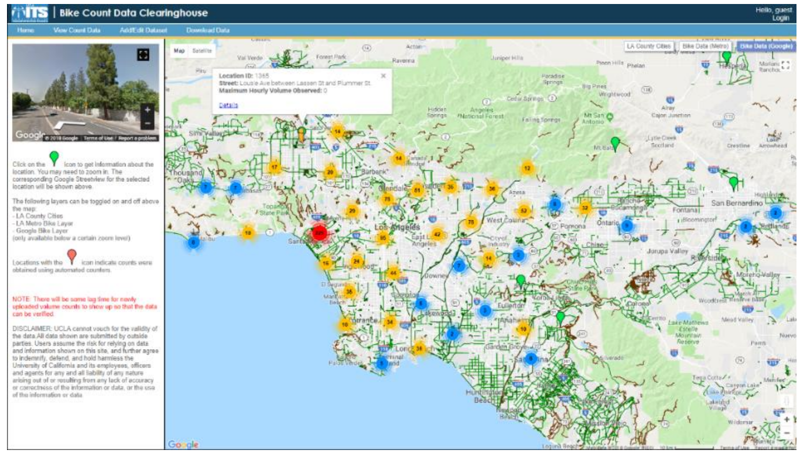

Figure 10: SCAG Bike Count Data Clearinghouse

Delaware Valley Regional Planning Commission (Philadelphia, PA)

Perhaps the most advanced bike and pedestrian count program in the U.S. is that of the Delaware Valley Regional Planning Commission (DVRPC).[50] DVRPC's program is housed within its travel monitoring program and includes a combination of short-duration counts and permanent count locations. For short-duration bike counts, DVRPC employs a cyclical approach, where each location is counted every 3 years, on a rotating basis. It is in the process of developing a similar schedule for pedestrian counts. DVRPC's experience highlights the significant staff requirement associated with maintaining a comprehensive count program, as well as the need to budget for data upload fees, which accumulate to a large sum for a large program.

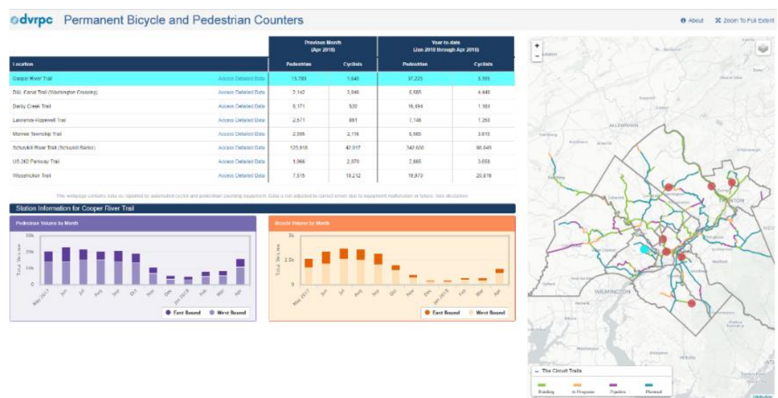

Figure 11: DVRPC Travel Monitoring Pedestrian and Bicycle Counts

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49. Colorado Department of Transportation. *"Non-Motorized Monitoring Program Evaluation and Implementation Plan."* 2016.
50. https://www.dvrpc.org/webmaps/pedbikecounts/

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